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MGIPC-S1-6 AR/54-7-7-54-10,000.
VEGETABLE TANNING MATERIALS
Early Boer settlers receiving seed of the newly established Australian Black Wattle from John Vanderplank, formerly a sea-faring man, at his farm—a favourite outpost—in the Midlands of Natal.

From a painting by Peter Leifwich

By courtesy of the Director of the Wattle Research Institute, Pietermaritzburg, Natal.
VEGETABLE TANNING MATERIALS

F. N. HOWES, D.Sc.

Royal Botanic Gardens, Kew

41987

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LONDON
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1953
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TANNING MATERIALS derived from plants have been used by man in many parts of the world from the earliest times for converting the skins of animals into leather or rendering them more suitable, more soft and more durable, for use as clothing and for other purposes. Tanning is in fact one of the oldest industries of the world and doubtless centuries ago, with some peoples, every man was his own tanner and tanned what skins he needed for himself and his family from the wild animals he slew. As mankind progressed and the tanning of hides and skins and the production of leather increased to become well-established industries, so did the demand and the use of vegetable tanning materials increase. With the development of world commerce, tanning materials came to be freely transported from one part of the world to another, often in very large quantities.

The progress that has been made in the tanning and leather industries, particularly during the last few decades, has called for changes in tanning technique and in the employment of the different kinds of vegetable tanning materials. In spite of the extensive use of mineral tanning substances (notably chrome tanning) and the interest in synthetic tans or ' syntans ' that has existed for many years, vegetable tannins are still in demand and essential for many classes of leather, especially heavy leather and sole leather, so extensively used for footwear.

At one time the use of vegetable tannins by the tanner was very much more rigid than it is now. With the better understanding of the processes involved in tanning and the chemistry of tanning, it is now possible to substitute one tanning material for another to produce the same type of leather. This is done by altering the chemical nature of the tan-liquor, i.e. by sulphiting and altering the degree of acidity or pH value of the tan-liquor or its salts or acids content. Among the major tans, for instance, wattle or mimosa may be modified to produce the same or similar results as chestnut, and chestnut in turn may be modified to produce similar results to quebracho. This was done on a large scale during the Second World War when the traditional tanning materials used in many countries became unobtainable, and it continues to be practised.

The world’s need of tanning materials continues to increase especially with the increasing world population and the tendency
for more and more of its people to wear boots and shoes. This applies perhaps with special emphasis to the peoples of Asia and Africa and some parts of the New World. Many feel that in the not-far-distant future there may well be a shortage of vegetable tanning materials for the world’s leather industries, particularly in view of the decreasing supplies of two of the most extensively used tanning materials—chestnut (through disease) and quebracho from South America through the cutting out of the slow growing quebracho forests. The chestnut and quebracho industries formerly provided between them some 250,000 tons of tannin extract annually. It is also felt in some quarters that increased supplies of mimosa or black wattle may well be the most practical solution to these decreasing quebracho and chestnut supplies and that the world’s rich potential supply of mangrove tannin might be more fully exploited, if certain difficulties such as high colour could be overcome, for extensive mangrove tracts occur throughout the tropics. It is due to considerations such as these that special attention has been given to both wattle and mangrove in this book.

Tannins are very widely distributed in the vegetable kingdom and the number of plants that contain tannin is legion. However, it is only those species that are rich or relatively rich in tannin that can be of interest as tanning materials. In this work an attempt has been made to deal at some length with all the important or commercial tans and more briefly with all those species known to be used in some part of the world in local or small-scale tanning but which do not enter world trade. With regard to tanniniferous plants not known to be actually used in tanning an attempt has been made (Chapter 41) to list all those species known to contain over 10% of tannin (dry weight) in some part or other of the plant, for it could be argued that such plants, or some of them, may one day be commercial tanning materials in their countries of origin. A few species, with a tannin content of less than 10%, have been included on account of special scientific or other interest that may be attached to them.

The importance of the tanning industry and of vegetable tanning materials may be judged from the fact that the annual importation of the latter (in crude and in extract form) to the United Kingdom alone is approximately a hundred thousand tons, and that the total annual production of vegetable tanned leather is about the same tonnage. The consumption of vegetable tanning materials in the United States is considerably larger and is believed to constitute about one third of total world consumption.
A word of explanation may be desirable in connection with the use of botanical names. As the average reader is not likely to be interested in the authority for the name but only in the plant itself the authorities for the names have been omitted purposely from the text. They are, however, available for those who may require them in the index of plant names at the end of the book. The families are also indicated in this index.

The writer is greatly indebted to the Director of the Royal Botanic Gardens, Kew, for the facilities afforded in carrying out this work, also to the British Leather Manufacturers' Research Association, the Colonial Products Advisory Bureau and to various other organizations and individuals who have kindly given assistance.

F. N. H.

Hanover House,
The Green,
Kew, Surrey
August, 1953
INTRODUCTION

Nature of Tannin

The word tannin is generally used as a collective term for a whole group of complex substances that are of common occurrence and are widely distributed in the Vegetable Kingdom and which have certain characters in common. They are frequently and perhaps more appropriately referred to in the plural as the tannins.

It is not possible to give a clear or concise definition in chemical terms of the words tannin or tannins. In this respect the tannins are similar to other large and complex groups of plant products, such as the gums and resins, for they are equally difficult to define in concise terms. Tannins are complex organic structures, often with very large molecules and high molecular weights (to the order of 2,000 or more). They are built up from the elements carbon, hydrogen and oxygen. Some contain smaller amounts of other elements such as nitrogen and phosphorus. They were at one time classed with the glucosides on account of the sugar groups that most of them contain, but they are now generally regarded as constituting a class by themselves, for certain of them, e.g. the hemlock tannins, lack the sugar group in the molecule.

The tannins are mostly uncrystallizable colloidal substances with astringent properties and with the ability to precipitate gelatin from solution and to form insoluble compounds with gelatin-yielding tissues. It is this property which enables them to convert hides and skins into leather. The tannins are precipitated from solution by many metallic salts such as copper and lead acetates and by strong aqueous solutions of potassium bichromate or chromic acid. They give blackish-blue or blackish-green colours with iron salts, a property that has been made use of in ink manufacture, although other organic substances may give similar colour reactions.

Tannins are usually considered to consist of two main groups—the hydrolyzable tannins (pyrogallol group) and the condensed tannins (catechol group). Quite frequently the tannin, or tannins, extracted from a plant bears the characteristics of both groups and is actually a mixture of pyrogallol and catechol tannins. The hydrolyzable tannins may be hydrolyzed by acids or enzymes and include the gallo-tannins (from plant galls) and the ellagitannins which produce 'bloom' on leather and which are characteristic.
of myrabolans, valonea, divi-divi and a number of other well-known tanning materials. The condensed or catechol tannins are not hydrolyzable and are characteristic of most of the important commercial tanning materials such as wattle or 'mimosa', quebracho, mangrove and hemlock. They are more astringent (tan more rapidly) than the pyrogallol tannins, have larger molecules and are less well buffered. The catechol tannins yield less sediment, or lose less on standing but the leather often tends to turn a reddish colour on exposure to light. They yield phlobaphenes or 'reds'.

The chemistry of the tannins is still far from being well understood and is too involved for consideration in a book of this kind. An abridged survey of the chemical nature of the vegetable tannins has recently been made by Rottsieper\textsuperscript{153}. Others who have contributed to the subject in recent years or discussed it at some length are Bergmann\textsuperscript{41}, Freudenberg\textsuperscript{75}, Gnamm\textsuperscript{83}, Nierenstein\textsuperscript{129} and Platt\textsuperscript{140}.

\textit{Distribution of Tannin in the Vegetable Kingdom}

The tannins may be said to occur throughout the greater part of the Vegetable Kingdom but to be more prevalent among the Angiosperms or higher plants, especially in certain Dicotyledon families, than they are among the lower organisms such as the Fungi, Algae, Mosses and Liverworts. The Ferns constitute an exception among the lower plants as tannin is sometimes very prevalent, the rhizomes of species of \textit{Aspidium} having been recorded with tannin contents of 3—10\% (dry weight)\textsuperscript{57}. The Gymnosperms have classes in which tannin is well developed, familiar examples being the Pines (\textit{Pinus}), Spruces (\textit{Picea}) and Hemlocks (\textit{Tsuga}). The Monocotyledons are poorly represented in species rich in tannin, many families and genera being normally devoid of tannin. The palm family (\textit{Palmae}) however affords an exception and tannin is well developed in some species such as the date palm (\textit{Phoenix dactylifera}), betel palm (\textit{Areca catechu}) and North American saw palmetto (\textit{Serenoa serrulata}).

Among the Dicotyledons there are many families in which tannin occurs very freely, the most notable being perhaps the \textit{Leguminosae} (e.g. black wattle), \textit{Anacardiaceae} (e.g. quebracho and sumac), \textit{Combretaceae} (e.g. myrabilan), \textit{Rhizophoraceae} (e.g. mangroves), \textit{Myrtaceae} (e.g. Eucalyptus) and \textit{Polygonaceae} (e.g. canaigre). Other families in which cells with tannin or tanniferous contents are common include the \textit{Ampelidaceae}, \textit{Annonaceae}, \textit{Caryocaraceae},...
OCCURRENCE AND FUNCTION OF TANNIN IN THE PLANT

Celastraceae, Crassulaceae, Ebenaceae, Eparidaceae, Ericaceae, Geraniaceae, Lecythidaceae, Loranthaceae, Myricaceae, Myrtaceae, Plumbaginaceae, Proteaceae, Rhamnaceae, Rosaceae, Saxifragaceae, Sterculiaceae, Tamariaceae and Vaccinaceae.

In many families tannin occurs in some genera and species but not in others, as in the Ranunculaceae and Rubiaceae. There are also certain families in which tannin is absent or comparatively rare such as the Gramineae (grasses), Cruciferae and Papaveraceae. The family Myristicaceae (to which the nutmeg belongs) is of special interest on account of the distinctive tanniferous tubes that occur in the rays of the wood of all species. As far as is known this type of tannin tube does not occur in any other family.

Plants rich in tannin occur both in temperate and in tropical or subtropical climates. Most of the commercially-important tanning materials such as wattle, quebracho, myrabolan, mangrove etc are products of warm countries. According to figures given by McNair, there are probably about twice as many species containing appreciable amounts of tannin in the tropics than there are in the temperate zone.

Tannins are usually regarded as restricted to the Vegetable Kingdom. It is of interest to note however that a tannin or tannin-like substance, giving all the usual reactions of vegetable tannins, has been described as present in the corn weevil (Calandra granaria). Possibly tannin-containing food materials may have had a bearing on the presence of the tannin or tannin-like substance in the insect.

Occurrence and Function of Tannin in the Plant

Tannin may occur in almost any part of a plant—root, stem or trunk, bark, leaves, fruit and even hairs. It may occur either in isolated individual cells, in groups or chains of cells (the more common method), or in special cavities or sacs. It may also be present in latex vessels and lactiferous tissue accompanied by other substances.

In living plant tissue, tannin is present chiefly in solution in the vacuoles. As the cell ages and loses its protoplasmic contents, the tannin commonly becomes absorbed in the cell wall. In dead tissue, tannin often accumulates in considerable quantity.

Tannins often occur freely in green or immature fruits, but the quantity decreases as the fruit ripens. They may also occur in seeds, often becoming more abundant after germination. Certain special plant structures may be rich in tannin, particularly those
INTRODUCTION

associated with movement. Tannin is often to be found in gland cells and the cells of pulvini (swollen leaf stalk bases). It is also very prevalent in the tissue caused through pathological conditions, e.g. in plant galls. Certain plant galls constitute the richest sources of tannin in the Vegetable Kingdom and are well-known commercial sources of tannin (see Chapters 37—40). The young, actively-growing tissue of plants is also liable to be very rich in tannin. An outstanding example is afforded by 'Dhawa sumac' (*Anogeissus latifolia*), for the young, red leaves and twigs of this Indian tree, when dried, may contain 50% tannin (see Chapter 32). However, in general, the highest concentration of tannin in normal healthy plants is commonly to be found in the bark.

The function of tannin in the plant or its physiological significance and its role in the metabolism of the plant is not well understood and has been the subject of much discussion. The same applies to certain other substances commonly found in plant tissue such as alkaloids, resins and gums. The general opinion now seems to be that tannin may serve several different functions and that its main function in one plant or group of plants may differ from that in another. It may be little more than a by-product in some plants but useful in others.

At one time teleological reasons were put forward to explain the presence of tannin. It was contended that the presence of tannin in leaves and green tissue would, owing to its astringency, prevent damage from browsing animals or other creatures and that it thereby served a protective role in the plant. Its presence in quantity in green fruits but not in ripe fruits, which commonly applies, was explained by stating that it was not in the interests of the plant that its immature or green fruits should be eaten, but that in eating ripe fruits animals often assisted in seed dispersal. It is sometimes contended that the presence of tannin in the epidermal or surface layers of leaves and shoots in temperate plants assists in resisting frost and that this may be the reason why many temperate evergreen plants have tannin well developed in their leaf tissue.

Tannin or solutions of tannin are known to be toxic to many plants. Concentrations of tannin as low as 0·1% and 0·8% have been shown to retard the growth of a large number of parasitic fungi. The spores of some fungi will not germinate in media containing more than 0·6% tannin. Some consider that one of the functions of tannin in the plant may be to assist in preventing infection by parasitic fungi when wounding or damage to the plant has taken place.
In more recent years the belief has grown that tannins may play some part in the formation of cork or corky tissue, that they may be intermediate products in the formation of cork tissue. Tannin is often very prevalent in bark which is the part of the plant where cork tissue is most freely developed. By treating cork in various ways decomposition products which show tannin-like properties have been obtained. Furthermore by passing carbon dioxide through mixtures of formaldehyde with tannins cork-like substances have been produced.

Tannins may play some part in the development of colour and pigmentation in plants. They show similarity in structure with the anthocyanin pigments. It is thought the disappearance of tannin during the ripening processes of fruits may be connected in some instances with the development of red, blue and yellow pigments so characteristic of ripe fruits.

The fact that young or immature fruits are frequently rich in tannin and that on ripening the tannin disappears or becomes much reduced in quantity or modified is of some importance economically for it applies to several everyday fruits such as the persimmon, the banana and the plum. In the persimmon, tannin is present in quantity in the unripe fruit, which is very astringent. On the ripening of the fruit, the tannin is considered to enter into combination with a colloid of a carbohydrate nature producing an insoluble gel, in which form the tannin is no longer astringent, or there may be a 'walling-off' of the tannin by a non-astringent layer. This process may be artificially stimulated in partially ripe persimmons by treating them with carbon dioxide and this is now a common commercial practice in some countries where persimmons are cultivated.

In the green banana, tannin occurs freely in the skin and the flesh. In the flesh, it is to be found mainly in the latex vessels which ramify through the flesh. On the ripening of the fruit these vessels lose moisture and their contents coagulate presenting a caked or cracked appearance under the microscope. This change is accompanied by the loss or lessening of astringency. In diseased or chilled bananas, the usual changes in ripening do not follow the normal course and hence their inferior edible qualities.

The tannin present in the flesh of a green banana may exceed 8%, while the flesh of a similar banana in the ripe condition may contain less than 2%. Similarly the skin of a green banana may contain 30—40% tannin and that of a ripe banana only 4—5%. 

V.T.—B
INTRODUCTION

Various methods have been employed in estimating the tannin present in plant tissue, the two best known and most commonly used being the Filter Method (F.M.) and the Shake Method (S.M.). In the latter method, which is now the more generally used, the tannin is absorbed by specially prepared or standard hide powder. In addition to the tannin the percentage of soluble non-tannins is invariably recorded, for this may be important to the tanner and in tannin extract manufacture. The Shake and the Filter methods do not give the same results but the difference between them is not unduly large and is roughly in the proportion of 100 'shake' : 110 'filter'.

Factors affecting Tannin Production in the Plant

The increased attention and study that has been given to plants yielding tannin in recent years has brought to light very forcibly the many different factors that may influence the production of tannin and the tannin content. These factors fall roughly into two groups—those that are environmental and those that are genetical or due to the inherent nature or make-up of the plant, i.e. its variety or strain.

With many tannin-yielding plants, the locality or the area where they grow and the soil conditions may affect tannin content. With mangroves, it is common knowledge that those that frequent shores on the Indian Ocean (e.g. East Africa and Madagascar) and the western Pacific region are richer in tannin than the same and similar species in the Atlantic region (e.g. West Africa and tropical America). Yet all grow at the same altitude and under similar circumstances in regard to temperature and estuarine conditions. With the common European oaks (Quercus petraea and Q. robur), it has been found that the bark of trees growing in poor dry soil has a higher tannin content than that of trees that have grown in damp lowlands. With the European chestnut, much used for the production of tannin extract in southern France and Italy, it has been found that wood from trees grown in southern Europe has a much higher tannin content (up to 50% higher) than trees of similar age grown in northern Europe and the British Isles. Temperature may here be one of the factors involved.

Altitude may have an important bearing on tannin production in some plants. This is believed to apply to some extent with spruce bark and to a large extent with the Siberian Saxifrage or 'Badan' (Bergenia crassifolia). With the latter, rhizomes grown at about 400 metres had a tannin content of 15%, while those grown
FACTORS AFFECTING TANNIN PRODUCTION IN THE PLANT

At 2,300—2,400 metres showed a tannin content of over 22.5%. At intermediate altitudes, corresponding intermediate tannin contents were found.

With many tannin-yielding plants the age of the plant has an important bearing on the tannin content. Frequently it is the middle-aged rather than the young or the old plants that have the highest tannin content. The same often applies with woody species where the tannin is concentrated in the bark. As trees age, the bark often becomes corky or develops a large amount of moss with little or no soluble tannin and this may cause a considerable reduction in the tannin content of the bark, the moss being in effect part of the bark. This applies particularly with the oak and with various Coniferous tan-barks. Studies on the black wattle in Natal have shown that in general it is the well-spaced middle-aged trees that average the highest tannin content and that the thicker the bark the greater is the tannin content likely to be. Close spacing is conducive to thin bark (this applies also with other tan-barks such as mangroves). With old wattle trees, exceeding 15 years, the proportion of moss increases and the bark is liable to become diseased.

The position of the bark on the tree is liable to affect tannin content in some species and this again applies particularly with the black wattle and the mangroves. In the black wattle, the tannin content is highest at the base of the trunk and steadily decreases towards the top of the tree. So appreciable is this that it has been found that the bottom third of the trunk usually contains more than half the total tanning matter from the whole trunk. In one experiment with 3—9 year old trees it was found that where the bottom 6 ft. of trunk yielded 36—40% tannin the top 6 ft. yielded 26—28%. With mangroves, the variation may not be so appreciable and in some instances may apply in the reverse direction to that already described for the black wattle, i.e., bark from near the top of the trunk is richer than bark from near the base. In regard to Malayan mangroves, it has been said the tanning value of bark changes with height up the tree or with any difference of position. No two strips of bark from a tree are the same. The differences from tree to tree are often of the same order as from species to species. With mangroves it has been found that bark exposed to the sun shows a higher tannin content than bark that is shaded. With American sumac (Rhus copallina and R. glabra) it has been found, and the same may apply with some other plants, that the tannin content of the leaves varies
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inversely with the height of the leaves from the ground. On an average the tannin content of the leaves decreased by 0.6% for each foot in the height of the plant, which is quite considerable. The deblossoming or removal of the inflorescences of young American sumac plants increased the tannin content of the leaves.

There is no doubt that in many plants tannin undergoes seasonal variations and that at certain times of the year it is more abundant than at others. This probably applies more to plants growing in temperate climates than to those in the tropics and subtropics where the seasons are less sharply defined. Willow bark in northern Europe is known to exhibit marked seasonal variations in tannin, July being the best time for harvesting. Studies throughout the year in the tannin content of the roots of canaigre and of European docks (Rumex spp.), which have attracted attention as possible tanning materials in war time, serve to illustrate this point.

Increased tannin production in a plant is often to be associated with pathological conditions. The best example of this is probably the abnormally-high tannin content to be found in plant galls. Some plant galls may contain in excess of 60% or even 70% tannin (dry weight), which is considerably in excess of even the richest tan-barks such as the black wattle and golden wattle of Australia, which may reach 40—45%. Many plant galls owe their origin to insects and to the irritation which they cause to the plant tissue. Some plant galls are believed to be caused through bacterial agency (see Chapters 37—40).

Early Uses of Tanning Materials
The tanning of hides and skins is without doubt one of the world’s oldest industries and goes back to prehistoric times. The probability is that the use of vegetable tanning materials was developed independently in different parts of the world by different primitive peoples, particularly in wooded areas where tan-barks would be in free supply. Early man made good use of the skins of animals obtained in the chase and at a later stage from his domestic animals. These were mainly used as clothing and for keeping the body warm, also for tents in some regions. Probably the earliest form of treatment given to skins, to render them soft and pliable as clothing, was ‘curing’ by rubbing with fat, a custom still much practised, especially in Africa. In some areas rubbing with alum-containing rocks is believed to have been practised, which would constitute the first form of mineral tannage and is a precursor of modern alum-tannage used for white leathers.
There have been many imaginative suggestions put forward as to how the benefits of vegetable tannage may have first been discovered, e.g. '... when our ancestors came from their caves and built wooden shelters thatched with bark and leaves, some observant savage with an enquiring mind noticed the effect of the wet leaves and bark of certain types of tree on animal skins, and so the first vegetable tannage began'.

At a later stage in man's progress 'leather played an important part in man's early struggle for existence and the successful tanner must have occupied an important position in the tribe which depended upon him for clothing, footwear, thongs for buildings, harness for animals etc. The armies of the world have marched on leather since the dawn of time, and leather shields, leather linings for armour and helmets, and leather tents were essential features of the army equipment'.

Among the early records of the production and use of leather and of vegetable tannage are those from Ancient Egypt, from evidence afforded by the tombs. Archaeological investigations of ancient civilizations in northern Germany dating back to 10,000 B.C. have now established the existence of leather and of leather tanning at that time. It may be assumed therefore that the art of leather tanning was practised by man at least 12,000 years ago. Articles of leather dating from about 5000 B.C. have been recorded from Egyptian tombs and these have been identified as deriving from cow, calf or goat. Leather was used in Ancient Egypt for such articles as bags, cushions, chariot flooring, harness, rope, dagger sheaths, quivers, sandals and dog-collars. Records show that the art of tanning had reached quite a high degree of perfection in Ancient Egypt 4,000 years ago. Samples of leather from the period 2000 B.C. have been found which have been dyed red, yellow and green. Evidence suggests that the rind of the pomegranate may have been the source of the yellow dye and, it is believed, chermes may have been used for the red. With regard to other materials used by those Ancient Egyptian tanners, there is good evidence that 'sant' pods or 'garad' pods (Acacia arabica) were used then just as they are used in Egypt and the Sudan at the present time. The remains of an Egyptian tannery dating from about 5000 B.C. and containing pieces of leather and jars with pods of Acacia arabica have been recorded. An interesting feature of the discovery (by the Turin Egyptologist C. Schiaparelli) was that the pods from the jars (found at Gebelein) were found on analysis to contain as much tanning matter as fresh pods.
The Greeks and the Romans were competent tanners and skilled in leather production. In Athens and other towns quite large tanneries are known to have existed. They have been referred to by Homer, Pliny and other writers. Among the tanning materials used were pine and alder bark, pomegranate, sumac, gall-nuts and acorn cups (valonea). The Greeks also learned to use Acacia pods from the Egyptians. The Roman tanners were known as coriarii. A tanners' district existed beyond the Tiber, in the xlv municipal region, and large quantities of leather were produced.

Evidence from China also points to skill in the art of leather manufacture and the use of tanning materials thousands of years ago. Tanning by smoke has been and is still much practised in China.

Little appears to be known regarding tanning during the Middle Ages. It may have undergone little or no change in European countries during that time. The Mediterranean countries were fortunate in possessing several useful indigenous tanning materials such as valonea, sumac, sant or garad pods already mentioned, and tizrah. In Britain and in many parts of Europe, oak bark was for a long time the most important and the most extensively used tanning material. It was the traditional tanning material of the English tanner for centuries until it was gradually superseded by imported tanning materials in the nineteenth century such as valonea, myrabolans, sumac and later quebracho and mimosa or wattle. In Europe, especially northern Europe, other tanning materials were used besides oak bark, such as pine and spruce bark and sometimes bark of birch, willow and alder.

With the development of world trade in the nineteenth century the number of different kinds of tanning material, from various parts of the world, that became available to the larger tanneries grew considerably. The result was that the tanners became accustomed to blending several different vegetable tanning materials in order to obtain the results required or the type of leather they needed. Knowledge, experience and skill were called for in this work.

In the twentieth century, two world wars and the consequent disruption of world trade, combined with the development of the tannin extract industries, were the cause of notable changes in the tanning industry. The tendency has been and is to use fewer different kinds of vegetable tanning material but to modify them, by chemical means, to produce the result or the particular type of leather required.
Present-Day Uses of Tannins

The leather industry has always remained by far the largest user of tannins but certain other industries use them to some extent.

Tannin is used in deep-oil-well drilling, in combination with caustic soda, to reduce the viscosity of the drill mud. Up to 40,000 tons of quebracho extract have been used annually in the United States for this purpose, which indicates that the consumption is quite considerable. Tannin has long been used in the preservative treatment of fishing nets (mainly cutch) and in ink manufacture, although it is used less now than formerly for ink, synthetic materials having been partly substituted for it. Tannin is also used in boiler-water treatment, for the prevention and removal of boiler scale. On the French State Railways chestnut extract is freely used. Quebracho extract may also be employed for this purpose. Tannin has been used to some extent in the plastics industry but not intensively. It also has medicinal uses as an astringent and has been used in the treatment of burns, but its use in this connection has fallen into disrepute. It is said to prone to cause the burned area to contract on healing thus causing a permanent scar. There is also reason to believe that when used freely, as with extensive burns, it may cause damage to the liver by absorption.110

Before dealing with the present-day uses of tannins or vegetable tanning materials in the leather industry, it may not be out of place to refer briefly to some of the main processes in the manufacture of leather, a subject on which there is now an extensive literature.190, 192, 118.

Hides and skins are generally a by-product of the meat industry but nevertheless are of very great importance in world trade and are handled in enormous quantities. A hide may constitute about 6% of the total weight of an animal. Fresh or ‘green’ hides, just removed from the carcase of an animal, make the best leather but as fresh hides are just as perishable as meat most of the world’s leather has perforce to be made from dried or preserved hides and skins. There is probably no country in the world where leather of some kind is not made from the locally available hides and skins.

It is customary in the leather and tanning industries in English-speaking countries to refer to the skins of the larger animals such as horses, cattle and buffalo as hides, and those of the smaller animals such as sheep, goats and pigs as skins. Leather may be made from the skins of various wild creatures such as antelopes, kangaroos, sharks, whales, seals, walruses, lizards, snakes and
crocodiles, but usually only in relatively small amounts and for special purposes. With fur skins, which constitute a form of light leather, the production of leather from the skin is secondary to the preservation and good display of the fur.

The main function of the skin of an animal is that of protection—to prevent the entry of bacteria or parasites into the body. The skin (and the hair on it) also plays a part in regulating body temperature, especially in those animals with sweat glands. Skins of animals vary much in texture and in potential leather quality from one animal to another and between different breeds. Sheepskins probably vary more with breed than do the skins of any other animal. The skin of the Merino sheep, famous for its wool, is loose fibred, ribby, and of little value. On the other hand the skins of various African breeds of sheep, with worthless hair, make excellent leather. With cattle the hides of the more refined or the dairy breeds are very much inferior for leather than the hides of scrub cattle. The South African Afrikander, now an established breed, yields a hide far superior to the Frisian.

Many other factors may influence the quality of a hide or skin for leather. Sex is one of them, the skin of a bull or a ram being heavier and coarser grained than that of a cow or ewe. The skins of young animals (e.g. calf) have a finer texture and grain pattern, and more moisture, than those of older animals. Skins of very old animals are inclined to be uneven in substance and not to tan well. Other factors which may affect the quality of the skin of an animal are latitude, elevation, climate and the foraging or feeding the animal has received. In general, hot climates tend to produce loose spongy leathers and cold climates dense ones. The season of the year when the animal is slaughtered may affect the hide or skin in temperate climates. Tanners generally prefer skins from animals slaughtered in the autumn.

There are two main classes of leather—' heavy leather ' and ' light leather '. The heavy leathers are those which, as the name implies, are thick and heavy, notably sole leather, belting, harness and luggage leather. They are tanned in the main with vegetable tannins which add weight or substance to them. The light leathers, which are much thinner and lighter, are derived from the smaller animals, also young animals like calves. Split cow hide is also included in this category. They are mainly used for the uppers of footwear, for gloves, garments and fancy articles but have innumerable other uses. They need to be soft and flexible, not hard and heavy like sole leather. Light leathers receive quite different
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treatment from heavy leather and are largely tanned with mineral
tanning materials (chrome tanning).

The tanner has therefore developed two basic techniques for
these two classes of leather. With heavy leather, the natural
cavities or voids between the fibres (filled with water or fluid in
the live skin) are filled with finely divided particles of the tanning
material during tanning. This imparts increased weight, thickness
and durability—desirable or necessary qualities in heavy leathers.
With light leathers the tanner aims at loosening the natural fibres
of the skin by destroying and washing-out some of the skin substance.
With both heavy and light leathers however, one of the main objects
of tanning is to make the hide or skin resistant to water, to bacterial
attack or decay and to wear.

The properties of finished leather such as colour and 'handle' or
'feel', are to a large extent dependent on the properties of the
individual tannins used. They are dependent also on certain
physico-chemical factors which may often, in the light of modern
knowledge, be easily modified by chemical means (e.g. pH value of
tan-liquor, tannin strength of liquor, acids and salts contents etc).
The tannage of light leathers is a shorter and simpler operation
than the tannage of the relatively-thick heavy leathers, which offer
so much more resistance to tannin penetration.

A tanner of heavy leather might use about 1 lb. of 100% tannin
for every 2 lb. of air-dry sole leather he produces. A tanner of
light leather, using vegetable tannins, would use much less tannin,
or not much more than half the amount. Mineral and synthetic
or combination tannages are largely used for light leathers and drum
tannage is much practised.

At one time the tanning of heavy leather took many months or
even years, as when oak bark alone was used. In modern practice
heavy leather may be tanned in two or three months. With light
leather, tanned rapidly, as short a time as only two days may be
required with modern methods. With heavy leather today the
hides used are usually tanned by the counter current process rather
than by the old 'contact' or pit process. In this process the hides
are subject to nearly-spent tan-liquor at first and then to slowly
increasing tannin concentrations in the tan-liquor. If this were
not done and the hide subjected to a high tannin concentration
straight away it would tend to be 'case hardened' or the outer
layer only tanned. Tan-liquors for modern, rapid, heavy leather
tannage may contain from 15—25% tannin according to the speed
of tanning required. Various methods are used for moving the
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hides in the liquors to accelerate the penetration and fixation of the tannin. In the light leather industry sheep and goat skins, being much thinner than hides, are frequently tanned by paddling them in a single liquor. Hides and skins have to go through various processes both before and after tanning before they become finished leather. These processes differ a great deal according to the type of leather it is desired to produce. The pretanning processes include soaking in water to clear off accumulated dirt, to remove excess salt or to restore some of the water lost in drying. The hides are then soaked in a lime solution, usually with sodium sulphide, to loosen the hair and epidermis which are removed, usually by machines. Were this not done as part of the 'beamhouse operations' their presence would impede tanning and prevent the production of well-tanned supple leather. The producer of heavy leathers soaks and limes for a long time whereas the producer of light leathers employs a mild or 'mellow' lime treatment. After deliming, skins for light leathers are bated. In olden times this was done by using fowl, pigeon or dog dung, obviously a nauseous operation. Special commercial preparations are now used in their place—usually a mixture of pancreatic enzymes and ammonium chloride. Leather that is to be glazed is usually heavily bated, for it gives to the grain a smooth, silky feel.

After tanning, the tanner is able to modify the character of the leather to a considerable degree in the finishing operations, which include oiling and greasing. With sole leather, a mixture of animal or fish oil with mineral and sulphonated oil is commonly used. For harness leather, a mixture of greases may be employed. In order to give harness leather more grease-holding capacity, and therefore greater flexibility, it is not so heavily tanned as sole leather. Leather is rolled to make it hard and firm and it may be loaded with various mineral substances with this end in view. Special care is necessary in the drying of leather; it may be easily spoiled by faulty drying.

Tanners formerly made their tan-liquors directly from the bark or crude material but for many years the tendency has been to employ tannin extracts more and more and bark less and less. It is frequently or generally found that, in order to obtain the type of leather required, the blending of different tanning materials gives the best results. For instance quebracho extract, when used in the usual sulphited form, penetrates hide rapidly and produces a leather that has good colour and handles well, but unfortunately
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tends to be flat and poorly filled. Chestnut extract on the other hand penetrates slowly but gives a firm, well-filled leather, in fact it tends to make the leather too firm or brittle. By mixing quebracho with chestnut, therefore, their respective properties are blended or united with very good results for the tanner. The quebracho—chestnut mixture has been a popular tanning combination in America and in Europe for many years.

The tanning blends now marketed commonly contain other tanning materials. These may aid in acid formation, increase penetration and improve the colour and general appearance of the leather. Myrabolans or myrabolans extract, when available, is commonly used to increase acid, especially with wattle or mimosa which is poor in acid-producing properties. Valonea or valonea extract is also much favoured in blends and for the production of many classes of leather on account of its 'bloom-producing' properties. Sumac is also much used to improve the colour and feel of leather.

A material now sometimes used in tanning blends is the so-called sulphite-cellulose extract. Although its tanning value is doubtful it is probably of use in modifying the character of the blend and in lowering costs. It is a solubilized lignin by-product of the sulphite paper industry and is produced in large quantities in paper-making countries.

The other (if possible!) methods of tanning leather, apart from vegetable tannage, fall into five categories:—(1) mineral tannage, (2) oil tannage, (3) aldehyde tannage, (4) synthetics and (5) combination tannages.

In mineral tannage the salts of certain minerals are employed, notably those of chromium and to a lesser extent of aluminium. Mineral tanning (with alum) has been practised in Egypt and China since early times. Most light leathers are today largely chrome tanned. Tanning with alum or aluminium compounds is still practised, especially with sheepskins for rugs and certain skins for furs, for it produces a white stretchy type of leather. Alum is frequently combined with chrome. Chrome tanning was introduced at the end of the nineteenth century. Its great advantage is its speed, for it may be effected in a few hours with drum tannage (the skins are rotated in drums with the tanning liquor). The leather has the characteristic duck-egg blue to bluish green colour. It is more stretchy and empty than vegetable tanned leather but more resistant to acids and water.

Oil tannage, also long practised in a primitive form, is not used much today. Certain fish oils, mainly cod-liver oil, which have the
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power of oxidizing, are employed. It is used in producing the wash leathers known as 'chamois' or 'shammy' leather. These are now made from sheepskin splits and not from the wild chamois of Europe.

Aldehyde tannage, in which formaldehyde or formalin is used, is not an old process, not more than half a century old, and is not extensively used. It produces a snow white, rather raggy type of leather, mainly used for gloves.

Synthetic tannins or 'syntans' have claimed considerable attention and have been much developed in recent years. There are several works dealing extensively with them. They are in no way similar or identical with the naturally occurring vegetable tannins and only resemble them in that they have a tanning action on hides and skins. During the Second World War the 'syntan' industry in Germany did much to meet the shortage of vegetable tanning materials caused by lack of imports. It was developed along three main lines—(1) 'auxiliary' and 'combination' syntans (for use in connection with vegetable tanning materials), (2) 'extra' and 'exchange' syntans (for replacement of vegetable tanning materials), and (3) 'supra' syntans for producing speciality goods such as white leather.

Combination tannages, as the name implies, are combinations of any of the tanning processes already described. A combination of vegetable and mineral tannage is frequently practised, especially for producing special types of leather. There is also a growing tendency to combine syntans with natural tanning materials. Heavy leathers may be given a preliminary chrome tannage and then be finished with a vegetable tannin. This shortens the time of tanning. The leather retains the properties of a vegetable tanned leather and acquires new ones such as resistance to moist heat. Light leathers may be pretanned with formaldehyde and then tanned with chrome, alum or oil in order to obtain greater flexibility and resistance. Combination chrome and vegetable tanned leather for bookbinding has been found to combine the resistance to acid deterioration of chrome leather with the good appearance and working qualities of vegetable tanned leather. There are countless other examples of the value of combination tannages for special purposes.

Extraction of Tannin and Extract Manufacture

The use of commercially prepared tannin extracts in place of barks or other crude materials in the tanning industry has been
developed a great deal in the last few decades. In the first quarter of the present century very few tannin extracts were available to the tanning industry, the most notable (apart from cutch) being chestnut (usually in liquid form), quebracho and mimosa or black wattle (usually in solid form). Later various other commercial tannin extracts made their appearance in different countries, among the better known being those of myrabolans and valonea.

There are many advantages in the use of tannin extracts in preference to crude materials such as barks and woods. It is only the soluble portions of the crude material that are of use to the tanner and these constitute only a small proportion of the raw material, consequently there is a great saving in freight charges, assuming the extract is made in the country of origin as usually happens. The tanner handles a much less bulky material, making much smaller demands on labour, storage space etc. The tanner is dealing with a much more uniform material of known or declared tannin content and is able to use much stronger tan-liquors resulting in more rapid tanning.

It must be borne in mind however that there may be certain disadvantages attached to the use of extracts or of some extracts. Actually in practice it is difficult to produce an extract with tanning properties exactly the same as the bark or raw material, for a certain amount of oxidation or of chemical change takes place during manufacture. This may be important in the eyes of the tanner, particularly if colour and mellowness are affected. Another consideration is that the greater solubility and faster tanning rate of extracts is prone to produce harder and coarser leather, if adequate safeguards are not taken. For this reason extracts are often used in the late stages of tanning when a higher rate of tannin fixation is not objected to.

The successful manufacture of tannin extracts on a commercial scale calls for much technical skill and the use of modern machinery and plant of a somewhat complicated nature, although in outline the processes involved are comparatively simple. The bark, wood or other plant tissue containing the tannin has first to be ground, shredded or reduced to a fine state of subdivision to allow thorough extraction of the tannin by the hot water treatment that follows. The aqueous solution of the tannin is concentrated or evaporated to dryness by special methods and is then ready for sale in liquid or more usually in solid form.

Owing to the increased cost of hand labour in all parts of the world mechanical handling and mechanization are freely practised.
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in the tannin extract industries as in other industries. When a tan-bark reaches the extract factory it may be handled largely by mechanical means. The same applies with woods yielding tannin, such as quebracho and urunday in South America, chestnut in Italy and France and 'redunca' in Western Australia. In reducing the raw material, bark or wood, to a degree of fineness necessary for thorough extraction by hot water various types of machines may be used—cutters, chippers, crushers etc. It is not necessary for bark or wood to be finely ground. In fact in practice fine grinding may be a drawback for with some materials it leads to clogging in the leaches. With barks, shredding is usually practised rather than actual grinding. Special crushing machines are manufactured for grinding certain materials such as valonea and myrabolans. The extraction of the tannin is carried out by running hot water through the ground material after it has been placed in the leaches which are large, closed, copper or wooden vats. These are usually arranged in sets or batteries of six or eight and worked on the counter-current principle, i.e. the fresh material is treated with the most concentrated aqueous extract and is then successively re-extracted with weaker solution until the almost spent material is treated with the fresh hot water which takes place in the last extractor of the battery. Care is taken that the material does not come in contact with iron which would cause staining and would itself soon corrode. Copper or gunmetal is commonly used in its place.

The temperature of the water used in extraction is important and the lowest temperature consistent with the extraction of the tannin from the material is employed. If higher temperatures are used darkening of the extract takes place with an increase in the percentage of non-tans and consequent lowering of the value of the extract. Temperatures vary with the tanning material employed, e.g. 50—60° C for sumac, 70—80° for myrabolan and mimosa or wattle, 80—90° for mangrove and 100—120° for woods such as quebracho and chestnut. The nature of the water used in extract manufacture is important. It obviously should not contain appreciable quantities of iron nor be very hard, for hard water causes loss of tannin through precipitation of the calcium and magnesium salts.

It is now a common practice to extract some tannins with sodium bisulphite or sulphite solution as this results in a higher yield of soluble tannin. This has been extensively done with quebracho and yields the so-called 'soluble quebracho' extract of the trade.
EXTRACTION OF TANNIN AND EXTRACT MANUFACTURE

In the preparation of tannin extracts, special precautions are necessary in concentrating or driving off the water from the final tannin charged liquor obtained from the leaches. The use of high temperatures or open vats leads to dark coloration and decomposition or oxidation. For this reason vacuum steam evaporators are now generally employed. Liquid extracts usually retain about 50% water and solid extracts about 20%.

The preparation of extracts in powdered form, a more recent development, is based on the same principles as the preparation of milk powder, dried egg etc or other substances prone to decomposition or change when maintained at a high temperature for any length of time.

The percentage of tannin in tannin extracts varies a good deal with different tanning materials and is largely dependent upon the quantity of soluble non-tans present in the original bark or material. Most solid tannin extracts contain from 60—70% tannin. Many vegetable tanning materials which are satisfactory in tanning leather when used in the crude form are unsatisfactory for the manufacture of tannin extracts because they possess a very high percentage of soluble non-tans. For practical purposes in tannin extract manufacture it is necessary that the tannin/soluble non-tannin ratio be more than 1, and preferably over 2. With black wattle bark and myrabolans the ratio is approximately 2.5.

A drawback with so many tan-barks, in various parts of the world, that have a high tannin content (over 20% of dry weight) is that they impart a dark colour to leather—usually reddish brown or dark brown. While this colour may not be in any way detrimental to the leather or to its wearing qualities there is a prejudice against highly-coloured leather in most countries. Colour is in fact of great importance to the tanner because buyers of leather estimate its quality to a large extent by its colour. This happens, rightly or wrongly, to be one of the customs or peculiarities of the leather trade. It is probably on account of the colour factor that mangrove bark or mangrove extract has not acquired the popularity it might have acquired with tanners. The high temperature often used in the extraction of tannin, either for tannin extracts or in leaching for direct use, commonly results in increased colour. This is because it brings into solution the less soluble tannins, which are darker, and the phlobaphenes or ' reds '. Colour is measured by means of a Lovibond tintometer in terms of red and yellow units.

In general, light-coloured tanning materials have a great advantage over dark-coloured ones. It is often possible to reduce or
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modify the colour by chemical means although this may involve additional expense. It is often done by bleaching with sulphite. In recent years it has been shown with some vegetable tanning materials that colour varies with the $pH$ of the tan-liquor, which is easily controlled. Control of $pH$ in tanning with babul bark ($Acacia arabica$) in India has made it possible to produce a much lighter coloured leather than is normally possible with babul bark. Modern methods have enabled wattle extract manufacturers in South Africa to reduce colour from 3-5 to 1-5 units.

World Trade in Tanning Materials

It is quite impossible to ascertain the total quantity of vegetable tanning materials that may be used throughout the world in the course of a year. Records are not kept of the materials used in the many small-scale tanneries, village or home tanneries that are so prevalent in many parts of the world. Such tanneries usually make use of the indigenous or locally available tanning materials. It has been estimated that in Turkey alone there are probably not less than 2,000 small-scale tanneries all using appreciable quantities of valonea in their operation. The export figures of valonea for Turkey (usually some 40,000—50,000 tons annually) therefore afford no criterion of the total quantity of valonea collected throughout the country. The total number of similar small-scale tanneries in other parts of the world, especially in Asiatic and in African countries, must run into hundreds of thousands.

In considering commercial vegetable tanning materials or those that enter world trade and for which statistics are often available, a striking feature is the way in which this trade has altered during the last hundred years. Up to and including the earlier part of last century, oak bark was the traditional and the most extensively used tanning material in the British Isles and in many parts of northern and central Europe. By the middle of the nineteenth century various imported tanning materials were being freely used, especially in Great Britain. For instance in the year 1863 the following were imported into the port of London—valonea (7,160 tons), gambier (7,000 tons), mimosa or wattle bark (2,940 tons), foreign oak bark (1,520 tons), cutch or catechu (862 tons). It will be noticed valonea and gambier greatly exceeded the other imports and together constituted 73% of the total.

Seventy-five years later (i.e. in 1948) imports of tanning materials to Great Britain were approximately 89,000 tons and two entirely different tanning materials, wattle (50,000 tons) and myrabolans
(16,000 tons) accounted for 74% of the total imports, the imports of valonea and gambier, so important in 1863, having become relatively small or negligible (Trade and Navigation Accounts). The figures for imports of quebracho from South America in 1948 were 12,000 tons, about a third of what they had been the previous year, due in large measure to restrictions imposed for currency reasons. This reduction in quebracho imports was largely offset in British tanneries by the increased consumption of wattle extract and bark. The annual consumption of oak bark in Britain, now all home grown, in recent years has been about 1,000 tons or not much more than 1% of the total consumption of vegetable tanning materials. This contrasts strongly with conditions a century or more ago when the figure for oak bark consumption would have stood at 100% or not much less.

In the countries of Continental Europe changes and fluctuations of similar magnitude but of a different pattern have taken place in the trade in vegetable tanning materials, apart from the abnormal or extreme conditions imposed by war. A very drastic and notable change that took place in many European countries in the latter part of the last century, especially Germany, was the substitution of traditional or old established tanning materials by quebracho. For the South American quebracho trade developed very rapidly and soon assumed very large proportions. The logs were first shipped, mainly to Germany, in sailing ships and could be sold in Europe very cheaply and at a price that made it unprofitable to exploit other materials like oak and Conifer barks. Later the solid extract was shipped from South America in place of the logs.

Chestnut extract, being locally produced, has long had a dominating influence in the trade in tanning materials in some European countries such as France and Italy. Before the Second World War Italy and France had limited their exports of chestnut extract to 70% of their total production. After the war this was reduced to 30%. For various reasons (especially disease of the trees) production of European chestnut extract has greatly declined. In recent years the annual production of chestnut extract in France has been about 22,000 metric tons (pure tannin) and in Italy about 26,000 tons. This home supply of chestnut has resulted in only relatively small importations of wattle and similar tanning materials from other countries. Switzerland is also a producer of chestnut extract—about 2,000 metric tons (pure tannin) annually. The annual consumption of vegetable tanning materials in various
INTRODUCTION

European countries in recent years has been approximately as follows—United Kingdom 42,000; France 30,000; Italy 27,000; Germany 23,000; Turkey 13,000; Sweden 11,000; Holland 7,000; Austria 6,000; Switzerland 4,000—5,000; Belgium 4,000—4,500; Greece 3,000—3,500; Norway 3,400; Portugal and Denmark 2,000—3,000 (figures in metric tons of pure tannin).

The three most important tannin extracts used throughout the world in the production of leather, in terms of tonnage, are quebracho, mimosa or wattle and chestnut. The yearly production of quebracho extract in Argentina and Paraguay is considered to be about 130,000 tons, and that of wattle extract some 78,000 tons (about 65,000 tons from South Africa and 13,000 tons from East Africa). With regard to chestnut, total European production, coupled with that from oak wood which is relatively small, is about 67,000 tons, while some 25,000 tons of chestnut extract is prepared in the United States, all of which is consumed in that country. The total production of these three extracts is therefore in the neighbourhood of 300,000 tons (figures expressed in terms of pure tannin in metric tons).

With the other tannin extracts that enter world trade the figures are relatively small. Cutch and gambier are of less importance than formerly in tanning. Mangrove extract is exported from Borneo and a few other places in small amounts. The production of myrabolan extract in India has increased but much larger quantities are now used in that country. The quantities of valonea, sumac, Eucalyptus extract ('myrtan'), or other extracts produced are not large.

Australia might be regarded as richly endowed by Nature with indigenous tanning materials and has exported some in the past such as wattle and mallet bark (Eucalyptus astringens). In recent years small quantities of Eucalyptus extract ('wandoo' or 'myrtan' from Eucalyptus wando) have been exported. Nevertheless, a large part of Australia's requirements in tanning materials have been met for many years by imports, notably South African wattle extract and Indian myrabolans.

The Indian Sub-continent is also richly endowed with indigenous tanning materials some of which, such as avaram bark (Cassia auriculata) and babul bark (Acacia arabica) have been extensively used since early times. There have, however, been notable changes in the internal trade in these materials in recent decades. Avaram and babul bark were largely dropped in favour of wattle bark or extract imported from South Africa. After the Second
World War political tension between the countries concerned led to cessation of supplies from South Africa but more restricted supplies were obtained from East Africa and there was a reversion to the use of babul and other indigenous barks in the big tanneries at Cawnpore and elsewhere.

The United States of America is by far the largest consuming country of vegetable tanning materials and is considered to use annually about 120,000 tons (100% tannin), or more than a third of the world’s total commercial output of vegetable tanning materials. About two-thirds of the United States’ tannin requirements have to be imported. In the early days the indigenous chestnut wood, hemlock and oak barks met the country’s requirements adequately but were unable to meet the greatly increased demands that arose later, and for many years reliance has had to be placed on imported materials, especially South American quebracho. Decreasing supplies of quebracho from South America (through over-exploitation) and greatly decreased supplies of home-produced chestnut extract (brought about by disease of the trees) have aggravated the position. Special efforts are being made in the United States to improve the supply of home-produced tannins. Particular attention has been given to the indigenous sumacs and canaigre but the prospect of any substantial increase in domestic supplies of tannins does not appear to be very promising so far.
BARKS
Plate I

A young plantation of Black Wattles in Tanganyika

Clearing for Wattles in Tanganyika. The troublesome bamboo clumps (Oxytenanthera abyssinica) are eventually towed out.

By courtesy of the Colonial Development Corporation.
WATTLE BARK

Wattle bark or wattle extract, also known as mimosa bark and mimosa extract in some circles, is today one of the most important tanning materials and is extensively used in the tanning of many different classes of leather. It is derived almost entirely from the black wattle (*Acacia mollissima*) an Australian tree now extensively cultivated in South Africa, especially Natal, and to a lesser extent in other countries. It is cultivated on plantation lines, usually on an 8—10 year rotation. Natal has been the main producing area of wattle bark or wattle extract for over half a century. As the writer has spent many years in Natal and has first-hand knowledge of the wattle industry there, it is proposed to deal first with the black wattle in Natal and later to refer to other wattle-growing countries and to the other tan-yielding wattles closely allied to the black wattle but which so far have been of little consequence commercially.

The importance of the wattle industry in South Africa may be judged from the fact that the annual export of wattle extract and of bark is in excess of 150,000 tons, the extract representing about two thirds of this amount. Over half a million acres are devoted to wattles in South Africa, four-fifths of which are in Natal, the remainder being in the adjoining areas of the eastern Transvaal the Eastern Cape Province and the Transkei. Stands vary from 10,000 acre plantations to a few acres on farms.

Several factors probably account for the success of the wattle industry in South Africa, important among them being a cheap labour supply and an outlet for much of the timber produced for use on the gold mines. Being a short-rotation forest crop not requiring a specialized knowledge of silviculture or forest management, wattle cultivation was readily taken up by farmers, municipalities, companies and others, active encouragement being given by the Government, especially in the early stages. The black wattle tree is fast growing under favourable climatic and soil conditions, and compared with other forest crops is easily and cheaply established and regenerated. Well-managed plantations in good areas have shown profits of over £4 per acre per annum including regeneration costs of £40 per acre over a 10 year cycle.
WATTLE BARK

History of the Black Wattle in Natal

It is a matter of interest that the black wattle was first introduced from Australia to Natal not to provide tan-bark but rather as a useful quick-growing tree to grow around the homesteads of farms and as a shelter belt for crops and livestock. The date of its first introduction is generally considered to be the year 1864 when it was introduced by the Vanderplank brothers—John and Charles. The former was the master of a schooner and called at Port Natal (Durban) on his voyages between Australia and England. In return for services rendered the Natal Government granted him a piece of land near Camperdown, about halfway between Durban and Pietermaritzburg, where he established a primitive dwelling as was the custom at that time. It was here, after his retirement from the sea, that he planted the first black wattle seed, sent to him by his brother Charles.

John Vanderplank’s Camperdown home appears to have been a popular port of call with transport riders and others with their wagons proceeding to and fro from Durban and the hinterland. It seems he was on good terms with both the early English and the early Boer settlers in those far-off days and his packing-case shack became the recognized outspan and social centre of the area. It was customary at that time for some of the highveld or ‘overberg’ Boer farmers to winter their herds in the milder lowland districts of Natal and to trek through Vanderplank’s area. It was but natural that, having noted the rate of growth since their last visit, they should obtain seed of these strange quick-growing trees which might grow equally well round their own shelterless homes, and also provide fuel. In this way John Vanderplank’s black wattle seed was soon distributed far and wide in Natal and beyond (see Frontispiece).

Although Vanderplank introduced the black wattle for shelter or for fuel he must have been aware of the tanning value of the bark for he had himself carried cargoes of the bark from Australia to England. In recent years a belief has arisen that separate early introduction of black wattle seed to Natal may have taken place as the following remarks indicate. ‘It is of interest, and possibly of some scientific importance too, that many of these plantations (in the Noodsberg district of Natal) may have derived from a source other than the Vanderplank “strain”. Mr. Holley states that unidentified seed received from Australia by Mr. Medley Wood, Curator of the Durban Botanical Garden, was planted on the Noodsberg farm “Killiecrankie” and turned out to be black

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HISTORY OF THE BLACK WATTLE IN NATAL

wattle. This, according to Mr. Holley, was the source of the seed from which the Broadmoor plantations were established 163.

The Howick and Noodsberg districts of Natal were among those where the black wattle was found to grow particularly well and it was in the latter district that the earliest large-scale plantations were established. It is recorded 168 that from 1884 the Hon. G. M. Sutton, later Prime Minister of Natal, sold a few tons of bark annually to a tannery in Pietermaritzburg (Lyle's tannery) at 3s to 3s 6d per cwt. and that in 1887 Messrs. Angus (Noodsberg) also prominent leaders in the industry shipped the first successful consignment of bark (about 10 tons) from Natal. In the previous year a smaller consignment had proved uneconomic, the profit being consumed in freight charges. It is said it was shipped at the rate prevailing for ostrich feathers, there being no category for wattle bark, but the following year this was adjusted. The early trials at Lyle's tannery in Pietermaritzburg, due to the initiative of the Hon. G. M. Sutton, not only established the value of Natal-grown black wattle bark for tanning but also established the inferiority of silver wattle bark as a tanning material, compared with black wattle. The rapid rise of the export industry is shown by the following figures for value of the bark exported: 1886—£11; 1890—£3,389; 1895—£17,209; 1900—£46,479 (8,900 tons); 1905—£84,434 (15,636 tons); 1910—£218,309 (41,048 tons). There has since been a sustained increase in production with the exception of the war periods which caused shipping difficulties. After World War II the world demand for wattle extract greatly outstripped supply in spite of the yearly export from South Africa of some 150,000 tons of extract and bark.

Prior to the first World War most of the bark exported went to Continental countries, especially Germany, where it was made into extract and generally mixed with other tanning materials. These proprietary extracts were freely imported into Britain and much used by British tanners with whom they had earned a good reputation. With the outbreak of war, supplies from Germany immediately ceased and British tanners were obliged to use more wattle bark or locally-made extracts.

The production of wattle extract in Natal was not seriously commenced on a commercial scale until 1916 when an extract factory for dealing with the fresh or green bark was established in Pietermaritzburg. For several years previous to this, however, the question of producing and exporting extract had been receiving attention. This first factory at Pietermaritzburg was soon followed
WATTLE BARK

by factories in other parts of Natal. Today there are several large and up-to-date factories with a total output that approximates to a hundred thousand tons of extract annually. For many years now the tendency has been for greater proportions of extract and smaller proportions of bark to be exported.

Climatic and Soil Requirements
The black wattle will grow or exist over a wide range of climatic and soil conditions but special conditions are required for healthy and vigorous growth and profitable bark production. In Natal the tree has been found to grow from sea level to quite high altitudes (± 6,000 ft.) but it is in the intervening areas, in the ‘mist belt’, that the tree does best. At the lower altitudes damage from insect pests is more severe and at the higher altitudes the increased cold is inimical, causing stunted growth. There may also be damage from snow. As seedling or young trees are very sensitive to frost, the establishment of plantations at the higher altitudes becomes difficult. The so-called ‘mist belt’ of Natal lies approximately between 2,000 and 4,500 ft. with a rainfall of 35—40 in. The mists, on condensation, also contribute considerably to the soil moisture. The soils vary a good deal in texture but provided they are deep and well drained the black wattle thrives, the most vigorous plantations being on the red or chocolate coloured lateritic soils. These soils are poor in humus and are regarded as poor agriculturally, nevertheless they have proved to be well suited for wattle cultivation. Such soils do not get entirely dry nor do they remain saturated after rain. They are relatively easy to work and to keep clear of weeds. Furthermore on these soils bark stripping is possible in the dry season whereas on the shaly types of soil trees will not strip at all in the dry season or only with great difficulty. Heavy clay soils are unsuitable or soils with anything in the nature of hard pan, especially near the surface. Light sandy soils may be suitable provided they have sufficient depth but are prone to give lighter yields of bark than the lateritic soils. The deep black alluvial soils which yield good maize crops may also grow good wattles but the sites where they occur are often subject to frost and are more difficult to keep clear of weeds during the early stages. As southern and eastern aspects are generally more favourable in regard to soil moisture in Natal than are northern and western aspects they are preferred for wattles.

In tropical countries, the black wattle has grown successfully at higher altitudes than it will do in Natal, as is to be expected.
SOWING

However, a drawback that has sometimes been experienced in such situations is the profuse development of lichen growth on the trunks of the trees, which lessens the value of the bark.

Cultivation

In Natal the black wattle is grown on land that has either recently been grassland, used for grazing, or on cultivated land which has generally been used for maize or 'mielies'. Contrary to what one might expect, the former generally gives the better results. Land that has formerly been cultivated usually gives a great deal more trouble with weeds. The suggestion has been put forward that the nitrifying or nodule bacteria found on black wattle roots may normally be present in the grassland of Natal. Deep ploughing of the grassland is not necessary and may be harmful if it brings sub-soil to the surface, for wattle seedlings seem never to thrive in sub-soil. Ploughing is best done in the autumn when the grasses are dying back (the winter in Natal being normally dry). One well-known authority on wattles in Natal (Dr T. R. Smr) recommended that the grass should always be burned before ploughing as 'burning' prevents regrowth from the long tops of the grasses. Another authority (S. P. Sherry) recommends that the grass should never be burned unless growth is so dense as to make ploughing impossible as 'the ploughing in of the grass cover will add materially to the normally low organic content of the surface soil with beneficial results to the ensuing crop'. It is quite conceivable that the nature of the grass cover may determine the advisability or otherwise of burning. Sowing of the seed is usually deferred until the spring and the advent of the first rains, the land having been reploughed if there is much regrowth of grass and harrowed to obtain a good tilth.

Sowing

Wattle seed that has had the hot water treatment is always used in sowing (see p. 36). In the early days of the industry seed was often sown broadcast (5–10 lb. per acre) but this was not satisfactory and rendered thinning and weeding more tedious. This method was followed by sowing the seed in regular orderly rows, either in continuous rows or in patches (spot sowing) at regular distances apart in the rows. Planting in situ has been found much more satisfactory than nursery planting under Natal conditions although it is understood nursery planting has been favoured under certain conditions in India. The rows may be arranged by
placing stakes in line at short distances so that several are seen at once. A labourer then walks from the end stake to the next, keeping the line of stakes in sight, and makes a slight depression or seed-bed with a hoe at predetermined distances apart (usually one to three paces). Another labourer follows and drops a dozen or so seeds into each seed-bed covering them lightly with his foot. The seed rate with this form of sowing is $1 - 1 \frac{1}{4}$ lb. of seed per acre.

Some wattle growers prefer sowing in continuous lines although the seed rate is higher—2$\frac{1}{2}$ to 4 lb. per acre or up to 12 lb. in areas of low rainfall. Maize planting machines may be adapted to take wattle seed, or a tin attached to a stick, with a hole in the bottom to allow the seed to trickle through, may even be used. A popular method of sowing wattles on suitable, well-prepared land is to employ a marker disc attached to the maize planter. The hoppers on one side only are charged with the wattle seed and also (usually) with a phosphatic fertilizer, or a single row planter may be used. The ‘marker’ is set for the distance required between rows.

Seed should only be sown when adequate soil moisture is present or if rain may be confidently expected in the following few weeks, otherwise there may be poor germination and considerable losses. Germination may take place about a week after sowing, but this depends upon weather conditions.

Espacement and Thinning

There has always been difference of opinion among South African wattle growers as to the best spacing to adopt. Local factors play an important part and what may be eminently suitable for one area may not be the best for another. In the past, the practice adopted has varied a good deal. With the shorter rotation, an espacement of 6—7 ft. may be employed. One row in about every six may be wider (10—12 ft.) to admit wheeled transport when felling and stripping. With 6 ft. between the rows young trees form a canopy which smothers weed growth at a comparatively early age. Common practice is to allow 6 ft. in the final spacing between trees in the rows. This gives light, straight poles but a wider spacing gives heavier poles and a greater weight of bark per tree. It is likely to be more advantageous where the longer rotation, in excess of 6—7 years, is used.

As with espacement of rows there has been much divergence of opinion in regard to thinning and practice has varied much in the past. Investigations have shown that the black wattle, which is normally fast growing with a rather superficial root system, is
adversely affected and does not readily recover from congestion experienced in its early stages. It is therefore important that thinning be carried out in good time, whether the trees have been sown in continuous rows or by spot sowing. The first thinning recommended is when the young trees are only 3—4 in. high. They are then reduced to 3—4 ft. apart in the rows. Later thinning may take place when the trees are 2½—3½, 7—10 and 15—20 ft. high. The likelihood of insect damage (frog-hopper) and other factors have to be considered in regard to thinning.

Weeds and Weeding
Adequate weed control is an important aspect of wattle cultivation as the seedling trees are easily destroyed by weeds. Annual weeds and grasses which grow rapidly, especially in the moister parts of Natal, very soon smother young trees if not kept in check in the immediate vicinity of the young trees. Weeding is usually done by natives hoeing along the rows but sometimes by mechanical means (disc cultivator) if the land is not too broken to allow of this. Care should be exercised to avoid undue root injury to young trees when weeding, for it is considered the wounds so caused are a source of infection for gummosis or other diseases. The more important annual weeds that are troublesome in Natal are Erigeron canadensis (horseweed), Bidens pilosa (black jack) and Tagetes minuta (Mexican marigold). The most troublesome perennial weeds are Rubus cuneifolius (American bramble), Acanthospermum australe (Star-burr), Solanum auriculatum (bug-weed), and Stoebe vulgaris.

With regard to grasses, often the most troublesome weeds with young wattles, several of the indigenous species are concerned. The most troublesome annual grasses includeDigitaria ternata (‘ umfongofongo ’) and Eleusine indica, while the most troublesome perennial grasses are Eragrostis plana and E. curvula (‘ umtshiki ’), Aristida junciformis (wire grass), Sporobolus capensis (‘ umsingizane ’), Cynodon dactylon (couch grass), Stenotaphrum secundatum (Durban grass), Panicum maximum and P. proliferum (‘ ubabe ’), Setaria chevalieri (buffalo grass) and species of Digitaria.

In East Africa a species of Ipomoea has proved to be a troublesome weed. It climbs up the young trees and seriously affects their growth, being difficult to eradicate when once established.

Rotation
The black wattle may be stripped for its tan-bark after as short a period as six years although rather longer rotations are now
WATTLE BARK

generally preferred for various reasons. It is this short rotation, very short for what is essentially a forest crop, that gives the black wattle a great advantage over other vegetable tanning materials derived from trees. When trees are stripped at six years of age the trees have generally not developed heavy bark, the bark being still in what is known as the 'baby stage', furthermore the timber at this age is of little use except as firewood. Another two years, increasing the rotation from 6 to 8 years, generally means a thicker bark greatly increasing the yield per acre, and stouter poles suitable for mine timber and other purposes. The rotation may be extended to periods up to 12 years. One of the oldest and most successful wattle estates in Natal now has a regular rotation of 10 years throughout its plantations. It is not considered good practice to defer stripping beyond 12 years, for after this period deterioration of bark and wood through disease or old age is likely to develop.

Regeneration of Old Plantations

After felling and stripping of the bark young wattle trees are commonly re-established on the same sites. There are thriving plantations in the older wattle growing areas of Natal that are now carrying their fifth or sixth successive crop of wattles with no apparent deterioration. Seedlings come up very freely in felled wattle plantations, especially where brushwood is burned, as the heat stimulates germination of the seeds. No actual sowing is therefore necessary but considerable hoeing or thinning may be needed to obtain the desired spacing.

In any felled plantation there is naturally a great accumulation of brushwood. In the past there has also been a good deal of timber that has not been disposed of owing to poor demand, Inaccessibility, or distance from rail-head. A common practice has been, and still is, to burn the brushwood or unwanted timber on the site as soon as it is dry enough in order to get it out of the way, reduce fire hazard at a later stage, and ensure rapid growth of young trees from the fertilizing effect of the ash.

This custom of burning the brushwood has been severely criticized by several notable authorities on wattles in Natal (Sherry, Craib, Hunt Holley) as bad forestry practice and a system of stacking the brushwood in contour lines to rot down of its own accord in the plantation has been recommended in its stead. It is contended that this method is of greater value to the land in the long run, adding appreciably to the humus content of the soil and checking erosion.
Much controversy has raged over this question, but the consensus of opinion now seems to favour the non-burning policy as being the more beneficial eventually. On the Broadmoor Estate (Noodsberg district, Natal) where the non-burning policy has been in force for over 25 years and careful records of bark and timber yields kept, very forceful arguments have been put forward by Mr. J. Hunt Holley concerning the benefits derived from such a policy. It is pointed out that, apart from increased bark and timber yields per acre, weeding difficulties have decreased to an unbelievable extent since the brushwood burning policy was dropped at Broadmoor. The case of those who believe that moderate and controlled burning in felled wattle plantations need not be inherently harmful has been ably put forward by Beard and Darby in their description of a burning versus non-burning experiment carried out for over 30 years on property of the Natal Tanning Extract Coy. Ltd.

Manuring
Manuring has not been generally practised in commercial wattle cultivation in South Africa, although experiments have been and are being carried out on this question. Present indications are that the use of fertilizers in mature plantations is likely to prove quite uneconomic but suitable applications to young trees may result in greatly increased growth and vigour with an early formation of a closed canopy and cessation of weeding and weedling costs. Most South African soils are deficient in phosphates and the application of superphosphate has proved very beneficial with young trees in most soils. The effects of lime and potash are less conclusive. Another result from the increased growth from phosphatic fertilizers is that the tender growing point of the tree is brought above the level of damaging frosts at an earlier date. The trees are also better able to withstand the attack of defoliating insects.

Seed Treatment
The seed of the black wattle is relatively small, weighing approximately 40,000 to the pound, and like many other seeds in the Legume family (Leguminosae) it possesses a very hard seed-coat which causes poor or delayed germination if some form of pretreatment is not given. Under natural conditions on the forest or plantation floor this impermeability of the seed-coat is gradually broken down but the process may be slow. In experimental work
nicking or chipping each individual seed (easily done with a razor blade) results in very good germination, but this is only feasible where small quantities of seed are being dealt with as in experimental work. Treatment with acid is effective and may give about 80% germination. Heat treatment is also effective. Where burning has been carried out on felled plantations seedlings come up by the thousand as a result of the effect of the heat of the fire on nearby seeds, even though many thousands of seeds must be overheated or destroyed.

In practice the convenient method of applying heat treatment to wattle seed intended for sowing is by the use of hot or boiling water and this has been the traditional treatment in Natal since early days. Experiments carried out at the Natal Wattle Research Institute at Pietermaritzburg by Moffett have brought to light some interesting points in connection with the hot water treatment, Tests carried out with hand-picked seed (i.e. seed all of the same age) and commercial seed (i.e. collected from the plantation floor) with hot water treatments at varying temperatures showed that the best or optimum temperature was about 90°C which gave an average germination of 92% as against 34% for 60°C, 59% for 70°C, 87% for 80°C, 89% for boiling point and 71% for 5 minutes' boiling.

It was shown that boiling of the seed was definitely harmful. Where the average germination was over 90% for hot water treatment at or near boiling point this was reduced to 68-4% with ½ hour’s boiling, 51-1% with 1 hour’s boiling, 20-6% with 2 hours’ boiling and 2-3% with 4 hours’ boiling.

It is interesting to reflect that in some of the older literature on wattle cultivation, boiling, even prolonged boiling of the seeds, was recommended. Not only did prolonged boiling have a marked adverse effect on germination but the resulting seedlings from boiled seed were much more subject to fungal attack after germination had started.

The following are the recommendations made by Moffett for the routine treatment of wattle seed for commercial planting. A volume of water several times that of the seed to be treated is brought to the boil in the late afternoon and the container is then removed from the fire and the water allowed to cool for about 5 minutes. The seed to be treated is then poured into the hot water and left to soak overnight. In the morning the water is poured off and the seed washed in two or three changes of clean, cold water (to remove the mucilage which exudes from the seeds) and
then spread out in the shade to dry. Immediately after spreading, the seed may be dusted with slaked lime, which gives a white coating and makes it more readily visible when sown on dark coloured soils. On fairly light coloured soils, the seed will show up as well or even better without lime dusting. If possible, seed should be treated two or three weeks before planting, but this is not absolutely necessary; seed freshly treated in the manner described will give a high germination. 'Treated seed when dried is indistinguishable from untreated seed.' Seed will keep for a considerable period after treatment without dropping in germination percentage, so that 'it is quite safe to keep treated seed from one season to the next.'

Pests and Diseases
The black wattle in South Africa is subject to a number of different insect pests and diseases which may seem surprising considering that the tree was introduced by seed and that probably at no time up to the appearance of these pests and diseases on black wattle had living or growing plants been introduced. There are however many indigenous species of Acacia in southern Africa and some of the insects that attack or feed on them have been found to be only too eager to use the wattle as a host plant when the opportunity occurs. This applies to the wattle bagworm, the worst pest in wattle cultivation in South Africa. The shoots of the black wattle are probably more constantly tender in growth than those of the slower growing indigenous Acacias or thorn trees. Besides the bagworm other insects which may cause damage to the wattle include certain caterpillars, 'froghopper', grasshoppers, locusts, cockchafer beetles, cut-worms and termites.

Pests—The three major insect pests of wattles in Natal are the wattle bagworm, 'froghopper' and 'wattle looper'. Any of these may cause serious damage to plantations when they occur in epidemic form.

The wattle bagworm (Acanthopsycye junodi) is a lepidopterous insect always present on some of the native species of Acacia in the thornveld. Damage to wattles is often most severe in plantations nearest to the thornveld and less severe or absent in the higher elevations. A detailed account of the insect has been given by Fuller. Its prevalence is very dependent upon weather conditions—moist or misty conditions retard it while hot dry conditions favour it. The newly-hatched larvae spin long silken threads and by 'ballooning' are carried by the wind to new feeding grounds.
WATTLE BARK

After feeding they spin tough silken bags for protection, hence the term 'bagworm'.

Plantations that have suffered severe defoliation by bagworm receive a serious check and may even remain stunted. The loss of the canopy often leads to invasion by grass and weeds which further hinders growth. Matured trees are liable to become bark-bound and stripping has to be deferred or delayed a year.

Intensive research has been and is being carried out in Natal on the control of wattle bagworm. Dusting with natural cryolite from the ground and by aeroplane has shown promise, also the use of gemmexane dusts. Ecological studies have now made it possible to predict likely infestation centres. There are a number of natural enemies of the bagworm in South Africa such as certain insects and parasitic fungi. Various birds feed on the larvae to some extent, as do field rats and monkeys when present, but the overall mortality for which they are responsible may be small in most districts.

The term 'froghopper' is used for two different insects which cause a similar type of damage, especially with young wattles. They are a jassid (*Bythoscoptus cedaranus*) and a capsid (*Lygidolon laevigatum*). Trees up to two years old are the most vulnerable. The tender leading shoots are attacked causing a check on growth, sometimes defoliation and the development of a witch's broom effect. Dusting with pyrethrum at the right stage is known to give good control.

The 'wattle looper' is a lepidopterous caterpillar (*Achaea lienardi*) widely distributed throughout Africa. It chiefly attacks wattles in the warmer areas at the lower altitudes and infestations are cyclic. In one season about 30,000 acres were defoliated by it. Dusting with natural cryolite is known to effect control.

Grazing animals, domestic or wild, may cause damage to young plantations by grazing off the young leading shoots, but this happens mainly during drought. Monkeys have been known to tear off strips of bark and young branches, presumably in search of exudations of gum.

Diseases—In Natal the black wattle is affected by both fungus diseases and what are believed to be physiological diseases or disorders. The two important fungus diseases are those known as 'wood rot' and 'Albert Falls disease'.

Wood rot, also known as 'collar rot', is believed to be due to any one of several Hymenomycetes. Often there are no visible symptoms until the tree is blown over revealing the rotting wood.
at the crown or collar. The fungi gain entry through wounds which should be avoided as far as possible in all operations.

The first severe outbreak of Albert Falls disease was in the Albert Falls District of Natal, the causal organism being later found to be *Rhizoctonia lamellifera*. The first symptoms are a yellowing or withering of the foliage and within a short period (5—15 days) even vigorous trees may be killed. Fortunately the disease does not appear to be common.

‘Gummosis’ and ‘Leaf Shedding’ are the most important or most serious physiological diseases. The former manifests itself by the free production of gum from cracks in the trunk and branches, usually after wet weather. The neighbouring bark blackens or becomes corky and is valueless. As yet the causes of the disease are not fully understood. In Leaf Shedding young and vigorous, or well-managed plantations of black wattle may suddenly lose their leaves and become almost defoliated. The malady is believed to be associated with supplies of soil moisture for it occurs both during periods of drought and of high rainfall.\(^{104}\)

**Stripping and Handling of Bark**

The stripping of wattle bark in Natal may take place in most months of the year, *i.e.* late spring, summer and early autumn, as rain usually falls at these times providing adequate soil moisture. During the winter, which is normally a rainless period, soil moisture is low and the bark does not peel off readily in most districts, so stripping is not attempted. In the very wet districts stripping may be possible throughout the year whereas in the dry districts it may be restricted to the few wet months. It is unfortunate that bark stripping has to be done during the rainy months, for rain often interferes seriously with the drying of the bark. Bark becomes very difficult to remove during a spell of cold weather.

In stripping the usual procedure is for the labourer to cut the bark or ring the tree about 4 ft. from the ground with a small axe and then to cut two vertical lines down the bark to soil level on opposite sides of the trunk often using the axe blade like a knife. The bark is then prized and pulled away, care being taken to pull away the bark right down to the roots, for if this is not done the stump will sprout again. Furthermore the basal portion represents the thickest bark on the tree and the richest in tannin. The tree is then felled, being cut in the area already peeled, and the side branches cut away as close to the bole as possible. It is then ringed again at set intervals, usually 4 ft., and the bark peeled off.
WATTLE BARK

in what are equal convenient lengths for bundling. Labourers may be provided with a four foot stick or rod as a guide. Alternatively the bark may be stripped off in long or irregular lengths and cut up afterwards. As the edges of the strips of bark curl inwards on drying the strips should not be wider than 3—4 in. when intended for dry bark, otherwise drying may be impeded.

Much of the bark harvested is now sold in the fresh or green state for extract manufacture, when it goes from the plantation to the extract factory with as little delay as possible. The time from stripping to arrival at the extract factory should not exceed 48 hours. The freshly-stripped bark is made into bundles, usually about 50 lb. in weight, by tying them with strips of thin wattle bark taken from branches. Iron wire should not be used in bundling as it causes a black (‘ink’) stain where it touches the inner bark. Wooden railway trucks are preferable to metal as they are less likely to cause sweating and deterioration of the bark. Green bark loses weight through loss of moisture in transit to the factory, the amount depending upon weather conditions. The average loss of weight in railway trucks has been estimated as 6% after one day, 11% after two days and 16% after three days.

It has been shown in recent years that the objectionable dark or reddish colour associated with wattle bark is due to oxidation caused by enzyme activity, and that treatment with sulphur dioxide or a solution of sodium bisulphite as soon as the bark is stripped destroys the enzymes and largely arrests the discoloration or oxidation. There are various practical difficulties in applying such methods in the plantation.

Many plantations are too far from the nearest extract factory for the disposal of green bark and the bark has to be dried, which is of course the form in which it is exported. Extract factories prefer green bark which is easier to chop up and less likely to yield dark-coloured extracts. In drying the bark in the plantation the common practice is simply to lean the pieces of bark, outerside upwards on branches or logs to be dried by the sun and movement of the air. The time needed varies much with conditions and the weather. Under favourable conditions the time required is not likely to be less than a fortnight. Rain often interferes seriously with drying and tarpaulins may be used. Freshly stripped bark may not suffer much from a shower or two but if rain falls when it is half dry there is a likelihood that it will darken or become mouldy and therefore become poor grade. Exposure of the inner side of the bark to sunlight is to be avoided as this also causes
A Zulu felling a Black Wattle tree in a Natal plantation, the bark at the base of the tree having been first removed.

Scene during felling and stripping in a Black Wattle plantation in Natal. The woman in the foreground is tying up a bundle of bark with thin strips of branch bark.

By courtesy of the Forestal Land, Timber and Railways Co. Ltd.
WATTLE BARK
darkening. With the best grades of bark the inner side of the bark is of a light straw or very pale brown colour. When properly dry a piece of bark becomes quite brittle and breaks with a clean fracture. Owing to the curling of the edges and the round shape it is commonly referred to as 'stick bark' to distinguish it from 'chopped bark' or 'green bark'. 'Stick bark' is usually made into bundles of about 50 lb. after compressing in a simple hand-press and tied with twine. For export this stick bark is chopped at the mill into small pieces about \( \frac{1}{2} \) in. square and baled in a hydraulic press or it may be coarsely ground and baled, the bales in each case weighing 200 lb.

In drying, the fresh bark loses from 38—58% moisture, the loss being greater with young thin bark than with thick bark. On an average it is considered 1.8 tons of green bark becomes 1 ton of dry bark after drying. Drying sheds are sometimes used, consisting of a corrugated iron roof with open sides, especially for the bark that has become half dried in the open. Their use involves a good deal more expense in handling etc and is often not practicable. Artificial or kiln drying has been shown to be quite practicable with wattle bark provided the temperature does not rise above a certain level (150° F). At higher temperatures deterioration of the bark or changes in the tannin may take place. Artificial drying appears to have been used in Java.

Under favourable conditions in Natal, with well-grown trees and the bark peeling well, a strong active labourer may strip as much as 1,000 lb. of fresh bark in a day although 800 lb. is more likely to be the average. This would include felling, stacking brushwood and carrying the bark to the roadside. Under less favourable conditions, with the bark not peeling freely, 500 lb. may be above the average. The work is often done on a piecework or task-work basis, the workers being mainly Zulus or kindred races.

Yield
As conditions vary so greatly in different areas in Natal according to climatic conditions, soil, prevalence of pests and diseases and cultural treatment it is not possible to give very definite figures with regard to the yield of green bark per acre. An average of 4 tons of fresh bark and 20 tons of timber per acre with 7 year old trees was considered a good crop 30 years ago, with the yield increasing to 8 tons of bark with 10—12 year old trees. On a large well-run wattle estate in a good district in Natal figures recently given for 10 year old trees averaged 7 tons of fresh bark.
and 33 tons of timber per acre. With regard to the yield of individual trees, a well-developed tree 12—13 in. in diameter at breast height and 60—70 ft. high may yield as much as some 200 lb. of fresh bark. Such a tree would not be less than 10 years old.

**Grading and Marketing**

Various methods of preparing wattle bark for export have been in vogue in South Africa. In the early days it was exported in bundles of stick-bark or coarsely chopped and packed in sacks (grain bags). In this form it was very extravagant in shipping space and better methods were soon adopted, making use of hydraulic or other power presses. With these the chopped bark is compressed under very high pressure in the form of bales wrapped in hessian and reinforced with steel bands or wire. A common size is 4 cu. ft. weighing 200 lb.

As the bark needs to be in a finer state of sub-division for direct use by the overseas tanner various kinds of grinding and shredding machines, also disintegrators, were soon in use, the shredded bark being also power pressed into bales with or without hessian. The advantage in freight charges of shipping power-pressed bark or extract is substantial. Whereas a ton of chopped bark in sacks occupies about 90 cu. ft. the same quantity when power pressed occupies less than 50 cu. ft. A ton of extract occupies about 40 cu. ft. or one ‘ship’s ton’.

During grinding or disintegrating a certain amount of fine dust is produced which, with the more efficient machinery, may be collected in the dust balloons. It contains a higher proportion of tannin than the normal ground bark but is not generally favoured in tanneries for use by itself owing to the difficulty of thorough wetting and complete leaching. It needs to be mixed with coarser material.

The grading of wattle bark is carried out visually by experienced Government graders. Grading by analysis, though desirable, has so far proved to be impracticable. However, tests have shown there is a remarkable correlation between an experienced grader’s results by visual grading and grading on chemical analysis. The three grades under which bark is exported are:

(1) **SA/CP (South African Chopped Prime):** extra heavy or thick, well-dried, mature bark of good external appearance and fracture.

(2) **SA/CA (South African Chopped Average):** well-dried, mature bark of average thickness, colour and homogeneity.
WATTLE BARK

(3) SA/CM (South African Chopped Merchantable): well-dried bark of good colour and other well-dried bark of colour below average.

There are similar gradings for ground bark, 'G' taking the place of 'C', i.e. 'SA/GP' 'SA/GA' and 'SA/GM'. The tannin content of these three grades is considered to be roughly over 37% tannin for 'prime', between 35% and 37% for 'average' and below 35% for 'merchantable'.

In the visual grading of dry bark the main points considered are maturity of bark when stripped, dryness, thickness, lightness of colour, estimated tannin content and freedom from corkiness, gum and mould. Dry bark may be sorted at the mill or factory, to comply with the different grades before it is baled.

The fresh or green bark delivered to the extract factory is also graded visually (by the factory graders) for the want of a better method. The system appears to have worked satisfactorily enough over a number of years in spite of the difficulties, one of the most serious being the inadequate sampling with fully loaded railway trucks of green bark. It is considered that a method of grading of fresh bark on tannin content, on arrival at the factory, rather than visual grading, would be desirable if sufficiently rapid methods of tannin estimation were developed, as now seems probable.

Grading is not carried out with the extract, which is sold under various proprietary names by different makers on a declared tannin content. The American market demands at least 62% tannin in the solid extract. For other markets the minimum is 60%.

The United Kingdom has been the chief importer of wattle bark or wattle extract from South Africa for many years and takes about 50% of the total amount exported. After World War II the United States and Australia were the next largest importers. Exports to Japan developed considerably, while India, at one time an important user, ceased importing altogether owing to self-imposed trade restrictions, but relied more on East African bark or extract. The United States would probably have increased imports were it not for the South African industries' policy of first supplying the needs of its traditional markets. Freight rates to the United States have also been unduly high, having increased four-fold since 1939 as against two-fold to the United Kingdom.

Wattle Extract

Wattle extract, or mimosa extract as it is better known to English tanners, was first successfully produced on a commercial scale in
South Africa at Pietermaritzburg, Natal, in 1916—during the First World War. Almost insuperable difficulties had to be overcome by those responsible because of the shortage of equipment and materials owing to the war. But with much improvisation success was achieved. The extract was at that time in keen demand for war purposes, especially leather for army boots, and good prices were obtained. Erection of other factories in Natal soon followed. The question of the preparation of extract for export had been seriously considered in various quarters from 1905 onwards. Wattle extract had been manufactured and used in tanning in the British Isles, Germany and other European countries long before it was first prepared in Natal. It is also of interest that an Australian wattle extract, of the consistency of thick tar, is reputed to have been shipped from Australia to England in 1823, fetching the remarkable price, for that time, of £50 per ton.

There were several obvious advantages to be derived from the manufacture of extract in Natal instead of shipping only the dried bark. The local conversion of green bark to extract obviates the trouble of drying the bark, so often fraught with difficulty owing to the uncertainty of the weather during the stripping season. Extract manufacture involves a considerable saving in rail, freight and handling charges, for one ton of extract contains the same amount of tanning matter as approximately two and a half tons of compressed bark. As the value of extract is much higher than that of bark the amount consumed in freight and handling charges is proportionally much less. There are also advantages from the user's or tanner's point of view. The tannin content of bark is subject to great variation, whereas that of extract is more or less fixed or guaranteed. The extract manufacturer with his elaborate and efficient plant is able to extract the tannin from the bark more thoroughly than the average tanner can do in his leaching pits. The use of extracts in place of bark saves the tanner much labour and time, also storage space. Furthermore the colour of the extract prepared from fresh bark is superior to that obtained from dried bark or extract made from dry bark.

There has been a notable improvement in the colour factor of prepared extract—or the leather produced from it—in Natal since the early days. Originally it stood at 3.5 (Lovibond tintometer reds units) but two decades later it had been reduced to 1.5.

The first stage in the preparation of extract is to reduce the bark to small fragments so that water may penetrate the material readily
and dissolve out the tannin. Fresh or green bark is put through a machine resembling the farm chaff-cutter. Dry bark may be so treated or put through a grinding mill or disintegrator. In leaching or extraction, various types of plant have been used from the old-fashioned open vats to the more modern press leaches and autoclaves operating under vacuum or at fairly high pressures. Bark is subjected to successive changes of liquid beginning with the stronger liquid and ending with pure water. Usually only a small proportion of extractive matter remains in the spent bark (2—3%). It is only the stronger or concentrated liquid that passes on for evaporation. Before evaporation the liquid is strained or filtered and then allowed to cool down which causes a certain amount of finely suspended matter to be deposited and fall as sediment to the bottom of the tank. In evaporation, now carried out under vacuum, various kinds of plant have been devised and patented.

When the extract attains the desired consistency it is run off into gunny bags in which it sets and in which form it is exported (weighing about 1 cwt.). Where extract is for local consumption evaporation to dryness is not essential, in fact is not desirable for much of the darkening takes place in the final stages of evaporation. For export, solid extract has marked advantages over the liquid form in freight and cost of containers. All the South African extract exported is in the solid form. In the ship's hold the bags of extract are often packed between layers of sawdust to prevent caking or blocking in the tropics.

The residue from extract manufacture or spent bark may be used as fuel but is otherwise of little use. Its manurial value has been shown to be extremely low, since much of the soluble and mineral matter have been washed out. It also decomposes very slowly.

Use of Wattle Extract in Tanning

For many years a prejudice existed against the use of wattle bark or extract in tanning on account of the high colour it gave to leather, and this held particularly in the United States. But thanks to improvements in quality of bark produced in the plantations and to improvements in extract manufacture this prejudice has been broken down. Another important factor has been the better understanding of the use of wattle extract in tanning and of the best method of blending it with other materials or modifying it for the particular type of leather that is required. Apart from this new ability to overcome any deficiencies that may be inherent in
USE OF WATTLE EXTRACT IN TANNING

Wattle, it has been shown that wattle has some very definite advantages of its own. In properly prepared tannages wattle has proved particularly well suited to the modern rapid methods of tanning heavy leather now so much practised. It also gives good quality light leathers when used in the appropriate blends. One of the advantages of the extract is that it does not form sludge in the tan-pit to any extent.

Wattle is essentially a catechol tanning material. It has a high pH value, a low acid and salt content and a comparatively low viscosity, especially in warm solutions. It is largely these attributes that account for its value in tanning blends, for with appropriate additions wattle liquors may be made suitable for almost any purpose. A typical commercial extract may have a tannin content of 61.5% and a soluble non-tan content of 20%, giving a ratio of approximately 3:1.

Wattle tannin is readily sulphited and is the most extensively used tannin for the manufacture of bleaching extracts. Leather tanned with it is well suited for bleaching either by the soda-acid dipping process or by the sulphite bleach. As it is sensitive to high temperatures it should be dissolved at a temperature below 190°F for the best results and the time of heating should be kept as short as possible. Agitation assists dissolving of the extract.

A typical method of sulphiting wattle extract is said to be as follows. 200 lb. of wattle extract are dissolved in sufficient water to make up 50 gal. of liquor; 4 lb. of sodium hydrosulphite are then dissolved in 2 gal. of water which is thoroughly mixed with the liquor. Live steam is then passed in for 30 min. Used alone this sulphited extract gives an extremely light coloured leather but the addition of 10% myrabolan or similar material is an improvement as it imparts a cream colour to the otherwise faintly pink leather.

The astringency of wattle tannin or the rate of fixation of tannin with the hide substance is high and on a par with that of quebracho. The rate of penetration is also good. Probably few other natural tanning materials combine the factors of astringency or fixation and speed of penetration as well as does wattle tannin. This accounts for its great value in present day rapid tanning processes.

Owing to the low acid content of wattle extract it is customary to delime hides and skins before tanning or to blend with other more acid materials or to add acid itself. For the latter purpose lactic and acetic acid have been recommended. With its low acid content when used alone, wattle tannin does not plump well
WATTLE BARK

for leathers like belting. Among the other vegetable tanning materials commonly used with wattle extract are myrabolans, valonea, chestnut, sumac and in some instances oak bark.

Tannin Content of Bark
The tannin content of commercial black wattle bark (air dried or about 12.5% moisture) may vary from 30—45%, while the average may be between 35 and 39%, the lower grades approximating to 35% and the higher grades to 39%. A comprehensive study of the tannin content of the bark under various conditions, in different parts of the trees and with trees of different ages has been made by C. O. Williams and the work is being continued at the Wattle Research Institute at Pietermaritzburg, Natal.

It has been shown by several different investigators that there is in general a definite correlation between bark thickness and tannin content, the thicker the bark the richer it is in tannin, also that bark thickness is to be correlated with diameter (at breast height). Thus tannin content may be governed to some extent by silvicultural conditions. Individual trees show variation in tannin content which is of a genetical nature.

As bark thickness is largely dependent upon age there is also an age correlation and trees 10—12 years of age may be expected to have the maximum tannin content under plantation conditions. Beyond this age, under Natal conditions, there is a tendency for woody or corky bark with a lower tannin content to develop, and for the tree or the bark to become diseased.

The nature of the bark and its tannin content are liable to be affected by rainfall and by soil moisture. It has been shown that in high-rainfall areas in Natal (over 45 in.) the bark may average 3% lower tannin content than bark from low-rainfall areas (below 40 in.). Although in practice the higher yield of bark from the high-rainfall areas more than compensates for the lower tannin content. Low winter temperatures, difficult climatic conditions or shallow soils may also affect bark thickness, giving thin bark with relatively high tannin content.

It has been shown that the bark at the bottom of the trunk, near or at soil level, is the richest in tannin and that it progressively diminishes towards the top of the tree although the diminution in tannin content may not be so very marked.

With regard to the distribution of tannin in the bark of the black wattle it has been shown that it is principally in the outer parenchymatous cells of the medullary rays, in the primary and
secondary cortex and in the phloem parenchyma. It is absent in the fibrous tissue and in the stone cells towards the outer edge of the bark.

Wattle Timber
The question of finding a suitable use or outlet for the large quantities of timber that accumulate after felling and stripping in the production of wattle bark was for a long time a serious consideration for South African wattle growers. In the early days of the industry there was a profitable outlet for timber from plantations within reasonable access of a rail head as mine props on the Witwatersrand mines. The smaller sized poles and thinnings could sometimes be disposed of as firewood but usually not very profitably. At a later period the supply of potential mine timber exceeded the demand and the timber was often burned or left to rot on the plantation.

After the Second World War, however, with the world shortage of timber of all kinds the demand for wattle timber increased, in spite of its limitations for certain purposes. The development of a hard-board industry with wattle wood as a basic material also made large demands upon available supplies, the first factory in Natal (at Escourt) utilizing some 60,000 tons of wood a year. The general opinion now is that wattle timber is not again likely to become a drug on the market.

The timber of the black wattle is hard and tough and is excellent for fuel and charcoal. Unfortunately it splits easily and planks from it will not take nails unless drilled first which is commonly done. In recent years it has been much used for shipping crates. It also has numerous other uses on farms and in the towns. It is used in fencing, for farm gates, scaffolding, for axe and pick handles and other purposes requiring a tough and durable grain. Large-scale tests have shown that well-matured and seasoned wood is very satisfactory as parquet flooring and that flooring blocks made from it compare favourably with other high quality blocks.

Other Wattles
Besides the black wattle (Acacia mollissima syn. A. decurrens var. mollis) there are several other Australian wattles that have been exploited or cultivated as a source of tan-bark in the past, notable among them being the green wattle (Acacia decurrens), the silver or blue wattle (Acacia dealbata syn. A. decurrens var. dealbata) and the golden wattle (Acacia pycnantha). These species are well known in...
South Africa, having been introduced at an early date. It is believed that the silver wattle was the first to be introduced to Natal, probably about the middle of last century and some time before the introduction of the black wattle. The green and the golden wattle may have been introduced about 1870 or after the black wattle. The terms black, green, silver or blue wattle etc may be differently used in Australia and refer to different species.

The black, the green and the silver wattle (as known in South Africa) are closely allied species and were at one time in fact regarded simply as different varieties of the same species (*Acacia decurrens*). All possess decurrent leaves. From underneath the base of the leaf-stalk there are two prominent ridges or wings running down the young branch from the base of the petiole. The leaves of all three species are bipinnate and there is a certain degree of similarity in pod, flower and other characters although all three are readily distinguishable. A notable difference between the black and the green wattle, important from the genetical point of view, is that the pod of the black wattle takes about 14 months to mature from flowering, *i.e.* ripens the year after flowering, while the green wattle requires 5 to 6 months only and ripens its seed in the same season as flowering.

The silver wattle (*A. dealbata*) was much grown in the colder districts and in the higher altitudes in Natal, as it is much more cold-resistant than the black wattle. It was cultivated as shelter for stock, for firewood and for mine props. With the first use of wattle bark for tanning in Pietermaritzburg in 1884 it was discovered that the bark of silver wattle was markedly inferior to that of the black wattle in tanning and the local tannery refused to take it. Unlike the black wattle it produces suckers or "runs" freely and often becomes a nuisance. Nowadays the sale of silver wattle bark as black wattle bark is prohibited by law. The mature bark of the silver wattle is of an ashy or dull silvery grey colour. The tannin content is usually in the vicinity of 20% and it is much darker than the black wattle in tanning.

The green wattle (*A. decurrens*) possesses bark equally rich in tannin as that of the black wattle, although the bark is rather thinner. Unfortunately the tannin is more highly coloured and produces a much more highly coloured leather. Were it not for this it might well have been cultivated in place of black wattle, for it is equally easily grown, yields good straight poles, is much more resistant to cold and to the two major insect pests, bagworm and froghopper. It is rather remarkable that in Natal plantations were
not established until 1929 when it was planted in the drier areas of the wattle belt where the incidence of bagworm is high, but later these plantations were converted to black wattle. If a suitable and economic means of decolorizing green wattle extract were to be devised doubtless there would be an immediate and substantial increase in green wattle cultivation. Green wattle grows better than black wattle on poor sites. It strips more readily than black wattle in dry weather. The yield of bark is about the same, as is the tannin content. The fresh bark of the green wattle has been satisfactorily used, especially during the Second World War, in extract manufacture when mixed with a much greater bulk of black wattle bark. In stripping the bark is harder on the hands than that of the black wattle.

The golden wattle (A. pycnantha), also called broad-leaved wattle, is quite distinct from green, black and silver wattle in that it does not have bipinnate or feathery leaves, but has lanceolate phyllodes. It is also a much smaller tree with much thinner bark. It occurs on the Cape Flats along with the ubiquitous Port Jackson willow or ‘saligna wattle’ (Acacia saligna). The bark commonly contains a high proportion of tannin (over 40%), higher even than that of the black wattle, but yields a more highly coloured infusion.
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However, the small size of the tree and its slow rate of growth have quite ruled out any possibility of large-scale cultivation for tan-bark. The bark is freely used in parts of Australia for tanning.

Other Australian Acacias have been introduced to South Africa and the approximate tannin contents of the bark are: *Acacia melanoxylon* (blackwood) 13%; *A. saligna* (saligna wattle) 20%; *A. cyclopis* (‘rooikrans’) 10%.

The following are other Australian wattles or species of *Acacia* with the approximate tannin content of the bark estimated in Australia

<table>
<thead>
<tr>
<th>Acacia Species</th>
<th>Tannin Content</th>
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</thead>
<tbody>
<tr>
<td><em>A. acuminata</em></td>
<td>14–20%</td>
</tr>
<tr>
<td><em>A. amoena</em></td>
<td>23%</td>
</tr>
<tr>
<td><em>A. bancroftii</em></td>
<td>20%</td>
</tr>
<tr>
<td><em>A. binervata</em></td>
<td>27–30%</td>
</tr>
<tr>
<td><em>A. brachybotrya</em></td>
<td>21%</td>
</tr>
<tr>
<td><em>A. cunninghamii</em></td>
<td>12–18%</td>
</tr>
<tr>
<td><em>A. complanata</em></td>
<td>10%</td>
</tr>
<tr>
<td><em>A. decora</em></td>
<td>23%</td>
</tr>
<tr>
<td><em>A. elata</em></td>
<td>27%</td>
</tr>
<tr>
<td><em>A. excelsa</em></td>
<td>16%</td>
</tr>
<tr>
<td><em>A. falciata</em></td>
<td>27–37%</td>
</tr>
<tr>
<td><em>A. flavescens</em></td>
<td>15–22%</td>
</tr>
<tr>
<td><em>A. harpophylla</em></td>
<td>14–17%</td>
</tr>
<tr>
<td><em>A. impexa</em></td>
<td>14–22%</td>
</tr>
<tr>
<td><em>A. linifolia</em></td>
<td>11%</td>
</tr>
<tr>
<td><em>A. leptocarpa</em></td>
<td>10%</td>
</tr>
<tr>
<td><em>A. maidenii</em></td>
<td>3–23%</td>
</tr>
<tr>
<td><em>A. microbotrya</em></td>
<td>19%</td>
</tr>
<tr>
<td><em>A. neriifolia</em></td>
<td>14%</td>
</tr>
<tr>
<td><em>A. oswaldii</em></td>
<td>10%</td>
</tr>
<tr>
<td><em>A. penninervis</em></td>
<td>14–34%</td>
</tr>
<tr>
<td><em>A. podalyriaefolia</em></td>
<td>8–12%</td>
</tr>
<tr>
<td><em>A. polybotrya</em></td>
<td>var. foliolosa 26%</td>
</tr>
<tr>
<td><em>A. pravissima</em></td>
<td>11%</td>
</tr>
<tr>
<td><em>A. prominens</em></td>
<td>15%</td>
</tr>
<tr>
<td><em>A. pruinosa</em></td>
<td>23%</td>
</tr>
<tr>
<td><em>A. salicina</em></td>
<td>20%</td>
</tr>
<tr>
<td><em>A. sentis</em></td>
<td>10–18%</td>
</tr>
<tr>
<td><em>A. vestita</em></td>
<td>28–33%</td>
</tr>
</tbody>
</table>

Wattle Breeding and Vegetative Propagation

The first research work on wattle breeding was commenced in Natal in the latter nineteen twenties by the late J. B. Osborn but his untimely death a few years afterwards put an end to the work. It was resumed in 1942 by Philp and Sherry. The main object of the work is to produce if possible a true breeding strain of black wattle with a heavy yield of high quality bark for tanning. There are good reasons for believing that this aim should eventually be achieved but many years may be needed to bring the project to fruition, for a tree crop is concerned and not an annual or quick-maturing crop. There is also the possibility of producing valuable hybrids between the black wattle and other wattles such as the green wattle or other species of *Acacia*.

The early breeding work and the work on certain wattle diseases (gummosis) brought to the forefront the need, in experimental work, of propagating the black wattle vegetatively. Normally the black wattle cannot be propagated by cuttings. Extensive experiments with many hundreds of cuttings of different kinds taken each month of the year, with and without treatment with hormone or root producing substances gave completely negative results, no root development taking place at all.
Eventually it was found that vegetative propagation could be effected by marcottage or a modified form of it. The technique adopted was first to ring-bark part of the stem of a young branch and cover that part with a split section of bamboo subsequently bound together, the lower node having a hole about the same diameter as the stem to be covered. The top node of the section of bamboo was removed altogether to allow it to be filled with a mixture, in equal proportions, of plantation soil rich in humus and a sand-moss-peat mixture. The top opening also served for watering when necessary. After $4\frac{1}{2}$ months a solid mass of roots had been developed in many instances holding the soil together in a firm cylinder. On severing and cutting back the rooted branches they were placed in a hot bed until well established. This method resulted in 26% success six months after planting, but it is considered further improvement might be effected, especially with the judicious use of hormone or root producing substances in the bamboo sections.\textsuperscript{112} While this method may be valuable in raising trees of homogeneous constitution in small quantities for experimental work it obviously could not be used in plantation work. The great value of having a means of vegetative propagation with a crop such as the wattle is for the rapid build-up of new strains for special features such as high tannin content and high yield of bark, resistance to frost in the young stages and to pests and disease, and general suitability for marginal areas.

Later it was found that instead of using split bamboo sections to hold the soil or rooting medium in position over the ring-barked part of the stem this could be more effectively and more conveniently done by enclosing the 'ball' in a stout plastic membrane tied top and bottom. With this method little attention was needed. Watering once a month was sufficient, even under dry conditions. It was found watering could be done by inserting a large hypodermic syringe under the tie at one end. Roots developed after two months.

The early genetical work on the black and green wattle\textsuperscript{137, 138} established the fact that pollination of the flowers is largely by bees of various kinds, that appear to visit the flowers mainly for pollen. In nature cross-pollination takes place freely, probably to the extent of about 90%, but both species are self-fertile. With the green wattle it was found that with selfing (using cellophane or grease-proof paper bags, preferably the former) viable seed was produced quite freely but more pods were shed than with the naturally pollinated flowers. The pods were shorter and with
fewer seeds. The germination rate of the seed was lower, 62% as against 79% for the naturally pollinated. Simple Mendelian ratios were observed in the selfed progenies of single trees. A high proportion of the trees worked with were considered to be heterozygous. The seedlings from selfed trees, after a few years' growth, were on the average shorter than trees of similar age from naturally pollinated seed. Many of the genetical features of the green wattle apply to the black wattle. The chromosome number of both is $2n = 26$.

Trees of what are believed to be natural green $\times$ black wattle hybrids have been located in Natal. Hybrids have also been freely produced by artificial pollination, the results of the early crossings, having later become well-established trees. The $F_1$ hybrids were often chlorotic in the seedling stage—regarded as an indication that the two parent species are fairly far removed from one-another taxonomically. Some of the offspring closely approached one or other of the parent species in their general characters. Others had new combinations of characters of both parents—considered to be a fact of great economic importance. About 25% of the progeny were dwarfs, considered to be 'probably the products of disharmonious combinations of polygenes'.

The genetical evidence so far produced supports the current view that the green and the black wattle are distinct species and not varieties of a single species as was at one time supposed. It also suggests that the possibility of combining desirable characters of both species in a new race of tan wattle is promising.

Apart from the production of green and black wattle hybrids and the inbreeding of black and of green wattle the genetical work carried on at the Natal Wattle Research Institute has been concerned with crossing black wattle with the silver wattle ($A. dealbata$), the golden wattle ($A. pycnantha$) and $Acacia baileyana$. Attempts have also been made with the use of colchicine to produce 'twin seedlings' in black wattle as these often have double chromosome numbers. As the Australian tan-wattle chromosome number is 26 ($2n = 26$) while that of the wild or indigenous African Acacias (so far investigated) is 52 it is felt the production of a green or black wattle with the double chromosome number might allow of its being crossed with the indigenous Acacias.

Varieties of black wattle, showing distinct morphological variations from the normal form, have been recorded in Australia. Tannin content of mature bark has varied from 32—52% and plots of selected strains have been established.
The Black Wattle in Other Countries

The black wattle has now been introduced to many other parts of the world and found to grow satisfactorily as an ornamental tree, for firewood, or for shelter, but only in relatively few areas has it been grown on plantation lines as a source of tan-bark as in South Africa. Areas where it has been established include the sub-tropics and the higher altitudes of the tropics of both the Old and the New Worlds. The following are some of the countries, other than South Africa, where it has attracted attention.

**East Africa**—East Africa (notably Kenya and Tanganyika) is the next largest producer of wattle bark and wattle extract after South Africa, although the actual production is considerably less. The black wattle was introduced into Kenya by means of seed from Natal in 1903, primarily with a view to providing fuel for the railways, but interest in tan-bark possibilities soon developed and many new plantations were established in the Kenya highlands, especially in the Kiambu, Nakuru and Uashin Gishu areas. The first extract factory was established at Limoru in 1928 and was soon followed by others. Much of the bark in East Africa destined for export or the extract factories is collected by the natives from the reserves or their own holdings and is of poor quality (dark in colour) and inferior to the Natal product. After the Second World War the high price and shortage of wattle extract led to extensive developments in wattle cultivation in southern Tanzania. With the cessation of Indian trade with South Africa, due to political reasons, India became an important user of East African wattle bark and extract. The eastern markets in general are not so particular in regard to quality as are those of Europe and America.

The black wattle tree has been grown in Nyasaland and in Portuguese East Africa at the higher altitudes but a trade in the bark has not yet been developed and the areas where the tree is likely to succeed are limited.

**Southern Rhodesia**—Extensive developments in wattle planting took place in Southern Rhodesia in the years following the Second World War. Some parts of the country, notably the highland eastern districts, are regarded as very well suited for wattle cultivation. On the eastern border the rainfall is suitably high (over 40 in.), mists prevail, and the black wattle thrives, yielding bark of good tannin content. Conditions are, on the whole, too humid for the wattle bagworm to be a serious pest. It has been estimated that some 2,000 square miles should be well suited for wattle
WATTLE BARK

growing and that the possibilities with wattle cultivation may be very great. Drawbacks may be distance from railhead and port and profitable disposal of the timber. With regard to the establishment of extract factories in newly-developed wattle areas the minimum profitable factory unit is considered to be one yielding 5,000 tons of extract per annum and for this some 25,000 acres of wattles are needed. Prospects of wattle cultivation in Northern Rhodesia are not considered promising on account of climatic conditions.

North Africa—The black wattle has been grown in various parts of North Africa and the Mediterranean region but conditions generally do not appear to have been well suited for large-scale production of bark. In parts of Morocco, plantations have been established for many years but have not so far proved very successful.

Madagascar—The introduction of the green wattle to Madagascar took place in 1909 and that of the black wattle in 1914. Both were cultivated partly for fuel but later the green wattle was dropped in favour of the black. Bark with high tannin content has been produced but production has not reached the proportions thought probable at one time—possibly due, in part at least, to insect pests.

Indonesia and the Philippines—At the higher altitudes in Java the black wattle has grown well, being used mainly for shelter purposes and reafforestation. Where bark has been exploited difficulty has sometimes been experienced in drying owing to the humid atmospheric conditions and artificial drying has been resorted to. In plantations with wide spacing it is considered that a ground cover such as Eupatorium palescens is desirable, the black wattle being a bad soil protector. The black wattle appears to have been satisfactorily established in some parts of the Philippines. It has also been grown in Japan and Hawaii.

Indian Sub-continent—The use of wattle bark or extract for tanning has greatly increased on the Indian Sub-continent in recent decades due to shortage of traditional tan barks such as avaram (Cassia auriculata) and babul (Acacia arabica). Wattle bark was first imported to India from South Africa during the 1914—18 war. By 1939, imports averaged 20,000 tons. This was considerably augmented during the Second World War and the vast output of leather from India for the fighting forces was only made possible by the importation of wattle bark or extract from South or East Africa. With trade restrictions imposed after the war imports were entirely from East Africa.
THE BLACK WATTLE IN OTHER COUNTRIES

The black, the green and the silver wattle were all introduced to India towards the middle of last century, mainly to provide fuel for the army. The silver wattle became the more common. The black wattle has grown well in some localities in southern India, at elevations of about 5,000 ft., but above this altitude there has been severe damage from cold, especially cold winds, and the black wattle is difficult to establish. In some of the colder areas winter protection of seedlings or young trees by means of straw tents or capes has been tried but involves much labour and expense. In the Nilgiris the planting of wattles along with a catch or 'taungya' crop such as potatoes has proved successful. It has been found in Kodaikanal that established Eucalyptus trees, three years old, and spaced 40 ft. apart, also Eucalyptus wind belts are a considerable help in establishing young wattles. Seed is sown in hoed patches 2 ft. in diameter and 6 ft. apart. Later the spacing may be altered to 12 ft. As the black wattle will not tolerate extremes of heat or cold it is unsuited to most parts of India and Pakistan. In the areas suited to it there have so far been no serious pests. The former lack of interest in wattle bark production in India is attributed to the low cost at which bark or extract could be imported from South or East Africa. However the greatly increased prices after the Second World War stimulated interest in wattle cultivation.

Ceylon—In many parts of Ceylon at the higher or middle altitudes the black wattle has grown well. It has been used as a wind-break for tea and for green manuring, also for shelter belts generally and for fuel. The bark has been utilized in local tanneries but has not been systematically exported. Gummosis and root diseases (Armillaria fuscipes and Fomes australis) have caused trouble in some areas.

North and South America—The black wattle has been found to grow successfully in various parts of the New World. It thrives in some parts of California where it is hoped to extend cultivation but the high price of land in suitable areas is an adverse factor. Promising results have been obtained in some parts of Brazil, notably in the State of Sao Paulo and the southern Santa Catarina and Rio Grande du Sol. In the last mentioned State, barks with over 40% tannin have been obtained. Five year old trees yielded 8—10 kg. of dry bark. Liquid, solid and powdered extracts have been prepared. In Jamaica (Blue Mountain area) the black and the green wattle have grown well.

Australia—Although Australia is the home of the black wattle and of other tan wattles the production of wattle bark is far below
WATTLE BARK

what it is in South or East Africa. Owing to much higher labour costs, especially in felling and stripping, Australia has been quite unable to compete with the producers in Africa, and in fact for many years has imported South African bark or extract in some quantity for her own tanning industries in spite of a high import duty. Another important consideration is that the Australian bark, being in the main from wild trees of all ages, and often of different kinds or varieties of wattle, compares very badly with the high grade uniform product from South Africa, which is from cultivated or plantation trees, of uniform age and all from a single species (black wattle). At one time, 50—100 years ago, considerable quantities of wattle bark were exported from Australia—about 20,000 tons annually. Owing to depletion of the trees and stripping having to take place farther and farther afield the quantity exported gradually diminished. In the early days there was much ruthless exploitation, trees of all ages being felled or the bark only removed from the lower portion of the trees and the rest left to waste. The opinion has been expressed that unless a method of removal of the bark by mechanical means can be devised, to minimize hand labour, there is unlikely to be any greatly increased production of wattle bark in Australia.

The black wattle occurs naturally over a fairly wide area of eastern Australia and was also very prevalent in Tasmania until it was largely cut out (the bark going to the mainland) or reduced by grazing or fire. Investigation in recent years in Australia has shown that some individual trees of black wattle have a very high tannin content of the bark, in excess of 45%. Such trees are likely to afford useful material for breeding work and plots have been established. The quality of the bark varies with the nature of the soil, being poorest in limestone areas. What is known as 'black wattle bark' on Australian markets often includes bark of the green wattle (A. decurrens) and silver wattle (A. dealbata).

The golden wattle (A. pycnantha) is of equal importance to the black wattle as a tanning material in Australia. The bark has a higher average tannin content than that of the black wattle and is in fact, in tannin content, one of the richest barks known. The species is particularly prevalent in parts of South Australia, the bark being sometimes known and sold as 'Adelaide bark'. In South Australia it has been estimated that some 125,000 acres occur, mostly in the Mount Lofty ranges and that yields may average 3 to 4 cwt. of dry bark per acre. In some parts of Australia, including Western Australia, small plantations of Acacia

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The Black Wattle in Other Countries

*Acacia pycnantha* have been established. Investigations have been made on the possibility of producing extract from the leaves, twigs and small branches of the golden wattle which, on the dry basis, contain about 12—17% tannin, about 4 tons of such material being available for every ton of bark.

Besides the species already mentioned two other species sometimes exploited for tan-bark in Australia are *Acacia penninervis* and *A. binervata*. 
MANGROVE BARK

Mangroves

The term 'mangrove' is used in a wide sense for any of the trees that may constitute the vegetation on the tidal mud flats of the tropics and parts of the sub-tropics. These mangrove swamps are one of the world's most distinctive forms of vegetation and are of great interest from the biological point of view. They cover extensive areas in some parts of the tropics, especially where rainfall is high and large rivers exist to deposit masses of mud and silt on reaching the sea. For it is the combination of mud flats and brackish water—a mixture of sea water and fresh water—that affords the conditions necessary for mangroves to thrive. As they are mainly restricted to tidal areas, a gently sloping seashore naturally favours extensive mangrove development more than does one which slopes steeply. Mangroves are often to be associated with lagoons and may be found growing as far up the estuaries of rivers as the water is brackish. The absence of severe storms is another factor which is favourable for mangrove development. Mangroves do not occur along sandy beaches or rocky shores, which are exposed to the full force of the waves and the wind, but only in estuaries, creeks, lagoons or low sheltered islands.

While mangrove swamps or forests vary from one part of the world to another they all have one constant and outstanding feature, viz. the presence of trees of the mangrove family (Rhizophoraceae) especially those belonging to such genera as Rhizophora, Bruguiera, Avicennia and Ceriops. Other families are also represented in mangrove swamps, particularly in the areas that are gradually reverting to normal dry-land conditions.

A notable feature of mangrove trees in general is the richness of the bark in tannins, the bark of several species being regularly used as a source of tannin or made into tannin extract in different parts of the world. Before considering mangroves as sources of tannin it may be as well to consider why they have always been of such special biological or scientific interest.

Biological Interest of Mangroves

Mangrove trees live with their roots in mud or soil continually permeated by sea or brackish water and at high tide young trees
BIOLOGICAL INTEREST OF MANGROVES

may be quite submerged—conditions of life that would absolutely destroy ordinary forest trees. Mangroves actually exist in a state of ‘physiological’ drought although surrounded by water, the water being salt, not fresh, and show many of the adaptations of xerophytic or drought-resisting plants, especially in the leaf structure. They have a thick cuticle, large mucilage cells, protected stomata, and especially a large-celled, thin-walled aqueous tissue, the dimensions of which increase with the age of the leaf and with the corresponding rise in the amount of salt contained.

The medium in which mangroves grow is poorly aerated and this accounts for the prevalence of the characteristic aerial roots, pneumatophores, or other adaptations for obtaining air. The conspicuous, asparagus-like, leafless branches or pneumatophores of Avicennia, which catch the silt from the rivers and debris from the tides, are a characteristic and familiar feature in mangrove swamps.

Another peculiar characteristic of mangroves or of the Rhizophoraceae is vivipary, i.e. the seed has commenced to germinate or become a seedling or young plant before it leaves the parent plant. In the common red mangrove (Rhizophora mucronata) for example the seedling grows to a length of 70—100 cm. by the development of a long dart-like or arrow-like radicle before dropping from the parent tree. When the seedling does fall it is ideally adapted or shaped for piercing the mud, usually remaining in an upright position and commencing to grow immediately. Growth in the early stages is very rapid. One observer records seedling growth in Rhizophora mucronata in East Africa as ‘twenty inches growth in so many hours’ (This may be a record for plant growth.) But once the leaves are clear of the average high tide level the growth rate falls off. Unlike land plants mangroves are not immediately dependent upon rain for growth. If the germinating seeds of mangroves do fall into deep water and not mud they float and may be dispersed or carried long distances by sea currents before they finally become deposited in mud or silt and develop. They soon acquire a vertical position of their own accord under such conditions.

As one writer (Fosberg) has stated ‘mangroves may be described as living in salt water, bearing their young alive, marching out to sea, and taking long ocean voyages’. Apart from supplying tanbark, mangroves may be extensively used locally for timber, for firewood and for charcoal. However, the most useful function they perform is in colonizing muddy coastal flats in the tropics and gradually converting or restoring them to normal dry land as their
MANGROVE BARK

roots collect and consolidate mud and debris. They do in fact wrest or reclaim land from the sea in a manner that no other agency, natural or man-made, can accomplish.

In the early stages of mangrove colonization the mangroves may be stunted and shrubby, but later, when they are properly established and their root systems have secured a firm hold in the substratum, they may develop into large, tall trees. There are areas where they reach 100 ft. in height with trunks 2—3 ft. in diameter. Being often closely spaced, the stems are tall and erect without side branches and thus well suited for poles for constructional work and for timber. Isolated specimens however tend to be much branched and spreading, stunted or crooked.

Tannin Content of Bark

The tannin present in mangrove barks of different kinds may vary from less than 10 % to over 40 %. It is only when the tannin content is fairly high that exploitation for tan-bark or for extract is worth while. Bark for export should have not less than 30 % tannin. For local extract manufacture barks with a lower tannin content may be profitable to work. Owing to the nature of mangrove swamps, with the mud, the masses of aerial roots and the tidal influence, there are many difficulties to be overcome in exploitation that do not have to be considered under dry-land conditions. However, in view of the prevalence of mangroves throughout the tropics, their permanence and ease of natural (or artificial) regeneration, it is considered that they constitute the world's greatest potential source or reserve of tanning material. Mangroves constitute in fact the only commercial tanning material of natural growth that seems inexhaustible.

The tannin content of mangrove bark is liable to vary a great deal not only between different species but within the same species. With variation within a species there are doubtless many factors that may play a part. The age of the bark or of the tree yielding it may be important, the tendency being the older the tree, the richer the bark. The amount of ross or dead bark present on old bark may, however, have a compensating effect, for it is normally much poorer in tannin than the living bark. It has been shown that mangrove trees growing in more or less isolated positions, or well exposed to sun and air, tend to have a richer bark than trees growing in dense formations, which are thus more shaded.

Beckley has shown with Malayan mangroves that the tannin content may vary according to the height up the tree where the
bark is taken. It would seem quite feasible to suppose that this might apply also in other areas besides Malaya. If mangrove bark is stored for any length of time the estimated tannin content may differ from that of fresh bark and the tannin may alter (become less soluble). The season of the year when the bark is removed may have a bearing not only on the tannin content but also on the pigments present or the colour produced with leather in tanning.\(^\text{13}\)

As an example of the range of variation that may be expected the following figures for tannin content of bark of the red mangrove (\textit{Rhizophora mucronata}) from different areas may be of interest: Tanganyika 36.5\%; Sundarbans (India) 35\%; Malaya 30-40\%; Philippines 27.6\%; Borneo 20\%.\(^\text{13}\) These are of course merely figures taken at random. It is the \textit{average} tannin content of the bark from any one area that is important commercially.

The name 'cutch' or 'kutch', used for the tanning extract prepared from mangrove bark, is actually a misnomer. However, the term is now in universal use and must be accepted. The name 'cutch' was originally used for the extract prepared from the heartwood of \textit{Acacia catechu}, an age-old product of India and Burma, exported in some quantity at one time (see Cutch, Chapter 19). When the extract of mangrove bark came into the market it superseded Indian cutch to a large extent (supplies of which had been irregular), and acquired the name 'cutch', being used for many similar purposes as Indian cutch. Other names that have been used are 'kaki cutch' and 'Baken cutch'.\(^\text{183}\)

With regard to the yield of mangrove bark per unit area, this naturally varies tremendously according to conditions, age and size of trees \textit{etc}. In India and the East Indies average yields of five tons of green bark per acre have been recorded.\(^\text{65}\)

\textit{Mangrove Cutch}

During the early years of the present century the interest and the trade in mangrove bark or extract increased greatly, supplies going mainly to Germany, the United States and Russia, with only small quantities to Great Britain. After the First World War, however, supplies to the British Isles increased. Between the two World Wars interest in mangrove for tanning fluctuated. In recent years notable developments have been (1) the increasing tendency to prepare and export the extract or cutch instead of exporting the bark on the part of producing countries and (2) the greatly increased production of extract from the American tropics, export being mainly to the United States.
**MANGROVE BARK**

*Value and Uses of Mangrove in Tanning*

It is not known when mangrove bark was first used in tanning but its use among primitive peoples (e.g. the Malays) for treating or preserving their fishing nets probably dates from very early times. Arabs on the Arabian coast recorded, as far back as A.D. 1230 that mangrove bark would tan. Early last century there was interest in European countries in the tanning properties of bark of *Rhizophora mangle* from the West Indies. This was soon followed by interest in the tanning properties of mangrove bark from Eastern countries such as Malaya, Borneo and India.

Mangrove bark was apparently in regular use for tanning in the West Indies over 200 years ago as the following remark from an old eighteenth-century encyclopaedia, referring to oak tannage, would suggest. 'The operation of tanning is performed on leather better in the West Indies than in England. They use three sorts of bark, the mangrove bark, the olive bark, and another; and the whole business is so soon done that a hide delivered to them is in six weeks ready to be worked into shoes though they bestow less labour than we do.'

The use of mangrove bark or extract in tanning is now widespread and, with the general shortage of vegetable tanning materials, there has been a keen demand for it. As a tanning material it has both good and bad points. Its main drawback is the reddish colour it imparts to leather, although in practice this is largely overcome by mixing it with other tanning materials which modify or reduce the intensity of the colour. Used by itself, however, it produces in leather an undesirable colour according to modern standards. The leather is also inclined to be somewhat harsh and thick-grained when mangrove is used alone. Unfortunately mangrove extract is very difficult to bleach satisfactorily. Blending is preferable to reduce the undesirable colour effect on leather. Various methods have been suggested for counteracting the colour, such as subsequent immersion of the leather in a solution of aluminium sulphate, or the addition of a light yellow dye or sulphite-cellulose extract to the tanning liquor. Used in blends mangrove may help to solubilize other tannins. The sludge or 'tanyard sediment' resulting from a blend of quebracho and mangrove is said to be flocculent and not tarry.

However, in spite of the drawbacks mentioned mangrove mixed with other tanning materials gives a very satisfactory tannage and is much used. Mangrove tannin is often regarded as the cheapest form of tannin available to the tanner. In France, a much used
and popular mixture is said to be about one third mangrove, two fifths chestnut, and the remainder oak or wattle. Both mangrove bark and the extract or cutch are in keen demand in the United States, more so than in the British Isles. It has recently been found that mangrove extract plus a wetting agent is a good substitute for quebracho in oil drilling (see p. 11) and a factory has been established in Panama to produce mangrove tannin for the oil industry. Owing to the preference shown by American and by British and European tanners for the extract rather than the bark itself and to the great saving in shipping space the ratio of extract to bark exported from producing countries has increased markedly in recent years. The average tannin content of mangrove extracts (solid) is probably about 65% with about 17% non-tans.

Mangrove bark is usually rather high in salts content, which is not surprising considering the manner of growth, the salt being present in the tissues and not just superficially. As would be expected the extract also possesses a relatively high salts content (mainly sodium chloride). This high salts content sets a limit to the amount of mangrove extract that may be used in tanning blends, especially for heavy leather tannage. The difficulty may be overcome by mixing the mangrove with a tan of low salts content such as wattle bark extract. With light leathers, this objection is less likely to arise. In the case of salted or pickled sheep skins, there is already so much salt present that the salt present in the tan itself may be of little account. The rate of penetration of the hide is slower with mangrove than with many other tans such as wattle, quebracho and chestnut, but the rate may be increased by sulphiting. Mangrove tannin is of the catechol class, with a fairly high pH and low acid content. Among the virtues or good points of mangrove bark or extract as a tanning material is its weight-giving property when used with heavy leather. This is probably as great or greater than with any other commercial vegetable tan. Mangrove tannin is very soluble and develops a minimum of insoluble matter. It produces very little sludge in the tanning liquor.

Considering that commercial mangrove tannin or extract may be derived from any of a dozen or more different botanical species it is not surprising that it should lack uniformity in its chemical properties. Actually the chemical composition of the tannin from different mangrove barks is not at all well understood153.
Mangrove Bark

Main Mangrove Areas

Mangroves occur in greatest abundance in those parts of the tropics where large rivers reach the sea. Extensive stands occur throughout Malaysia and Polynesia, especially Borneo, Malaya and the Philippines, also in Australia, Indo-China and the Indian Sub-continent. Madagascar has large areas of mangroves and supports a mangrove extract industry. Parts of East Africa are also rich in mangroves.

Mangrove swamps or forests also occur freely in west tropical Africa and in central America, northern South America, some of the West Indies and parts of the south eastern United States of America. The mangroves of West Africa and the Americas (i.e. the 'western' region) differ notably from those of East Africa and other countries in the Indian Ocean or the Pacific (i.e. the 'eastern' region). Several species of mangrove are restricted to one or the other of these two main regions, for instance, Avicennia marina (syn. A. nitida), Conocarpus erectus, and Laguncularia racemosa are well-known mangroves of the Americas but do not occur in the Indian Ocean—Pacific Ocean regions, where one finds instead such species as Rhizophora mangle, Bruguiera eriopetala, Ceriops candolleana, Avicennia officinalis etc. These, in turn, do not occur in West Africa or the Americas. In general, the mangroves of the eastern region are considered to be richer in tannin and better suited for extract manufacture than those of the western region. Other mangroves which possess a bark rich in tannin and which may be exploited for tan-bark are Rhizophora mucronata, Bruguiera gymnorrhiza, B. parviflora, B. rheedia, Ceriops roxburghiana, C. candolleana, Kandelia rheedia, Carapa moluccensis and species of Heritiera.

'Eastern' Region

East Africa—Mangroves have been exploited for tan-bark for many years in parts of East Africa, notably Tanganyika and Portuguese East Africa, also in Madagascar. Madagascan mangrove extract has long held a good reputation.

In Tanganyika the production of mangrove bark for export has varied considerably. Since the Second World War it has not been great and has gone mainly to the United States. For the three years 1946—48 production averaged 3,529 tons of bark per year. It has been estimated that the potential annual production, assuming the necessary labour and river craft were available, would be about 10,000 tons of bark. The total extent of the mangrove areas in Tanganyika has been estimated to be about 120,000 acres.

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The following are the main areas (gazetted areas) which have been granted to concessionnaires from time to time: Bagamoyo 3,705 acres; Dar es Salaam 8,645 acres; Kilwa 34,580 acres; Lindi 3,500 acres; Mafia 1,000 acres; Tanga 27,400 acres; Rufiji 38,909 acres; Mikindani 19,760 acres. The important concentrations of mangroves are those of the Tanga district extending almost continuously from the Kenya border near Jasini to south of Tanga harbour. Owing to rivers being in flood, some areas are not accessible for part of the year (April to June). This applies especially to the largest area—the Rufiji Delta. The

![Red Mangrove](image)

**Figure 2. Red Mangrove (Rhizophora mucronata): one of the most important mangroves for tan-bark in the eastern tropics and East Africa**

mangrove areas, which are under Government control, are rested from time to time. Mangrove forests are present on the adjoining islands of Zanzibar and Pemba, which are also worked for bark, 16,500 tons of bark having been exported in 1946 and 1947. During the Second World War and immediately afterwards the mangrove stands were heavily over-exploited for bark, building poles and firewood and required to be rested and recuperated.

A good account of the mangrove forests of Tanganyika has been given by Grant. He stated that they consist of only seven species, and that in some areas a single species only may be present or a mixture of two or three species only. The seven species concerned, with their Kiswahili names, are *Rhizophora mucronata*, 'mkaka' or 'mkoko'; *Ceriops candolleana*, 'mkanada'; *Bruguiera gymnorrhiza*, 'mshinsi' or 'mchumsi'; *Avicennia officinalis*, 'mchu';
The Red Mangrove (Rhizophora mucronata) at low tide. It is an important species for tan-bark. The trunk is entirely supported by stout prop roots.

Plate III
Sonneratia caseolaris, 'milana' or 'mpira'; Heritiera littoralis, 'msikundazi'; and Xylocarpus moluccensis, 'rnkomavi'.

It is pointed out that these species vary much with regard to the degree of salinity of the water they will tolerate. Avicennia officinalis, Rhizophora mucronata, Sonneratia caseolaris, and Ceriops candolleana, 'in this order are at home in salty water'. Xylocarpus moluccensis likes it less and Heritiera least of all. With regard to shade tolerance Rhizophora mucronata, Bruguiera gymnorrhiza and Ceriops candolleana take first place, then Xylocarpus moluccensis, Sonneratia caseolaris, Avicennia officinalis and Heritiera littoralis. None thrive in dry mud but Ceriops candolleana and Heritiera littoralis are the most accommodating in this respect. The usual or the natural succession is from Avicennia officinalis through Rhizophora mucronata to Ceriops candolleana in the salt situations and Avicennia officinalis through Bruguiera gymnorrhiza to Ceriops candolleana or Heritiera littoralis in the less saline or nearly sweet water sites.

A very old trade in barked mangrove poles (called 'boriti') has existed between East Africa and countries to the north (Arabia and Persia) for building purposes, mainly the construction of multiple-storied square houses, the poles being valued on account of their length and straightness and of their strength and durability. Arab and Persian dhows have carried on the trade from early times bringing merchandise of various kinds south and returning with boriti. The poles are cut for preference from Rhizophora mucronata and Ceriops candolleana although Bruguiera gymnorrhiza is also used. They are usually from 3—7 in. in basal diameter with little taper, and between 18 and 24 ft. long. The three species mentioned are also favoured and much used for charcoal.

In collecting the bark the natives fell the trees, remove the bark and transport it to depots for drying. Mangrove bark cannot be stripped off in the way that wattle bark is removed. However, it is not difficult to remove as a rule and comes off in large irregular pieces. There is a tendency, which needs to be watched by those in authority, for natives to remove the bark of standing trees to a height of about 10 ft. and to leave the tree to die with the loss of the rest of the bark. After drying, the custom in East Africa is to break up the bark into small pieces with wooden clubs after which it is packed in bags and is then ready for shipment. The bark of Rhizophora mucronata is most in demand with the natives, owing to the fact that it is 'non-fibrous' and easily broken up into small pieces with a club. The bark of Bruguiera gymnorrhiza, Ceriops candolleana and Xylocarpus moluccensis, although also rich in tannin,
is of a 'fibrous' nature and not adaptable to the club treatment. In the past, the tendency therefore has been to exploit Rhizophora most for bark. However, it is understood that American users do not mind the fibrous bark.

Figures for the tannin content of East African mangrove bark have been given by various different investigators, from which it would seem that the tannin content is liable to vary a good deal with any one species. The age of the tree and the season of collection may be largely responsible. The following have, however, been given as average figures: Rhizophora mucronata 37%; Bruguiera gymnorrhiza 43%; Ceriops candolleana 24%; Xylocarpus moluccensis 29.8%. The tannin content of the bark of Ceriops candolleana is considered to be too low for profitable export of the bark but the bark should be well suited for extract manufacture at or near the area of production.

Like mangroves in other parts of the world those of East Africa regenerate quickly provided a suitable number of seed-trees are left during felling. For many years the Government Forest Department has carried out silvicultural operations aimed at replacing the less valuable species like Avicennia officinalis and Sonneratia caseolaris with the more valuable species already mentioned, or in hastening the development of the latter. The ripe or germinating seeds of Rhizophora mucronata and Bruguiera gymnorrhiza are collected by the ton by natives from canoes at high tide and systematically planted by simply dropping them in the mud at a given spacing in suitable locations at low tide. Such planting gives better and more even stands than result from natural regeneration. It is said that with this technique a pioneer Avicennia officinalis stand may be transformed in about 10 years to almost pure Rhizophora mucronata underwood with Avicennia officinalis overwood, while after another 10 years the change to Rhizophora mucronata is complete. With mangrove planting in East Africa serious damage may be done by crabs which destroy the seedlings soon after planting. The same trouble has been reported in the Philippines. With natural regeneration this trouble, if it occurs, is not noticeable.

Mangroves occur along the east coast of Africa as far south as the Transkei in the Eastern Cape Province, becoming progressively smaller with increasing distance from the tropics. Along the Natal coast and in Durban Bay Rhizophora mucronata and Bruguiera gymnorrhiza are to be seen. Samples of bark of the former from Portuguese East Africa were found to contain 33.6% and 17.8%.
tannin, and of the latter, from the mouth of the Matafufil River in Pondoland, 27.9% tannin.

**Madagascar**—Mangroves have long been exploited for tannin in Madagascar, also for mangrove extract which has held a good reputation. The mangroves occurring on the Madagascan coasts are fundamentally the same as those in East Africa with the following two species, *Rhizophora mucronata*, 'hongkolahy', bark 35% tannin, and *Bruguiera gymnorrhiza*, 'tsitolana', 23.8%, often predominating. Other noteworthy species are *Ceriops boviniana*, 'honkovavy', 23.4%; *Carapa obovata*, 'foby', 23.8%; and *Heritiera littoralis*, 'moromona', 11.6%.

**Borneo**—The extensive mangrove swamps or forests of Borneo have been exploited for tannin for many years but unlike East Africa it is the extract or cutch which is exported rather than the dried bark. The large tracts of mangroves, mainly on the east coast, are accounted for by the low coast line, the many rivers and the absence of violent storms. A detailed account of them has been given by Foxworthy and Matthews. The most important tannin-yielding species (with common names and tannin content) are considered to be *Rhizophora candelaria* (= *R. conjugata*), 'bakau' or 'bankita', 25–30% tannin; *Rhizophora mucronata*, 'bakau' or 'taggai', 25–30%; *Ceriops tagal* (= *C. candollea*), 'tengah', 25–35%; and *Bruguiera gymnorrhiza*, 'lenggadi' or 'pututan', 25–30% tannin. Some of these species are of course important in East Africa and in other areas whose shores are washed by the Indian and Pacific Oceans.

The first mangrove extract or cutch factory was established in 1892 at Santubong in Sarawak but was closed after a few years. Five years later another company started a factory at Marudu Bay, and more factories followed in other areas. Borneo cutch, also known as 'brown cutch', has had a good reputation for many years. The early or primitive method of cutch manufacture was to make bundles of freshly gathered bark, 10–15 lb. in weight, tied together with thin rattan canes. These were boiled in open vats and the liquor was evaporated to the consistency of pitch, when it was run into moulds to cool and harden. The tying into bundles facilitated the removal of spent bark and the handling of it subsequently as fuel. The cutch produced in this way was crude and dark coloured, as might be expected, owing to the high temperatures and the open firing.

With present-day factories the extraction is carried out on modern lines in open wooden leaches heated by steam pipes and
evaporation is conducted in vacuum-pan. A better and a lighter-coloured extract is produced. Leaching of the bark should be carried out soon after collection, otherwise it deteriorates and the maximum amount of extract cannot be obtained. On an average, one ton of extract should be obtained from three tons of ‘tengah’ bark (*Ceriops candolleana*) or four tons of ‘bakau’ bark (*Rhizophora mucronata* or *R. candelaria*). In recent years the export of mangrove extract from Borneo has been between 4,000 and 5,000 tons annually. About 75% of this has gone to the United States of America. Investigations on the spent bark from factories have failed to reveal any special use for it. It is considered unsuitable for paper manufacture but it might constitute a source of furfural if this could be economically developed.  

There is an important difference in the management or exploitation of the mangrove forests of Borneo compared with those of Malaya and the Philippines. In the two latter countries, there are large human populations, the population density being high and there is a correspondingly great need and demand for fuel or firewood. Consequently, the main use of the mangrove forests is for firewood. In Borneo on the other hand the population density is relatively low. There is not the same demand or urgency for firewood with the result that more attention may be given to the collection and production of tan-bark from the mangroves. Mangrove forests which are being managed for the production of bark need to be run on a longer rotation than when required primarily for fuel.

*Malaya*—In Malaya the area covered by mangroves has been estimated to be about 430 square miles, nearly all on the west coast and normally under Government control in regard to concessions. An admirable account of them has been given by Watson. The Malayan mangroves have long been an important source of fuel in Malaya and are also used for charcoal, poles, and fishing stakes. The bark has not been regularly exported as a tan-bark but a certain amount finds use in local tanneries, mainly run by Chinese.

When required for use in local tanneries the bark is broken up by means of heavy hammers on small, stone anvils and thrown into brick or concrete vats with cold water and the vats then filled up with hides which are turned daily. Every few days, the old bark is taken out of the liquor and freshly pounded bark is put in its place. The bark is always used fresh, not dried, and there is a preference among tanners for thick bark or bark from old trees.
Well-developed Mangrove trees (Rhizophora candelaria) in Malaya. They are often esteemed more for their timber than their tan-bark.
MANGROVE BARK

Doubtless the tannin content is higher than that of thin bark. The bulk of the bark used in this way is said to be derived from *Rhizophora mucronata* (‘bakau kurap’, 27-9% tannin).

Cutch factories, such as exist in Borneo, have not been established in Malaya. Mangrove cutch may, however, be exported to Singapore from Borneo and elsewhere and re-exported as Malayan cutch. However, a small amount of tannin is said to be prepared on the spot for use by fishermen in preserving nets, cordage, sails and salt-water clothing, the life of which is reputed to be prolonged at least three times. For this purpose the bark of *Ceriops candolleana* (‘tengar’, 24% tannin) is specially favoured, so also is the bark of *Carapta obovata* (‘sujireh bunga’, 34% tannin).

The following are other important species in the Malayan mangrove forests besides those already mentioned: *Rhizophora candelaria*, ‘bakau minyak’, 16-4%; *Bruguiera gymnorrhiza*, ‘tumu’, 19%; *Bruguiera parviflora*, ‘lenggadai’, 6-1%; *Bruguiera caryophylloides*, ‘berus’, 15-8%. The figures for tannin content of the bark are average figures from those given by Beckley, who points out the wide variation in tannin content likely to occur in Malayan mangroves.

Philippines—In the Philippines extensive mangrove swamps or forests occur and the more important species of mangrove are the same as those in Malaya and Borneo. A comprehensive account of the mangroves of the Philippines has been given by Brown and Fischer. As in Malaya, mangrove bark is used in local tanning and there has not been extensive export of mangrove bark for tanning nor manufacture and export of extract or cutch. Some of the best and largest stands of mangrove are in Mindanao, Mindora and Palawan. In Sibuguey Bay, Mindanao, there is a well-developed swamp covering an area of 25,000 hectares, normally capable of yielding 20 metric tons of fresh bark per hectare averaging 28—30% tannin on the dry weight. However, throughout most of the Philippines the mangrove swamps are very scattered and this may have discouraged the establishment of cutch factories in the past. The main use of the mangroves of the Philippines hitherto has been as fuel for which they have been and are extensively employed. Artificial regeneration or the actual planting of mangroves has been practised by the inhabitants from early times—probably one of the few areas in the world where this applies.

The more important mangroves yielding tan-bark in the Philippines with their common names and the average tannin
MAIN MANGROVE AREAS

content (as referred to by Brown and Fischer) are as follows: *Rhizophora mucronata*, ‘bakaun-babay’, 27.6%; *Rhizophora candelaria*, ‘bakaun-lalaki’, 27.8%; *Bruguiera conjugata*, ‘busain’, 32.4%; *Bruguiera parviflora*, ‘langarai’ 9.1%; *Ceriops candolleana*, ‘tangal’, 31.3%; *Xylocarpus granatum*, ‘tabique’, 23.2%. With regard to yield of bark per tree figures given by Foxworthy and Matthews indicate that with *Rhizophora mucronata*, one of the best known and widely distributed of mangroves, the expected yield might be as follows: 3 inches in diameter 4 kilogrammes; 6 in.—19 kg; 9 in.—52 kg; 12 in.—98 kg; 15 in.—178 kg; 17 in.—266 kg.

Indian Sub-continent and Indo-China—Mangroves are to be found in the localities which favour their existence all along the coast line of the Indian Sub-continent, Burma and Indo-China. They occur from the delta of the Indus in Sind along the west coast to Trivancore and from the Sundarbans southwards along the east coast of the Sub-continent and down the coast of Chittagong, Arakan and Burma. They are also common on the Andamans and adjoining islands. The mangrove forests of Arakan are estimated to occupy 948 square miles. Other extensive tracts occur in the Sundarbans, the delta forest of the Irrawaddy and in Mergui, Tavoy and South East Madras.

Some of the better known tan-bark species already referred to in connection with the Malayan region occur throughout India such as *Rhizophora mucronata* and *Bruguiera gymnorrhiza*, while others such as *Ceriops candolleana*, *Bruguiera eriopetala* and *Xylocarpus gangeticus* or *Carapa moluccensis* are more restricted or localized in their distribution.

Various investigations of the mangrove tan-bark of the Indian Sub-continent and Burma have been made in the past, the most comprehensive being probably that of Fraymouth and Pilgrim. The results of work on Indian mangroves have been conveniently summarized in Indian Forest Department publications. The following are the more important species with the better known vernacular names and tannin contents of the bark as given in the above publications: *Rhizophora mucronata*, ‘bhará kandál’, 25%; *R. candelaria*, 25%; *Ceriops candolleana*, ‘chauri gorañ’, 29%; *C. roxburghiana*, ‘bara gorañ’, twig bark 19—25%, leaves 9—15%; *Kandelia rheedii*, ‘goria’, 17%; *Bruguiera gymnorrhiza*, ‘kanka’, 28—35%; *B. carophylloides*, ‘kakandán’, ‘madama’, 18—19%; *Lumnitzera racemosa*, ‘kripa’, ‘kadivi’, 15—19%; *Sonneratia caseolaris*, ‘ora’, ‘thirala’, 11%; *S. apetala*, ‘keowra’, bark 11%. 

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MANGROVE BARK


Australia—Mangroves are well represented on the Australian Continent but so far have not been exploited commercially to any extent, difficulties of extraction and high labour costs being doubtless among the reasons for this. Tannin contents comparing well with those for mangroves in other parts of the world have been recorded for some species. A good account of them has been given by COGHILL51. Genera represented in the mangrove swamps of Australia include species of Avicennia, Bruguiera, Carallia, Carapa, Ceriops, Excoecaria, Rhizophora, Sonneratia and Tristania.

The most common or familiar mangrove in the southern half of the Continent is the grey or white mangrove, Avicennia officinalis, common also in Africa and the eastern tropics and sub-tropics generally; but, as in these areas, it is of no promise as a source of tannin with its very thin bark and low tannin content. The black mangrove, Bruguiera gymnorhiza, is distributed all along the tropical coastline and often constitutes 25 % of the vegetation of the extensive mangrove swamps of these regions. Tannin content has been found to vary from 29—36 %51. The red mangrove (Rhizophora mucronata) is the commonest mangrove of Western Australia where it may form pure stands of considerable extent. It occurs also along the coast of Queensland especially in estuaries and may reach 2 ft. in diameter although it is more usually 8—12 in. On large trees the bark is thick and not difficult to remove, the average yield of fresh bark for large trees being given as 170 lb. Tannin content estimations of Australian bark of this species have varied from 29-1 % to 39-8 %51. The mangrove known as ' larchanama ', Ceriops candolleana, is also widely distributed along the tropical coastline. It usually has a slender trunk and does not exceed 18 ft. in height. Tannin content with Australian bark of this mangrove has varied from 24—34 %51. With regard to other Australian mangroves the bark of the orange mangrove, Carapa moluccensis, from Queensland was found to contain 21—23 % tannin, but others such as Carallia integerrima, Excoecaria agallocha (milky or poison mangrove), E. dallachyana, Sonneratia alba and species of Tristania were found to be low in tannin content, less than 20 %51.

Other Mangrove Areas in the ‘ Eastern ’ Region—Among the many other countries in the Indian and Pacific Oceans that are within the tropics and sub-tropics, mangroves are common. In some of these countries they are or have been exploited commercially to some extent for tan-bark. Mangrove bark has in the past been
collected in New Caledonia and exported to France. In Papua there are abundant supplies of mangrove bark, the main botanical sources being Bruguiera rhedii, Rhizophora mucronata and Carapa moluccensis. During the First World War bark was shipped to Australia. In Sumatra and elsewhere in Indonesia, mangrove bark has been exploited, mainly for local use, for many years. The bark also finds its way to Singapore, from whence it may go to Hong Kong and elsewhere. Cutch is also prepared.

A report on mangrove bark and cutch from Fiji has been given. It is interesting here to observe that Rhizophora mangle has been recorded from Fiji. Mangrove bark from the Seychelles (Aldabra Island) was found to be quite rich in tannin, including the little-known mangrove Pemphis acidula with 43% tannin.

‘Western’ Region

Tropical America—Mangroves are common throughout the American tropics and the West Indies, also on the Florida coast where conditions favour their growth. The most extensive stands are to be found at the mouths of the great rivers such as the Amazon and the Orinoco. In addition to the Amazon delta, mangroves are common in the tidal marshes and swamps along the coastline of northern and north-eastern Brazil, especially along the coast of Maranhao. Along the coasts of the Guianas, Venezuela, Colombia and Ecuador, mangroves occur freely. These often cover considerable areas or consist of large well-developed mangrove trees, where they have not been cut out or, in some instances, over-exploited for timber. The stands in Venezuela were seriously depleted many years ago. For instance the mangrove forests about Lake Maracaibo were denuded of large trees and produced only small-sized poles for fencing, constructional work or firewood. Those at Porto Cabello are said to have been practically destroyed and reverted to areas of low scrubby growth.

In earlier years, little attention was given to the production of tan-bark or tannin extract from the mangroves of south and central American countries, such exploitation as there was being for timber or for fuel. In more recent years, however, the general world shortage of tanning materials has caused more attention to be paid to them as sources of tannin, particularly in Venezuela and Colombia, in which countries the production of mangrove bark or of extract has made great strides.

Most of the commercial tan-bark from the mangroves of the New World is derived from Rhizophora mangle, the red mangrove, which
MANGROVE BARK

is very closely allied botanically to *Rhizophora mucronata* the important species so widespread in the 'eastern' region. Other noteworthy species, often found with *Rhizophora mangle*, are: *Avicennia marina* (syn. *A. nitida*) black or olive mangrove or 'manglé negro'; *Laguncularia racemosa* white buttonwood, or 'manglé blanco'; *Conocarpus erectus*, buttonwood, or 'manglé boton'.

*Rhizophora mangle*, known in Spanish American countries as 'manglé colorado' or in Brazil as 'mangue vermelho' has the same growth and general characteristics as *Rhizophora mucronata*. As the tree develops the original or basal part of the stem decays leaving the main stem supported some 10 ft. or more from the ground by a great mass of stilt-like aerial roots. These may occupy an area 30 ft. in diameter. In the more favourable areas, as in the Orinoco delta on deep mud soils and rich muddy banks, the tree attains very large dimensions and may reach 100 ft. in height with a diameter up to 3 ft. although the more usual diameter is less than 2 ft. Such trees may have a clean length of bole of 30—40 ft.

The vast mangrove swamps of the Amazon and the Brazilian coastline have been little worked so far. An American writer (E. F. Horn) states: 'These vast mangrove swamps offer interesting possibilities for development on a large scale as the timber frequently occurs in almost pure stands with a high volume per acre. The logging of these mangrove swamps presents problems similar to the logging of cypress and swamp hardwoods in southern United States. An overhead method of logging is indicated owing to the great mass of tangled roots on the ground. Donkey engines for skidding-out the logs could be mounted on scows of shallow draught which could be floated to the edge of the mangrove swamps at high tide. The logs could be peeled mechanically at the mill and the bark sold to tanneries, or tannin extract could be manufactured. The wood of Red Mangrove is very hard, heavy, strong, tough and durable. It has an air-dry specific gravity of 1·00 to 1·10 and weighs 62 to 69 pounds per cubic foot. It is recommended for all purposes requiring strength, toughness, resilience, and resistance to wear, insects and decay. It is especially recommended for cross-ties. Tests made by the Pulp and Paper Section of the Forest Products Laboratory at Madison, Wisconsin, revealed that Red Mangrove is a promising pulp material by the soda process, owing to the exceptionally high yield of cellulose on the volume basis as a result of the high density of the wood. The exportation of the products resulting from the
utilization of these mangrove forests to the world’s markets presents no difficult transportation problems owing to their location on tidewater.

The bark of *Rhizophora mangle* seems to vary a good deal in tannin content which is usually from 20—30%, the larger and older trees yielding the richer bark. Both *Laguncularia racemosa* and *Conocarpus erectus* are commonly associated with *Rhizophora mangle* but their barks possess a lower percentage of tannin, usually about 16%. Both vary in size from low shrubs to trees 60 ft. in height and 1—1½ ft. in diameter. The tendency is for mangroves to become more shrubby towards the northern and southern limits of their range.

The leaves of many mangroves are rich in tannin. Those of *Laguncularia racemosa*, containing about 10—20% tannin (dry weight), have been used in South America in tanning, being referred to as ‘mangue’ or ‘mungua’. The tanneries of Santos, São Paulo, and its environs utilize over a million kilos of mangrove leaves a year apart from bark, those of Santa Catarina some 400,000 kilos of leaves. In tanning the tannin penetrates slowly because of the high content of sugary matter and acid, yielding a full, soft, bright yellow leather with a greenish tinge and of medium weight.

Mangrove barks of the species already mentioned from various parts of the West Indies and from British Guiana and Honduras have been investigated in the past. They are, however, fundamentally the same as the mangroves already referred to. The mangroves of Florida have also been investigated but, so far, economic considerations in the United States have been against their exploitation commercially for tannin.

**West Tropical Africa**—Mangroves are common along the West African coast and in the Congo region. A detailed account of the mangroves of the Congo has been given by Pynaert. The more important species are the same as those that occur in the American tropics and are considered more or less of similar value as sources of tannin. Along the West African coast the rivers flowing to the sea are often impeded at their mouths by sand bars and may be obliged to follow courses parallel with the sea coast for some distance before finally breaking through to the sea. This leads to the formation of lagoons often running for several miles or extending considerably inland. Such lagoons, in addition to the estuaries, afford favourable conditions for the development of mangrove formations which are common along the coastline.
are generally of a low growing or shrubby nature, not attaining as large dimensions as they do in some parts of the tropics.

The most conspicuous species of mangrove throughout West Africa is the red mangrove, *Rhizophora racemosa*, also common in the American tropics. It frequently grows in great profusion and in pure stands in the swamps adjoining and along the banks of lagoons. The numerous aerial roots descending from all angles to the mud below often form a completely impenetrable mass. The natives of West Africa use the tree in many ways. The poles are frequently used for native dwellings and in making native bridges. The wood is used for fuel for which it is excellent, burning with intense heat. It even burns readily in the fresh state. In West Africa it is favoured for charcoal for use in fish ovens.

It has recently been shown by Keay that what has generally been referred to as *Rhizophora racemosa* in West Africa in the past really consists of three closely-related species, viz *R. racemosa*, *R. mangle*, and *R. harrisonii*. All occur from Senegal to Angola, *R. racemosa* being the most common. They are easily distinguished by such characters as the number of flowers in the inflorescence, the length of the flower stalk and nature of the leaf bud (acute or obtuse). All three also occur on American shores where *R. mangle* is the most common and best known. They have all been included under *R. mangle* by some writers.

Investigations have shown that the average tannin content of the bark of *Rhizophora racemosa* from West Africa is considerably below 30%, which is generally considered to be the minimum tannin content a tan-bark should have in order to be profitably exported. However, such bark might be advantageously used in the local manufacture of extract or cutch. The other West African mangroves that have been investigated have an even lower average tannin content.

*Avicennia marina* (syn. *A. nitida*), the white mangrove, is also a common mangrove in West Africa as it is in the American tropics. It may reach a height of 40 ft. but is usually about half this height in West Africa and may exist as quite a small shrub. Where the larger trees exist, the wood may be used for boat and house building by natives and also for fuel and charcoal. Bark from southern Nigeria was found to contain 12.5% tannin. *Laguncularia racemosa* (bark 12–24% tannin), usually a small to medium sized tree, and *Conocarpus erectus* (bark about 18% tannin), generally a spreading shrub, are other West African mangroves that are also to be found in the New World tropics.
OAK BARK

Oak bark has long been an important tanning material, especially in European countries, doubtless because of its being so readily available. In the British Isles the bark of the two common oaks i.e. the pedunculate oak (Quercus robur syn. Q. pedunculata) and the sessile or Durmast oak (Quercus petraea syn. Q. sessiliflora) has been the traditional material of the leather tanner from very early times. The dressing of skins and the preparation of leather was carried on in most English towns and villages in mediaeval times. Two quite different processes were practised, cattle skins being immersed in a decoction of oak bark, and skins such as those of deer and sheep being tawed with alum and oil, the two trades being regarded as distinct. In the year 1184 a law was passed to prevent a tanner or tawer from carrying on his trade within the bounds of a forest except in a borough or market town, the object being to prevent the poaching of deer for the sake of the skins.

The famous English leathers of the past, known throughout the world for their high quality, were produced on a basis of good quality hides and skins with oak tannage. The merits of oak bark as a tanning material are perhaps best exemplified with heavy leathers, particularly sole leather. It is commonly regarded as the most suitable tanning material for the best grades of heavy leather. A serious drawback, however, particularly in this age of haste and speed, is its slow penetration of the hide and the resulting slow tanning process. This slowness has an important bearing on costs to the tanner. As other cheap and more rapid tanning materials came to the fore in the latter half of last century, oak bark was largely replaced by them in many English and European tanneries. However, the shortage of imported tanning materials in Britain and certain European countries during the two world wars revived interest in oak bark and led to more extensive use of the locally available supplies.

The pedunculate oak (Q. robur) and the sessile oak (Q. petraea) are the two common oaks throughout the whole of northern Europe. They are very similar and for commercial purposes the timber and the bark are not differentiated. The main botanical difference between them is that the pedunculate oak has stalkless or almost stalkless leaves and the acorns on a long stalk (or
OAK BARK

peduncle), while the sessile oak has sessile or stalkless acorns and distinctly stalked or petioled leaves. Intermediate or hybrid forms are common. The pedunculate oak is usually found on heavy land and at low elevations while the sessile oak is more common on hilly or mountainous areas and in drier soil.

Stripping

It is only for a short period during the year—when the sap has commenced to rise and buds to form in the spring—that oak bark may be stripped from the trees, for at other seasons it adheres tightly to the wood and cannot be peeled off. The best time for stripping is when the buds are expanding into leaf and the stripping season seldom extends beyond four or five weeks. In most parts of southern England bark stripping commences about the third week in April, but much depends upon the season, whether early or late, and upon the district. In Scotland the work starts about a month later. The weather during the short stripping season is vital and is anxiously watched by those engaged in the work.

The bark ' runs' best or is easiest to remove during open mild weather. Cold winds and rain, or frost have an adverse effect as does a dry soil. The bark peels best in the early morning and late afternoon—less well at midday. The larger stems are peeled more easily at the beginning of the season, the smaller stems at the middle or end of the barking season. Those engaged in the work test individual trees with their barking irons or 'spuds' to see whether the bark comes away easily before commencing felling or stripping. In England it has been stated that the sessile oak peels more readily than the pedunculate oak although the pedunculate oak may be peeled about ten days earlier than the sessile oak. It has been proved that oak bark is richer in tannin in the spring than it is in the summer which is an additional, if less obvious advantage of stripping in the spring.

In England the usual method of stripping is for the bark to be removed in large pieces from the trunks of the selected trees to a height varying from 3—6 ft. This operation is often referred to as 'breeching'. The trees are then immediately felled and the bark removed from the rest of the trunk and from the limbs and main branches. At one time all branches down to 1 in. in diameter were peeled but the smaller branches are now frequently neglected. It is important that the peeling is done soon after or on the same day as felling for if left, even for a short time, the bark clings and peeling is difficult.
STRIPPING

Apart from the axes and saws used in felling and cutting some special tools are used, the most important of which is the 'spud' or barking tool, of which there are several types. The one commonly used in England is generally about 2 ft. long. It has a handle like an ordinary garden fork and a steel point somewhat resembling the ace of spades in playing cards. A scraper is used for removing the outer dead bark or lichen growth ('ross') and a light wooden mallet for beating the bark when it does not peel easily. With old trees the rough outer bark or dead bark is of little or no use for tanning and is best removed. Hammering or the use of the mallet has the effect of loosening the bark and rendering it easier to remove but should only be applied as a last resort for the practice is harmful to the bark. The severe bruising causes discoloration or even decay and encourages mould. There is liable to be a serious loss of tannin should rain fall on such bark. In bygone days the favourite tool for removing the bark was of bone and it consisted of the leg-bone or tibia of a horse fixed in a wooden handle and filed to a chisel point at one end. This was in use in parts of Britain up to the end of last century.

The bark is removed by flayers (often pronounced 'flayers'), in large pieces where possible, which are generally some 2½ ft. in length. Branches are often severed from the main limbs and supported in convenient positions in a trestle or like structure to facilitate peeling.

In order to be independent of the natural movement of the sap in the oak and the restricted season for oak barking, a system of steaming the bark in order to loosen it was adopted or tried in France last century. With this method bark could be removed at any time of the year or dealt with in winter. Billets of wood with bark attached were steamed in a retort at a centre or factory. Later a portable unit for use in the woods was evolved. Obviously such methods are likely to prove expensive and this doubtless accounts for their not being developed further. The leather produced from steamed bark was said to be soft and fine and excellent for saddlery but was not so good for sole leather.

A practice sometimes carried out, especially on the continent of Europe, is first to ring the base of the tree and then to detach the bark in vertical strips and to leave the strips hanging on the trunk, still attached at the top, until they have dried, when they are removed. Not all trees lend themselves well to this method and there is probably a greater risk of tannin loss through rain. The trees are left standing and felled in the autumn, which is conducive

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OAK BARK

to good timber. This method has the advantage that the wood of such trees is likely to be superior to that of spring-felled trees. Spring felling is not viewed with favour by the forester or timber merchant.

Where coppice oak is being exploited for bark the methods and the tools used differ somewhat from those employed with more mature trees. The bark of the comparatively young coppice shoots (usually 20—25 years old) is much thinner than that of mature or exposed trunks, consequently the tools or peeling irons may be lighter in construction. Coppice bark constitutes the highest quality in oak bark and is the richest in tannin. It is often difficult to peel and peeling cannot be carried out without a certain amount of hammering. It is said to be no longer produced in the British Isles.

**Drying**

After removal from the tree the pieces of bark are dried by exposure to sun and air. This may be done by simply placing them on brushwood. A better method is the employment of a simple rack consisting of a stout rod supported about 2 ft. from the ground by forked sticks driven into the ground at either end. The pieces of bark are placed against the rod, a row on either side, the whole having a tent-shaped appearance. The outer part of the bark is uppermost and protects the inner part from rain. It may be turned from time to time. In favourable weather the bark becomes dry, or dry enough for stacking, after about a fortnight. When dry enough, the bark will have curled and will crackle crisply on being broken. Well-seasoned bark has a creamy colour on the fleshy side. Bark too long exposed to sun and rain becomes dull brown on the inner side and is lacking in tannin. Rain is likely to be more disastrous to freshly peeled bark than to bark nearly dried.

**Stacking**

After drying, the bark may be tied into bundles and despatched without delay to the tannery. Alternatively it may be placed in sheds, if available, or ricked. Ricks may be any length but should not be more than 9 ft. in width. They are built with the highest point in the centre and with the largest pieces of bark on the top. This assists in throwing off the rain. Ricks are generally covered with a tarpaulin as a safeguard against rain.

Oak bark may be sold as stripped from the tree (termed 'long rind') or it may be sold 'batched', i.e. chopped into pieces about 4 in. long.
Yield

The yield of bark naturally varies a good deal with the age and condition of the trees. Trees growing close together, as in coppice, tend to have a thinner bark than those growing as isolated specimens or well spaced in a wood. Trees of the latter class are said to yield roughly 5% of their total weight in bark, while the bark loses about a third of its weight in drying. It has been stated that with 40 year old trees 9—12 lb. of bark may be expected for every cubic foot of timber, and with older trees, in which the bark becomes relatively thicker, the yield may be 10—16 lb. of bark for every cubic foot of timber. Another writer considers that a well-balanced tree with a good head will yield about 6 cwt. of bark for every ton of measurable timber. Trees in close woodland may yield a ton of bark for every 4½ tons of wood.

Quality of Bark

The best qualities of English oak bark are said to be largely derived from Sussex and Hampshire and may contain 12—14% tannin.
A representative of a tannery in Surrey that uses oak bark extensively expressed the opinion to the author that his tannery did not like Welsh bark because of its 'mossy' (presumably lichen-covered) nature. In general, the tannin content of English oak bark varies from 8 to 13%. A good sample does not contain less than 10%. The bark of fairly young trees or coppice oak is superior to that of very old trees. The soluble non-tans in oak bark may vary from 2—9% and average about 5%.

Oak bark is usually employed in tanneries as it is, and is less frequently made into extract. It is now usually mixed with other tanning materials that penetrate more quickly. In Northern European countries it has often been mixed with pine bark and in North America with hemlock bark. A certain amount of Swedish oak bark extract has been imported into Britain in recent years.

Oak bark tannin is a mixture of pyrogallol and catechol tannins in the proportion of one to two, but the real nature of oak tannin still remains rather obscure and there are those who consider that the tannin in the plant may not be the same as that obtained in extraction—that a change takes place in the tannin during the process of extraction. The tannin has a medium pH value with moderate salts and acids content. This is considered to be the reason why oak bark is effective as a single tanning agent where tanning is carried out without technical control. Some consider that with oak bark the soluble non-tans play an important part in the tanning of leather. Tannin is also present in the acorns or fruits and in the leaves and wood (see Oak Wood, Chapter 18). A tannin extract is said to have been prepared from acorns in Croatia. Accounts of the chemistry of oak bark tannin have been given by Rottsieper, Nierenstein, Balfe, and others.

Spent Oak Bark
The spent oak bark from tanneries, unlike many other spent tan-barks, is by no means a waste or worthless product, at any rate as far as the United Kingdom is concerned. It is the favourite material for the covering of roads that cross horse racing tracks and is much used for this purpose. If the oak bark has been mixed with myrabolans or valonea in tanning it may not be used in this way owing to the hard lumps present. In earlier days, spent oak bark from tanneries was sometimes spread on the road outside dwellings where there was illness to lessen the noise from horse-drawn traffic. It is also used in circus rings.
Plate VI

Oak Bark being fed into a grinding mill

Ground Oak Bark being placed in the tannery pits or leaches of an old English tannery
From the Common Ground filmstrip "Tanner"

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Another use for spent oak bark from the tannery is in the manufacture of white lead or lead oxide (for paints) by the 'stack process'. In this process the spent oak bark, termed 'tan', is placed in layers between the porous pots of acetic acid covered by the metallic lead (in 'latticed' form) used in the slow oxidation process that takes place. The spent bark provides by fermentation the heat and carbon dioxide necessary for the process. Other more rapid processes have now largely replaced the 'stack' process.

Spent oak bark was also much used for hot-beds in gardening at one time, being considered more lasting in its effects than horse manure. It was much in favour as a hot-bed for pineapples in England in the eighteenth century.

Other Oak Barks
Besides the two common European oaks already referred to, there are other oaks in Europe whose barks are used for tanning to a greater or lesser degree. In Central Europe the Turkey or evergreen oak (*Quercus cerris*) and the woolly oak (*Q. pubescens*), with grey or downy leaves, are both used. The latter is not cultivated and in the wild state is usually found growing intermixed with other trees. In southern Europe and Mediterranean countries the bark of the evergreen oak (*Q. cerris*) and the Kermes oak (*Q. coccifera*) are used for tanning, also the cork oak (*Q. suber*) to some extent. An interesting point with *Quercus coccifera* is that the root bark is used for tanning as well as that of the stem. It is rich in tannin (15–25%) and in North Africa (*Q. coccifera*) is esteemed for tanning and is known as 'garouille'. In the south of France and in Spain the bark of the evergreen oak is commonly utilized as a tanning material, being known in Spain as 'enzina'.

Oaks are very well represented in North America where there are many species and the bark of several has long been used in tanning. It is not so much the actual tannin content of the bark that has determined its use in tanning but rather the proximity of tanneries. The bark of the white oak (*Q. alba*) has been used a good deal, not because it is particularly rich in tannin but because of its very wide distribution and prevalence in many areas. Among American oaks this species probably resembles the common European oaks the most closely. The so-called 'chestnut oaks' are among those most esteemed for tanning in the United States, the best known species being *Q. prinus*, a deciduous tree of the eastern United States reaching 60–70 ft. in height. The tannin content of the bark may be in the neighbourhood of 16% and the tannin is light.
OTHER OAK BARKS

coloured. On the western side of the North American continent a species held in high esteem for tanning is the Californian Tanbark oak (*Quercus densiflora* or *Lithocarpus densiflorus*). The black oak (*Q. kelloggii*) is also esteemed.

Among the other American oaks that have attracted attention from time to time for tanning are *Quercus bicolor* (swamp white oak); *Q. cocinea* (scarlet oak); *Q. falcata* (Spanish oak); *Q. laevis* (scrub oak) bark 12.7 % tannin; *Q. maxima* Ash. (red oak) bark 10.9 %; *Q. montana* (chestnut oak) bark 10.8 %; *Q. muhlenbergii* (yellow chestnut oak); *Q. palustris* (pine oak); *Q. phellos* (willow oak) bark 10.1 %; *Q. rubra* (red oak) bark 8.7 %; *Q. velutina* (black oak), bark 8.4 %; and *Q. virginiana* (live oak) bark 15 %.

In Florida a special process was developed experimentally for dealing with scrub oaks, such as *Q. marilandica*, *Q. laevis* and other species, which are normally too small or crooked to be peeled by the usual methods. The entire tree or shrub is chipped or comminuted in situ by a small portable clipper. The bark and the wood chips are then separated mechanically and the bark dried by heat and sent to the tanning extract plant for leaching.

The genus *Quercus* consists of over three hundred species, many of which are Asiatic. The barks of several species, notably those that occur on the Indian Sub-continent, have been shown to be rich in tannin. These do not appear to have been used appreciably in local tanning, probably because of the ready availability of other tanning materials in the areas concerned. A list of these Indian oaks, with the tannin content of the bark, has been given by Edwards, Badhwar and Dew. For information on the use of oak wood in tanning see Chapter 18.
SPRUCE BARK

The bark of the common European spruce (Picea abies: syn. P. excelsa) has long been used in many parts of Europe as a tanning material, especially in north, east and central Europe. In Rumania, where the bark is known as 'molift', it is second only to oak bark in importance as a tanning material. Spruce bark is not particularly rich in water-soluble tanning material but, as the tree is very prevalent in many areas, the bark is easily obtained. During the two World Wars, with the cessation of imported tanning materials to many European countries, much larger quantities of spruce bark were employed in tanning. For instance, in Switzerland, during the Second World War, the exploitation of spruce bark increased six-fold.

The fact that spruce bark and spruce extract have been referred to in the British Isles as 'pine bark' and 'pine extract' in the past is confusing and to be regretted. There also appears to have been some confusion in the use of the German words 'Fichte' and 'Kiefer' although it seems to be generally agreed that the former should refer to spruce (Picea) and the latter to pine (Pinus).

Both spruce bark and the extract prepared from it are now widely used commercially for tanning on the continent of Europe. A better understanding of the nature of the tanning materials in the bark is probably largely responsible for this. A considerable proportion of the tanning material present in the ordinary dried bark is there in insoluble form and is not extracted by diffusion with water or indicated by the Official Method of Tannin Analysis. It has been shown that in the fresh or living bark on the tree much of this tannin is present in soluble form and that after cutting and during the process of drying it is converted to the insoluble form by the action of enzymes or ferments. If the enzymes are destroyed by heat (steaming) or by chemical agency immediately after cutting or stripping, this conversion to the insoluble form is arrested and much higher percentages of tannin may be obtained by the usual methods of treatment. It is claimed that it has been found experimentally that the yield of soluble tannin may even be doubled in this way. For the steaming of fresh bark in the forests, the use of potato steamers has been suggested.
**Distribution**

The common spruce may reach 150—200 ft. in height with a girth of up to 20 ft. but is usually much smaller, especially in mountainous districts where it is often very common. On young stems the bark is brownish in colour, thin and smooth, but on older trees it becomes thick and an outer layer of dead bark or ross may be developed. In its natural distribution the tree extends from the Pyrenees, the Alps and the Balkans northward through south and east Germany to Scandinavia and eastwards into Russia. It does not occur naturally in western Europe or the British Isles, but is often cultivated—for timber and for ornament. There are many ornamental forms or varieties in cultivation, including dwarf forms favoured for rock gardens. The common spruce is important as a timber tree and the ‘white deal’ at one time freely imported to Britain from Baltic ports is the product of this tree. In Germany, there are large pure forests of the common spruce, especially in the Harz mountains. It also covers wide areas in company with other trees such as pine, birch, alder and willow. Apart from its timber value, the tree is the source of Burgundy pitch and young trees constitute the common Christmas tree of European countries.

**Bark Collection**

The best average age of spruce for the collection of tann-bark is considered to be 40—60 years. With younger trees, the bark is liable to be too thin, while with older trees the proportion of outer dead bark or ross becomes very high. This part of the bark has a relatively low, soluble tannin content, the tannin present being largely of an insoluble nature. However, as spruce is grown or exploited mainly for timber there are other considerations that may determine felling age.

Before the removal of the bark, the trees are always felled. This may be any time in the early part of the season (May to August) after the sap is flowing. At this time the bark peels readily. The bark is cut round the bole at distances of about a metre and then cut longitudinally and removed with a barking iron. Hammering is not often resorted to, for it spoils the bark just as it does with oak bark. The bark is dried in the open, through the agency of sun and wind, with the flesh side downwards in the same manner as oak bark. With trees felled later in the year than August, it is often impossible to dry the bark properly. Trees felled in the late winter (February) may be barked in the spring but the bark is liable to deteriorate as tann-bark and have a
lower tannin content, owing to changes in the tannin taking place. The quicker the bark can be dried, the better is its quality likely to be and the less soluble tannin becomes converted to the insoluble form (phlobaphenes). Artificial drying is possible and doubtless desirable in damp districts but the cost of labour and fuel has to be considered. A combination of natural and artificial drying is also possible.

Tannin Content of Bark
The tannin content of spruce bark is extremely variable and may range from 5% to 18%, although 10—12% appears to be about the average for most areas, with 7—9% soluble non-tanns. Detailed figures have been given by various Continental workers. The age of the tree and the accumulation of moss or dead bark may have an important bearing on tannin content as has already been pointed out. Altitude and soil conditions may also affect the tannin content. In the eastern Alps it is considered that the best bark comes from warm chalk or dolerite areas at altitudes of 600—900 m. The variable nature of spruce bark may account, in part at least, for the fact that it is prized in some areas for tanning but quite neglected in others.

The employment of sulphite extraction results in a greatly increased yield of tannin as compared with water extraction, for the insoluble tannin, especially that in the dead bark, is extracted with sulphite. The increase in the tannin obtained by sulphiting is commonly as much as 100%. The sulphited extract in liquid, or more recently in solid form, is now extensively used. The liquid extract may have a tannin content of 22—30% and the solid extract one of 53—59%. It has a rather high acids content and tends to produce a relatively large quantity of sludge in the tan-liquor. Although widely used, spruce tannin was, for many years, not considered the best of tanning materials for high quality leathers. It is well suited for tanning in combination with other tanning materials such as mimosa or quebracho extract or other ‘low acid’ tanning materials. Tests have shown that the tannin yield with spruce bark is slightly reduced by replacing part of the sulphite or bi-sulphite by certain active agents and that the liquors so obtained have less sludge, give a mellower tannage with increased rate of tanning, and yield a leather with better colour and elasticity.

Tannin occurs in other parts of the spruce tree to some extent besides the bark. The possibility of utilizing the cones and needles
as a tanning material has been considered. The cones contain about 7% or more of tannin and the needles about 5%, but the high proportion of soluble non-tans, and the objectionable gummy deposit produced, renders their use in tanning impracticable.

*Other Species of Spruce*

There are some forty different species of spruce or *Picea* distributed throughout the northern hemisphere, about half of which are native to central and western China. Tannin is known to be present in the bark in appreciable quantity in about half a dozen species, the other species, some of which are little known or comparatively rare, having not yet been investigated.

The Sitka Spruce (*Picea sitchensis*) of western North America, yielding the most valuable of all spruce woods, has attracted some attention as a possible source of tan-bark, the bark being richer in tannin than that of the common European spruce. The tannin content of the bark is said to vary from 11—37% and the soluble non-tan content from 8—25%. Other species of *Picea* with the recorded tannin content of the bark are as follows: *P. glauca*, White Spruce, N. America, 21.6%; *P. glehnii*, Yezo, 19%; *P. jezoensis*, Japan, 11.3%; *P. mariana*, Black Spruce, N. America, 12.1%; *P. pungens*, Colorado Spruce, N. America, 8.7%. 

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HEMLOCK BARK

HEMLOCK BARK was for a long period the most important tanning material in the United States and Canada, and has been known from early colonial days. Along with oak bark, it was the tanning material mainly used when the tanning of leather on a commercial scale was first started in those countries. It was responsible for the characteristic colour of the American 'red' leather of last century. As other tanning materials became available they were mixed with hemlock bark in the tanneries and the reddish colour imparted by hemlock became less conspicuous or less intense. The bark and later the extract were also exported in some quantity from North America to European countries, mainly Great Britain, at one time. Its use in North America preceded that of chestnut.

Hemlock bark may be derived from either the Eastern or Canadian Hemlock (*Tsuga canadensis*) or the Western Hemlock (*Tsuga heterophylla* syn. *T. albertiana*), both large forest trees of North America. Along with other species in the genus they are sometimes referred to as 'hemlock spruce' or 'hemlock fir'. It is the bark of *T. canadensis* that is best known as a tanning material and that has been most extensively used in tanning. In fact it is only in comparatively recent years that the bark of the Western Hemlock has attracted serious attention as a tanning material.

The Eastern Hemlock

The Eastern Hemlock (*Tsuga canadensis*) is widely distributed in the eastern highlands of North America and occurs from Nova Scotia westward through southern Canada and the Lake States to Minnesota and southward to northern Georgia and Alabama. It usually occurs mixed with other conifers or hardwoods but sometimes in more or less pure stands. At one time the only commercial use of the tree was as a source of tan-bark, trees being felled and left to rot on the ground after the bark had been stripped off. Compared with most conifers the timber is inferior, being brittle, splintery and often cross-grained. It has an objectionable odour when fresh. However, at a later stage, when the white pine forests were being depleted, more attention was paid to it for paper pulp and for rough construction work, boxes *etc.*
The Eastern Hemlock commonly reaches a height of 70—100 ft. with a girth of 6—10 ft. The bark is thick, channelled, and reddish brown in colour. The tannin content is considered to vary somewhat with locality, the bark from Michigan and Pennsylvania being regarded as among the best.

Owing to its handsome appearance the Eastern Hemlock is sometimes planted as an ornamental tree. It was introduced to Europe early in the eighteenth century and there are now many horticultural forms or varieties. The pendulous forms, in which the hemispherical mass of pendulous branches completely hides the interior, are perhaps the most interesting. In Britain it thrives best in the moister parts of the country. It is prone to branch into several stems near the ground when grown as an isolated specimen.

**Collection of Bark**

As with the oak the best time for the removal of the bark from the trunk is in the spring when leaf growth has started and there is free movement of sap in the trunk. In the more northerly parts of the Eastern Hemlock zone, the barking season is from early May to early July whereas farther south the season may be from April to June in various districts. Another similarity with oak bark stripping is that the bark is more easily removed in warm damp weather during the peeling or barking period than in cold weather. It is also more easily removed in the early morning or late afternoon than at midday. The bark has an average tannin content of 10—11%.

The thickness of the bark varies a good deal with the age of the tree. It may be 2—3 in. thick at the base of the tree, while it gradually becomes thinner towards the top of the tree; it averages about 1½ in. The common method of bark stripping is for the men to work in crews, usually consisting of four men—one 'fitter', one 'spudder' and two 'log buckers'. The 'fitter', who is usually in charge, first cuts two rings about 4 ft. apart at the base of the tree. The bark from between these rings is removed by the spudder with the aid of his metal spud. The tree is then felled and further rings cut in the bark at 4 ft. intervals from the entire length of the workable trunk. The bark is then removed and the trunk sawn up into log lengths for timber. A crew may fell trees and peel the bark sufficient for 3—4 cords (approximately 4 tons) in a day or produce 240—270 cords in a season, which is limited to about two months.35
HEMLOCK BARK

As the strips of bark are removed from the fallen tree they are leaned against the trunk to dry. This generally takes from 1 to 4 weeks according to weather conditions. The bark is usually dried with the inner or fleshy side of the bark uppermost. To those accustomed to oak and wattle bark, this may seem strange, for with oak bark care is always taken to have the underside downwards and the ross or outer part of the bark upwards, most of the tannin being in the fleshy bark and not the ross. With hemlock bark the reverse holds for the ross has a higher tannin content than the fleshy part of the bark. Having become dry, or 'merchantably dry', the bark is removed during the summer or autumn months by sleds, wagons, or mechanical means, to the nearest railroad or depot. Where roads or tracks are bad, it may even be left until the first fall of snow and removed on sleighs. In mountainous districts, log chutes may be used for handling the bark. The bark deteriorates in tanning quality if left exposed to the weather too long.

The dried bark is usually dealt with or estimated according to cords, a full cord (128 cu. ft.) measuring 8 ft. long, 4 ft. high and 4 ft. wide. A common conversion factor of one cord being equal to one long ton is in use. In some regions it is assumed that one acre of average hemlock timber will yield about seven cords of bark, but much depends upon the nature of the forest, the age of the trees etc. With the shortage in supply and the greatly enhanced price of vegetable tanning materials of all kinds, more careful methods are now used in bark stripping and bark is removed from trunks or branches of much smaller diameter than was formerly customary.

Utilization of the Bark
Hemlock bark is always considered to be in a better state for use, either in the tannery, or for extract manufacture, after it has become 'seasoned' or after it has been stored for at least several months. The tannin is more readily extracted or leached out from such bark than it is from bark more or less straight from the tree. It is also less likely to cause mottling or uneven coloration in the leather.

Before leaching, the bark goes through the bark mill where a shaver or revolving disc reduces the bark to small fragments. Fans and separators remove the dust while air blasts may carry the rest of the milled bark to the leach house. The shredding or pulverizing type of machine is not favoured with hemlock bark, as
too fine a product is inclined to interfere with proper circulation of the leaching liquor.

Leaching of the milled bark may be carried out either by the open vat method at atmospheric pressure or by the closed or autoclave method at high pressures and temperatures. Most of the American hemlock extract is made by open vat extraction. The vats are fundamentally the same as those used in the tannery leach house, being broader than deep and usually made of pine, cedar or cypress. The leaches are generally arranged in series of six or eight. Hot water entering at the end leach proceeds from one leach to the other, gaining in tannin strength as it goes. In the final leach, which contains the freshly ground bark, the warm or hot liquor is sprayed evenly over the ground bark by means of a revolving sprinkler. In this last process the liquor then reaches its maximum tannin concentration and is removed to the storage tanks to await concentration. The slow sprinkling of the liquor on the freshly ground bark in the last leach is designed to prevent channelling or floating which would be prone to take place if the liquor were simply poured in. Steam pipes are used to maintain the liquor at a suitable temperature. The spent bark may be used as fuel in the boiler house.

Multiple-effect copper evaporators are used to concentrate the liquor to the desired strength (usually 25—27% tannin content), which may be shipped either in railway tank trucks or lorries, for local use, or in barrels for long-distance shipment. The powdered or solid form of hemlock extract, which commonly contains 54—58% of a catechol tannin, is made from the finished extract by special vacuum dryers.

Tanning Properties
Hemlock bark or extract (also called 'Miller's tannin'), is considered to be one of the best materials for sole and heavy leathers generally, such as belting, harness, case, bag and strap leathers. It is favoured by some tanners for sheepskins. A characteristic of the bark, however, is the absence of any appreciable quantity of sugars, with the result that the liquor from it does not produce acids by fermentation, and it is usual to add a little organic acid to the tan-liquor. The other notable characteristic, already referred to, is the reddish colour imparted to the leather. By combining hemlock with other tanning materials, such as oak bark or quebracho, as is commonly done, the colour can be considerably modified. Among English tanners, the colour may be
HEMLOCK BARK

considered a very serious drawback, but with American and Canadian tanners, more accustomed to hemlock, it may cause less concern.

In American tanneries there has been a preference for oak bark where available, in preference to hemlock, and this may have been due in part to the old established belief that oak bark always produces the best leather. However, tests have shown that, with many classes of leather, oak bark is not inherently superior to hemlock in actual tanning properties, apart from colour and appearance. A claim has been made that harness leather made with hemlock is largely superior to that made from American oak.\(^3\)

**The Western Hemlock**

The Western Hemlock (*Tsuga heterophylla* syn. *T. albertiana*) is a tall, slender tree growing in humid regions in pure stands or mixed with other conifers along the west coast of North America from Alaska to California and inland in some regions, extending east to Montana in the northern portion of the belt. The first printed reference to the tree occurs in an account of the voyage of Admiral Vancouver, the British navigator, who visited Puget Sound in May 1792. The tree was introduced to Britain in 1851 and thrives in the wetter parts of the country where good soil conditions prevail.

In some countries the Western Hemlock is esteemed as an ornamental tree but has not, as yet, been cultivated for timber, although there are those who consider its comparatively rapid growth and freedom from pests and diseases warrant more attention being given to it in afforestation, in spite of the timber being inferior to that of many conifers. It is a taller tree than the Eastern Hemlock, and in its natural habitat may reach 150—200 ft. in height and 3—6 ft. in diameter, often with a pyramidal habit. An interesting point about the tree is that it is one of the few conifers whose seedlings may grow without being in touch with mineral soil. Seedlings often grow on fallen tree trunks or rotting stumps without being in touch with the soil. They may remain thus for many years before the roots finally reach the ground. Another characteristic of the tree is its extreme tolerance of shade.

In earlier days in the United States and Canada, the timber had a poor reputation and trees were often left standing while other conifers, such as Douglas Fir, Sitka Spruce and Western Red Cedar, were felled. In more recent years, however, it has come to be held in higher esteem. Various factors probably account
for this, two of the more important being a better understanding of its seasoning (the freshly cut timber having an abnormally high moisture content) and of the uses for which it is best suited. It is also probable that the poor quality of Eastern Hemlock may have been the cause of initial prejudice against Western Hemlock. The timber is superior to that of Eastern Hemlock in nearly all its technical properties. It is now considered suitable for all ordinary building work, especially indoor finishing and flooring. It is favoured for boxes, especially butter or food boxes, being non-resinous, tasteless and odourless. Like the Eastern Hemlock, it is much esteemed for paper pulp, which is its main use.

Bark
The bark of the Western Hemlock is similar in outward appearance and in structure to that of the Eastern Hemlock. Important differences however are that the ross, or outer bark, is thinner and the furrows shallower. The bark averages about $\frac{3}{8}$ in. in thickness, while that of the Eastern Hemlock averages about $1\frac{1}{2}$ in. Another important difference is that the tannin content is markedly higher than that of Eastern Hemlock, being approximately half as much again. That of the Eastern Hemlock averages (in the spring) 10–11%, while that of the Western Hemlock averages 15–16%.

It has been established that the tannin content of the bark varies quite considerably according to the season. Figures given by Smoot and Frey\textsuperscript{170} for trees either standing or just felled (at Kingcome Inlet, British Columbia) illustrate this very forcibly. They are as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Tans</th>
<th>Non-Tans</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 5th</td>
<td>12.05</td>
<td>5.73</td>
</tr>
<tr>
<td>February 14th</td>
<td>13.66</td>
<td>5.98</td>
</tr>
<tr>
<td>April 12th</td>
<td>14.84</td>
<td>6.82</td>
</tr>
<tr>
<td>May 15th</td>
<td>15.5</td>
<td>6.78</td>
</tr>
<tr>
<td>June 15th</td>
<td>15.30</td>
<td>6.40</td>
</tr>
<tr>
<td>July 20th</td>
<td>14.15</td>
<td>5.01</td>
</tr>
<tr>
<td>August 15th</td>
<td>11.34</td>
<td>4.14</td>
</tr>
<tr>
<td>September 15th</td>
<td>10.52</td>
<td>4.05</td>
</tr>
<tr>
<td>November 15th</td>
<td>9.00</td>
<td>3.89</td>
</tr>
</tbody>
</table>

It is apparent that the tannin content is at its highest during the spring and early summer months or during the 'peeling' or barking season, which is a fortunate coincidence. It has to be remembered, however, that felling for paper pulp or timber is not
HEMLOCK BARK

restricted to this season and that there are serious difficulties associated with the exploitation of the bark which do not apply with the Eastern Hemlock.

In many of the felling areas the large size of the logs and the impossibility of their being man-handled is a serious obstacle to bark removal. The usually tangled undergrowth and the much wetter conditions that apply in the Eastern Hemlock regions are other difficulties. Inaccessibility and the frequently rough nature of the country constitute still further difficulties. In general, bark removal and exploitation in the woods are often more or less impracticable or uneconomic.

In recent years the possibility of utilizing the bark for tannin after the log reaches the pulp mill has received serious attention, for the bark has to be removed before pulping in any case, but here again there are serious difficulties. It is customary for logs to be in contact with water before they are dealt with at the mill and this in itself reduces the tannin content of the bark. Logs are commonly transported by water. On reaching the pulp mill, whether by land or by water, they go into the mill's log pond where they may remain for varying periods. The loss of tannin from the bark depends upon the length of time the logs are in the water. On removal from the pond the logs are washed to remove mud etc and are then squared by removal of the slabs with bark adhering. The slabs are then cut into billets and the bark removed mechanically (by revolving blades or studded discs). As removed the bark is in the form of a wet pulpy mass about half of which consists of wood. It has little or no value and is usually sent to the refuse burners. The tannin content of this wood–bark mixture is normally very low, only 2.9 to 6%\(^{170}\), and too low for profitable exploitation of the tannin.

In more recent years, the removal of the bark from the log by hydraulic means at the mill has been carried out. This has the advantage, from the milling point of view, that less wood is wasted. It also means that the bark, when removed, has much less wood mixed with it and is correspondingly richer in tannin. But even so the bark averages a much lower tannin content than that peeled in the woods in the spring.

Where logs have been immersed in sea water, the salt that remains in the bark is a serious factor in any attempt at utilizing the tannin. It is, of course, freely water soluble and so becomes mixed with the extract in extract manufacture. During the evaporation process, the salt percentage naturally increases greatly.
TANNING PROPERTIES

Tanners of sole and heavy leathers have a serious objection to the presence of excessive amounts of salt in the extracts they use. Tannin extract made from sea-water-floated logs of Western Hemlock in Canada was found, on the basis of laboratory tests, to be just as efficient as commercial quebracho extract as a viscosity-reducing agent in mud drilling (for oil)\(^1\).\(^{115}\)

**Tanning Properties**

Like most other tan-barks the bark of Western Hemlock needs to be stored for at least four months before use. If this is not done, not only is the bark more difficult to leach but the tan-liquors are liable to impart an uneven colour or mottled appearance to the leather.

It has been shown that the extract from Western Hemlock bark may be used alone for producing marketable commercial leathers. Leather tanned with it alone has been described\(^1\)\(^{170}\) as firm but not harsh and with excellent fibre weave and fibre strength. It blends readily with other tanning materials. Used alone, the deep reddish colour given to the leather is undesirable according to modern standards. Wearing tests with sole leathers tanned with Western Hemlock extract have given favourable results\(^1\)\(^{170}\).

It is said\(^1\) that a factory for the preparation of extract from the bark was first established as far back as 1893, near South Bend, Washington, but, owing to insufficient capital, the general financial depression of that time, and to the opposition or antagonism of the Eastern Hemlock bark interests, it did not survive for long. However, the promoters claimed to have demonstrated the feasibility of such an enterprise under more favourable circumstances.

There are other reasons why Western Hemlock bark was not regularly exploited at an earlier stage in the colonization and development of North America. The cost of transporting the bark or extract, which at that time was liquid, not solid, with about 25% tannin content, to the tanneries on the more advanced eastern side of the continent was prohibitive, the distance being about 3,000 miles. The difficulty in barking the large logs, the thick undergrowth and heavy rainfall have already been mentioned. The free supply of various imported tanning materials at about the turn of last century, and their low cost, also contributed to the long neglect of Western Hemlock bark.
The important Australian genus *Eucalyptus*, with some 600 or more species, is known to include many species whose bark is rich in tannin. Some of these have been grown in various other parts of the world, usually as timber trees, for fuel or as shelter belts. So far, however, it is only in Australia that eucalyptus bark has been exploited as a tan-bark on a large scale and then entirely from wild trees.

*Mallet Bark*

Mallet or maletto bark is the product of *Eucalyptus astringens* (syn. *E. occidentalis* var. *astringens*), a medium-sized tree of limited distribution in Western Australia, where it is known as red or brown mallet or 'flat-topped yate'. Early in the present century it was intensively exploited for tan-bark, most of which was exported to Germany. Owing to the restricted distribution of the trees in Western Australia and the excessive or ruthless exploitation that took place the production of bark rapidly diminished after a time. The tree occurs mainly on the east and west of the Great Southern line between Pingelly in the north to Tambellup in the south, its natural habitat being the ironstone ridges. In the year 1905 the production of bark approached 20,000 tons, three-quarters of which was exported. By 1913 this had fallen to 5,000 tons and later diminished still further, all available supplies being used in Australia.

Mallet bark is of interest in that it is one of the world's richest tan-barks, with a tannin content that is often well over 40%, and reaching as much as 52 or 55%. When exported the bark is generally in pieces 2—12 in. long and brown or yellowish-brown in colour. It is readily leached with cold water, 90—95% of the tannin being extracted. Its tanning properties are good. Used alone it gives an orange tint, but this is easily avoided by mixing with other materials. A disadvantage when used alone is that the leather is inclined to darken on exposure to light and to assume a reddish tint. With its low soluble 'non-tan' content (8%) it needs to be mixed with other tanning materials or acids to induce swelling or good plumping, especially with leather required for belting, etc.
MUGGA OR RED IRONBARK

The red or brown mallet tree reaches an average height of about 60 ft. with an average girth of 6 ft. at breast height. The bark is thin and is readily stripped off when the 'sap is up'. About 15 years are required to reach maturity. It is considered that it could be grown on the same lines as the black wattle. There was interest in the possibility of growing brown mallet in some countries at one time, e.g. in South Africa, Morocco and California, but it appears to have been pushed aside in favour of black wattle.

The commercial mallet bark exported from Western Australia has sometimes been a mixture of brown mallet bark with the bark of the white or silver mallet (E. falcata var. ecosiata), blue mallet (E. gardneri), swamp mallet (E. spatulata) and merritt (E. flocktoniae).

Mugga or Red Ironbark

The tree known as Mugga or Red Ironbark (Eucalyptus sideroxylon) has attracted attention in recent years as a possible commercial source of tan-bark, particularly in Morocco, where plantations of the tree have been found to do well. This tree has a wide distribution in Australia and occurs freely in many areas on the eastern side of the continent. It is notable for its handsome rosy-red flowers, although some forms have creamy-white flowers, and also for the bark of the trunk which is jet black and often much furrowed. It has been grown in other parts of the world as an ornamental tree or for its timber.

The bark is rich in tannin which varies from 30% to as much as 45%. Fourteen year old trees 50 ft. high with a diameter of 8 in. at breast height are said to have yielded 176 lb. (80 kg.) of green or fresh bark in Morocco. As the tree freely produces suckers or shoots after felling, it is considered that plantations could be re-established without the need for replanting and could therefore be economically worked. What may be a drawback is that after 10 years of age there is a tendency for kino to develop, and this darkens the tannin extract.

Small-scale tanning trials have shown that the extract is very astringent and that it is somewhat comparable with wattle and with sulphited quebracho. Used alone, fixation of the tannin in the hide is slow and the resulting leather is too soft and rather dark and reddish in colour. Improved results have been obtained by extracting with sodium bisulphate solution used either alone or with other natural or synthetic tanning materials.

In Morocco it is contended that the tree would take less out of the soil than the black wattle, but this would seem very doubtful,
especially where the 'non-burning of brushwood' policy in black wattle cultivation is adopted.

In South Africa the tree has been found to grow successfully in many areas and some trees investigated have yielded bark with 21—28% tannin, the tannin content varying with the height of the bark from the ground, as is known to apply with black wattle and with mangrove.

**Wandoo or Redunca**
Both the bark and the wood of the wandoo (*Eucalyptus wandoo* syn. *E. redunca* var. *elata*) of Western Australia are commercial sources of tannin (see Chapter 20).

**Kino-impregnated Bark**
The production of a large amount of kino is a characteristic of many species of *Eucalyptus*. It usually forms in cavities ('veins' or 'pockets') which may be superficial or deep-seated. As much as 10 gallons have been taken from some kino pockets. When first formed it is thin and watery, later becoming syrupy and finally a semi-crystalline mass. Kino-impregnated bark is available from many species of *Eucalyptus* which are felled for timber, and the tannin content of kino is high. For use in tanning the deep red colour would be a drawback and the insolubility in water would have to be overcome (by sulphiting). The redgum or marri (*E. calophylla*) is one of the species that produce kino very freely.

**Other Species of Eucalyptus**
There are many other species of *Eucalyptus* whose bark is rich, or relatively rich, in tannin, but which have not been seriously exploited for tannin. There are many reasons for this. Often they do not occur in great abundance or they occur in remote areas, or the tannin or leather produced from them is unduly dark. The following are some of the species known to yield bark with a tannin content in excess of 10%, the approximate tannin content being indicated for each species.

- *Eucalyptus accedens* 18%
- *E. alba* 30%
- *E. basistoma* 18%
- *E. caleyi* 17%
- *E. calycogona* 16%
- *E. campasiote* 26%
- *E. citriodora* 12%
- *E. clevelandi* 14%
- *E. coriacea* 12%
- *E. coromandeliana* 20%
- *E. croebra* 15%
- *E. diversicolor* 11—22%
- *E. eugenioides* 12—19%
- *E. falcata* 32%
- *E. foecunda* 19%
- *E. flocktoniae* 18—21%
- *E. gardneri* 22—31%
- *E. haemastoma* 12%
- *E. leucoxylon* 22%
- *E.
OTHER SPECIES OF EUCALYPTUS

AVARAM BARK

AVARAM BARK (Cassia auriculata), known also as ‘tarwad’ or ‘tawar’, is one of the best known and most important of the indigenous tanning materials of the Indian Sub-continent. At one time very large quantities were used in Indian tanneries, estimated at 20,000—50,000 tons per annum, but in recent years, for various reasons, wattle bark or extract has largely taken its place in Indian tanneries. The bark has never been exported to any extent.

The shrub yielding this bark is common in many of the hot, drier parts of the Indian Sub-continent, especially in the south and west, from the Ajmer and the Jumna rivers southwards. It covers large areas in the Deccan and also occurs in the dry zone of Upper Burma. It is used to some extent as a green manure and has medicinal uses.

Collection
To obtain the bark, the shoots or branches that arise from the base are simply cut off and the bark subsequently peeled off and dried. As the thin strips of bark dry, they assume a light brown or cinnamon colour and a cornet or quill-like shape, being about 6 in. long and \( \frac{3}{4} - 1 \frac{1}{2} \) in. in diameter. They are used by the tanner in this form. As they are thin there is considered to be no need for grinding.

The bush coppices freely and after a year the next lot of shoots may be cut for their bark. The avaram tracts are often far removed from the villages. Head-loads of the sticks may be cut in the morning by the men and brought back to the village for women to strip off the bark. If the stripping is not done soon after the sticks are cut, it becomes impossible to remove the bark, especially in hot weather.

Stripping the bark is a tedious process as the sticks are seldom more than 1\( \frac{1}{2} \) in. in diameter and average about \( \frac{3}{4} \) in. The usual method is to place the stick on a flat stone and to beat it with another stone or piece of wood to loosen the bark which is then pulled off with the fingers. Attempts have been made to design a machine to do the stripping and so help in this village industry. The bark is thin and a head-load of sticks yields only 4—5 lb. of dry bark. With the black wattle, by way of contrast, a single tree may yield 30 lb. of dry bark.
TANNING PROPERTIES

Tannin Content
The avaram bark delivered to Indian tanneries usually has a tannin content of about 18%, with about 10% of soluble non-tans. A tannin content of over 20% is not uncommon and figures as high as 25% have been recorded. The age of the bush or the coppice shoots may affect the tannin content, the older bark having a slightly higher percentage. Stems older than about 5 years are

Figure 3. Avaram (Cassia auriculata): the bark of this shrub is esteemed as a tanning material on the Indian Sub-continent

not desirable owing to the development of a reddish dead outer bark which gives a darker colour in tanning. Mysore bark is stated to be sometimes preferred to Madras bark and to have a higher tannin content but definite evidence that this is so seems to be lacking. There is also a belief that plants grown in soils rich in lime may show a higher tannin content than those from other soils.

Tanning Properties
As a tanning material, avaram bark has long been held in high esteem by tanners in India and it is due to it that the large Madras export trade in light-tanned or half-tanned leathers was built up. Although wattle has largely superseded avaram in the tanning of
AVARAM BARK

hides (cattle), avaram is still in keen demand for skins (goats and sheep) or ‘East Indian kips’. Avaram is self-bating and penetrates rapidly, yielding a pale-coloured tough and elastic leather. Used alone, the leather is prone to develop a reddish colour when exposed to the sun but the completion of the tanning with myrabolans prevents this. It is considered the ideal tanning material for the tannage of half-tanned skins or kips, to be further tanned at their destination. Another advantage is that it is easy to use and yields uniformly good results even in the hands of inexperienced tanners. Most of the bark collected is consumed in Madras.

Cultivation
Irregular or uncertain supplies of avaram bark in the past have drawn attention to the possibility of cultivating the shrub on plantation lines and experimental plantations were established as long ago as 1908. However, it seems the bark could not be produced economically from plants maintained under cultivation. The straggling nature of the plant proved a drawback with field cultivation, while the large amount of labour needed in preparing the bark was a serious problem.
BABUL BARK

While avaram bark (*Cassia auriculata*) may be the most important indigenous tanning material in the southern part of the Indian Sub-continent, Babul bark (*Acacia arabica*) claims this honour in the more northerly areas. Like avaram bark, babul bark has been largely supplanted by wattle bark or extract in the tanneries in northern India and Pakistan in recent years. This applies particularly in the large tanneries of Cawnpore, an important centre of the leather industry, where for many years babul bark has been the main tanning material. Reasons for the fall in the consumption of babul bark in the large tanneries are considered to be the diminution in supplies available owing to failure to replant trees at the rate they have been felled and failure to market the bark as satisfactorily as its chief competitor, wattle bark.

During and just after the Second World War, the large tanneries such as those of Cawnpore, used wattle bark or extract in preference to babul. In 1948, however, importation of South African wattle bark was stopped for political reasons. Supplies were then obtained from East Africa but these were insufficient to meet the demands of Indian and Pakistani tanners with the result that babul again came into use. It has always been extensively used in the many small village tanneries throughout the areas where the tree occurs. The total annual requirements of babul bark for northern India and Pakistan have been estimated at about 100,000 tons.

The babul tree is widely distributed throughout the drier parts of India where it is probably the most important tree economically and where it may occur in quite large forests (as in Sind), as small patches, or as isolated trees. In the Hyderabad and Jerruck Divisions of Sind the tree is estimated to cover some 170,000 acres. Normally the tree is almost evergreen and has a short trunk, a spreading crown, and feathery foliage. In mature trees the bark is dark brown or nearly black with deep longitudinal fissures. It is an important source of fuel and is much cultivated for this purpose. Gum is obtained from it and the pods are largely used as fodder for livestock. They are also used in tanning (see Sant Pods, Chapter 28). The tree also occurs in Burma, Ceylon and westwards through Arabia into tropical and southern Africa. Several varieties or forms are recognized, differing mainly
BABUL BARK

in pod characters (Troup). Among the Indian or Pakistan varieties, that known as 'godi', 'tei' or 'telia babul', which is the typical form with moniliform pods (constricted between the seeds) is considered to yield the best tan-bark and is the one usually exploited for this purpose. In spite of the wide distribution of the tree in Africa and elsewhere it is only in the Indian Subcontinent that the bark has been extensively or regularly used in tanning.

Apart from the bark the pods are also fairly rich in tannin. In this connection, it is interesting to note that in India the bark and not the pods of Acacia arabica are used in tanning, whereas in Africa the pods are a much-used tanning material but not the bark (see Sant Pods, Chapter 28). Pods from Africa are richer in tannin than those from India.

Collection
The production of babul bark is generally a by-product of the production of timber or fuel. In collecting the bark, it is usually loosened first by beating with a wooden mallet, this being done after the tree has been felled and cut into lengths. When dry, it is chopped into smaller pieces and packed in gunny bags for the tannery. No grading is done and grinding, which is difficult owing to the toughness of the bark, is carried out at the tannery, usually in the dry season.

Tannin Content
With the bark delivered to the tanneries the tannin content is said to average about 12% with 8% soluble non-tans, the tannin being of the catechol class. The tannin content of the bark of some trees may reach 20%, while the bark of young trees and branches may be well below the average of 12%. A solid extract containing 46% tannin was prepared from babul bark in India, but its preparation ceased during the trade depression of the early nineteen thirties.

Tanning Properties
Used alone, babul bark produces a leather which is rather harsh and dark coloured but which nevertheless possesses firmness and durability to a high degree. Babul bark tans slowly. It has long been the practice in Cawnpore tanneries to modify the undesirable properties by the use of myrabolans. With modern methods of tanning, the scientific control of pH etc, the colour and other

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difficulties have been largely overcome and 'for sole and heavy leather, it is generally agreed that babul produces as good a result as is required'\textsuperscript{63}. In combination with myrabolans it may also be used, with care, for soft, light-coloured leathers.
BIRCH BARK

The bark of the common European birch (*Betula verrucosa* or *B. pubescens* syn. *B. alba*) has been used for tanning in northern European countries from the earliest times, especially in Russia. The tree has a very wide distribution and extends from Iceland and Scandinavia eastwards throughout the whole of northern Europe (including the British Isles) to north-east Asia. Extensive forests of birch exist in Russia. It is the hardiest of European trees and occurs farther north and at higher altitudes than any other tree. It will also thrive in wet and acid soils where few other trees will grow. Trees may reach 80 ft. in height or more in favoured situations, but are usually much smaller. At high altitudes they may not exceed a few feet.

Birch bark consists of an outer and an inner portion. The former is often white in colour and can be peeled off in paper-like strips. It is impervious to water, hence the use of birch bark in roofing and for canoes. The inner portion of the bark contains the tannin, which may be present to the extent of 10—15% with soluble non-tans averaging about 11%\(^\text{158}\). The best age for removing the bark is when the trees are 50—60 years of age, for with young trees the bark is more difficult to remove. In the trade, birch bark appears in smooth, hard pieces \(\frac{1}{2}\)—2 cm. thick. The older trees yield the richest bark\(^\text{83}\).

Tanning with birch bark yields a pliable, light coloured, yellowish-brown leather well suited for 'upper' leather in footwear. The bark is often mixed with some other tanning material such as willow bark. The oil obtained from birch bark by distillation is used to dress the leather tanned with the bark. It is this that gives to 'Russian leather' its characteristic odour and feel.

Other species of birch or *Betula* in North America and in India are known to be used in tanning or to possess tanning properties similar to the European birch\(^\text{87}\).
WILLOW BARK

The bark of several species of willow (Salix) has been used in tanning in northern European countries from early times. Like birch bark, it has been and still is extensively used in Russia, Finland, Scandinavia and to some extent in other European countries. It yields a light coloured, yellowish-brown leather that is soft and flexible and favoured on this account. Danish and Scottish glove leather is said to have been tanned with willow bark at one time. The tanning properties of willow bark are considered to be not unlike those of birch and the two are often mixed.

In more recent times a tanning extract has been prepared from willow bark in Russia. It is said that prior to the Second World War some 70,000 tons of willow bark were collected annually in Russia. Since then, production is stated to have greatly increased and a considerable quantity of bark is used in the production of extract. There have also been proposals for increasing the production of willow bark in Germany.

Some two hundred species of willow or Salix are known to exist and hybrid forms occur very freely. All probably contain some tannin in the bark but many are dwarf in habit or for other reasons are never exploited for tan-bark. The tannin content of the bark of the larger species probably averages 8—10%, but it is often well over 10% and 18. In Russia, the more important species supplying tan-bark are considered to be the following, the approximate tannin content of the bark being indicated: Salix viminalis (common osier) 12%; S. caprea (goat willow) 10—12%; S. viridis (syn. S. russelliana) 12%; and S. repens (creeping willow) 13%. Other species said to be used in tanning in Russia are S. alba 5—7%; S. cinerea 8—11%; S. fragilis 7—8%; S. nigricans 7—10%; S. pentandra 6—7%; S. triandra 11—17%. Besides the European species, some species of Salix in other parts of the world are recorded as having been used in the tanning of leather. These include S. conifera and S. discolor in North America and S. saqsaq (S. aegyptiaca) in North Africa. Bark of the commonly planted weeping willow (S. babylonica) in South Africa was found to have a tannin content of 7—9% but is not used in tanning.

Some investigators have found the average tannin content of willow bark to be higher in the southern parts of Russia than it
WILLOW BARK

is in the northern areas. It has also been found that the ratio of 'tans' to soluble 'non-tans' in willow bark varies with the seasons. With bark from the trunks of willow trees the tannin content is highest near the ground and decreases towards the top of the tree. This is known to apply with other tan-barks, e.g. black wattle and mangrove.

The willow bark used in tanning is often a by-product of some other enterprise, i.e. the bark that is stripped from willow rods in basket making or the making of wicker furniture or other articles such as hurdles. Bark of this kind is comparatively young, the shoots from which it is derived being grown as coppice. Planting of willows is usually carried out on moist soils, by means of cuttings. Harvesting is possible after 4—8 years and is done in the spring when the bark peels readily. For transportation, the bark is commonly made into narrow bundles about a yard long. The bark is tough and fibrous and the colour varies with different species.

The powdered Russian extract prepared from willow bark is said to have a tannin content of about 42% and soluble non-tan content of about 35%. Used in the natural state it tans or penetrates leather very slowly but is much improved by sulphiting. In Russia the extract is used in tanning various classes of leather.
PINE BARK

Among the true pines (Pinus), many species are known to contain tannin in the bark, the amount varying from less than 5% to over 20% in a few instances. Many species in this large genus have not as yet been investigated in regard to their tannin. A few species, with bark relatively rich in tannin, are known to be used to some extent in the tanning of leather in the countries of origin.

The pine that is or has been most freely used in tanning is probably the Aleppo pine (Pinus halepensis). It is common in countries bordering the Mediterranean and occurs also in Portugal and western Asia. It has been grown in many other countries, mainly as a wind-break and in soil-erosion control, and is very drought-resistant. The bark is at first smooth and silvery grey but later becomes reddish-brown and fissured and scaly on old trunks. Estimations of tannin content of mature bark by various investigators vary from 13—25%. It is reputed to be used in tanning in Algeria and Tunis and other Mediterranean countries and to yield a reddish leather. Trade names by which it has been known are 'snouba' or 'scorza rossa' (red bark) whilst a common Arab name is 'sellekh'. The Calabrian pine (Pinus halepensis var. brutia) is a variety of the Aleppo pine but has a more easterly distribution. It is similar in tanning properties and may also be used in tanning.

The bark of the 'chir' pine (Pinus roxburghii), a common tree in the Himalayas, has been used in that region in local tanning. It may contain from 11—16% tannin. The bark of the North American Loblolly pine (Pinus taeda) is also reputed to have been used in local tanning and to contain about 12% tannin. Other pines whose bark has been recorded with over 10% tannin include Pinus echinata, N. America, 11—18%; P. khaya, Burma, 7—10%; P. lariocc, N. America, 13%; P. palustris, N. America, 17—18%; P. ponderosa, N. America, 5—11%; P. rigida, N. America, 14—16%; P. sylvestris, Europe, 16%. In recent years the bark of the Monterey Pine, Pinus radiata (syn. P. insignis), sometimes called 'insignis pine', has attracted attention as a tanning material in New Zealand. This pine, which is native to Monterey County in California, is now extensively grown for timber in various other countries, especially parts of
South Africa, Australia and New Zealand. It is valued mainly for its rapid growth and its ability to withstand exposure and strong sea winds. In New Zealand it grows particularly well and may reach a height of 100 ft. with a trunk diameter of 4—5 ft. The timber has been much used there for boxes for dairy produce and for other purposes. In New Zealand, the bark has been found to be rich in tannin (17—18%). When blended with black wattle or mimosa (30% *P. radiata*: 70% mimosa) good results were obtained in tanning leather.

As with spruce (*Picea*), the needles and cones of pines contain tannin but only in relatively small quantities.
LARCH BARK

The bark of the common European larch (Larix decidua syn. L. europaea) contains tannin and has long been in use in parts of Europe and Russia for tanning, possibly mainly in areas where other tanning materials are difficult to obtain. The bark was used at one time in Scotland for the tanning of bazils or basans (sheep skins). The tree is not native to the British Isles but was introduced early in the seventeenth century and is cultivated extensively for its timber.

The larch has a wide distribution throughout Europe, especially in the mountainous areas. It extends from the Alps to northern Russia and Siberia where it gives place to the Siberian larch (Larix siberica), a closely related species. There are several geographical forms or varieties of the European larch which show differences in growth characteristics and in other ways. Well-grown trees in favourable localities may reach a height of 100—150 ft. and 10—15 ft. in girth. Trees are generally felled for their timber long before they reach these dimensions.

The bark of young stems or branches of larch is smooth and grey but on the older branches and trunks (over 20 years old) it becomes brown or reddish-brown and may flake off in thin irregular plates. The bark at the base of old trees in cold districts may become very thick indeed. It may even reach a foot in thickness in the Alps. Such bark consists mainly of ross or dead bark with a comparatively thin layer of living bark next to the wood.

Much of the tanning material in the dead bark is not water-soluble and may only be extracted by sulphite treatment. In this respect the bark resembles that of spruce. It also has similar tanning properties to spruce, including a high sugar content and high acid content of the liquor. The average amount of water-soluble tannin present in the bark is in the region of 8—9% but there is wide variation, for instance one investigator records 13.8% water-soluble tannin for a 40 year old tree, whereas the sulphite-soluble tannin for the former was 4.6% and for the latter 14.8%.

Probably more attention has been given to larch bark tannin in Russia than in any other country. In recent years (commencing in 1936), a tanning extract has been prepared there from larch.
LARCH BARK

bark. Considering the vast areas covered by larch throughout Russia, it is obvious that larch is potentially a very important indigenous tanning material in that country, and capable of supplying many thousands of tons of tanning extract annually for the Russian leather industry. Larch bark extract in the solid and the powdered forms is also prepared in Sweden.

Little appears to be known regarding the tanning properties of other species of larch. Bark of the North American western larch (Larix occidentalis) has been recorded with 10.6% tannin\(^{13}\) and the Asiatic Dahurican larch (L. gmelini) with 9%.
ALDER BARK

Alder bark has been used to some extent in tanning, mainly in eastern and south-eastern Europe, notably the Balkans, and in Turkey. Considering the prevalence of the common alder (*Alnus glutinosa*) in Europe and the fact that the bark is fairly rich in tannin it may seem surprising that the bark has not been more widely used. Reasons for this are probably the presence of much reddish-brown colouring matter in the bark and the fact that, used alone, the bark has a tendency to make leather brittle. For these reasons the bark is often mixed with other tanning materials. Its use is probably restricted to small-scale tanneries and to home tanning.

The bark may contain from 9 to 16% tannin or more. Bark from old trees may have a low tannin content owing to the development of corky or dead bark and the fact that some of the tannin becomes insoluble. Young trees may be barked in much the same way as is done with oak. The grey or speckled alder (*Alnus incana*), native to both Europe and eastern North America, resembles the common alder in its tanning properties. Other alders whose barks are recorded as having been used in tanning are *Alnus nepalensis* and *A. nitida* in India and *A. cordata* in Italy.

The fruits or cones of the alder, fresh or dry, are also fairly rich in tannin. Fresh ripe fruits of the common alder have about 14% tannin or about 16% when dry. When the fruits have hung on the tree for a year the tannin content drops to about 9% and more colouring matter develops. They may be used for tanning in the Balkans. The fruits of a Japanese alder, *Alnus firma*, and an American alder, *A. maritima*, have been recorded as having 26% and 25% tannin respectively.
Plate VII a

A well-grown Quebracho tree in Argentina, probably about 120 years old

By courtesy of the Forestal Land, Timber and Railways Co., Ltd.
QUEBRACHO

The quebracho tannin extract industry of South America is of interest on account of its rapid growth and the large dimensions it attained within a comparatively few years in the earlier part of the present century. At one time it supplied more tannin units for the world’s tanning industry than any other vegetable tanning material. This leading position among tanning materials was not to last, however, and was later taken by wattle and wattle extract (or mimosa), due to the increase in wattle planting that took place in many countries, particularly South and East Africa. Wattle is likely to retain this ascendancy over quebracho for various reasons, the main being the ruthless and over-exploitation of existing stands of quebracho trees that has taken place, and the
slow rate of growth of the trees which is adverse to the establishment
of plantations. Wattle on the other hand is relatively quick
growing.

*Early History*

The use of quebracho (pronounced 'kaybratsho') for tanning
would appear to date from the early seventies of last century. At
first the wood was exported only *to a small extent for tanning*
although the timber had long been extensively used for all manner
of purposes, on account of its durability and hardness. In the
early days of the industry only the logs were exported, these being
cut into convenient lengths and stripped of the sapwood before
shipment. The logs were shipped mainly to European countries,
particularly Germany, which was the largest importer for many
years. They were largely transported in sailing ships and could
be marketed very cheaply in Europe. German interests were also
well represented in the quebracho areas of Argentina. The first
use of quebracho in Europe is said to have been in France. Con-
signments of logs were received in France in 1873. Later, logs
were shipped to the United States in increasing quantities, also
wood chips.

Unlike many other tanning materials quebracho does not
appear to have been used throughout the ages by local inhabitants
in preparing leather. There seems some doubt as to how, why, or
when the valuable tanning properties of quebracho wood first
became known. However, one writer states, 'In the early
seventies of the nineteenth century, a workman employed in some
tannery noticed the coloration of the water in which some quebracho
sawdust was lying, and thought it might contain some tannin.
Experiments were made and proved conclusive, and samples were
sent in 1872 to Havre and Hamburg [89].

The manufacture of quebracho extract from the wood, which
had been started in Europe, was soon commenced in Argentina
and Paraguay. The first extract factory to be erected in South
America is reputed[7] to have been one erected at Puerto Casado in
Paraguay in 1889. This was followed a few years later by several
other factories. The preparation of the extract locally obviously
had great advantages and effected an enormous saving in freight.
By 1924 some two dozen factories were operating in northern
Argentina and western Paraguay with capacities of 250—2,500 tons
of solid extract per month or a total output of 150,000—
200,000 tons per annum[49]. Since that time, this very
large production has dwindled considerably for reasons already
given. The consumption of quebracho extract in Argentina has
naturally increased with increasing industrialization. After the
Second World War when the yearly export figure for extract was
162,000 tons the quantity used in Argentina was nearly 30,000
tons. Before the war, Germany and Japan were two of the chief
importing countries.

Botanical Sources
The name quebracho is a contraction of the colloquial Spanish or
Portuguese term 'quiebra-hacha' (axe-breaker) and was originally
used for many different Latin-American trees that happened to
have very hard wood. However, the trees exploited for tannin
under the name of quebracho and of commercial importance
consist only of: (a) Schinopsis balansae commonly known as
'quebracho colorado', or more precisely as 'quebracho colorado
chaqueño', or as 'quebracho femea', or 'Santa Fé quebracho',
and (b) Schinopsis lorentzii (syn. Schinopsis quebracho-colorado)
known also as 'quebracho colorado', and more precisely as 'quebracho
colorado santiagueño' (to distinguish it from the former), also as
'quebracho macho', 'quebracho vermelho' or 'Santiago quebracho'.

There is also a form or variety of 'quebracho chaqueño'
popularly known as 'quebracho horco' and regarded botanically
as Schinopsis lorentzii variety marginata. It differs in leaf characters
and it is claimed that the seeds germinate more readily than those
of the ordinary 'quebracho chaqueño'.

The genus Schinopsis (fam. Anacardiaceae) is represented in South
America by at least eight species but only the two species already
mentioned are commercially important for tannin. However, the
following South American or tropical American species, not used
for tanning, may also be known by the name of quebracho—
Aspidosperma quebracho-blanco (Argentina), Aspidosperma spp. (Surinam),
Astronium fraxinifolium (Colombia), Diphyys robinoides (Honduras),
Iodina rhombifolia (S. America), Krugiodendron ferreum (Honduras),
Lonchocarpus michelianus (Salvador), Lysiloma acapulcense
(Honduras), Lysiloma divaricata (Salvador), Piptadenia constricta
(Salvador), Poepigia procera (Salvador), Sloanea sp. (Jamaica),
Tabebuia chrysanthha (Honduras), Tecoma sp. (Honduras).

The two important tannin-yielding quebrachos (Schinopsis
balansae and S. lorentzii) are closely related trees. Both have a
dense heavy wood, dark reddish brown in colour after exposure,
QUEBRACHO

but a lighter colour when freshly felled. That of *S. balansae* is the richer in tannin, the heartwood containing some 20—25% tannin on an average as against 16—17% for *S. lorentzii*. The flowers in both species are rather small and inconspicuous and the light brown fruits winged and resembling those of a maple (*Acer*). Those of *Schinopsis balansae* are slightly larger, being commonly 1½ in. long with the wing ⅙ in. in width, while the fruits of *S. lorentzii* barely exceed 1 in. in length or the wing ¼ in. in width at its widest part. *S. balansae* is never entirely free of its leaves which are simple and of a somewhat tough, leathery nature. *S. lorentzii* bears compound sumac-like leaves. In size *S. balansae* is the smaller tree although the heartwood is considerably richer in tannin than that of *S. lorentzii*. In both species the size of the trees varies much with soil and environment and of course with age. They are usually clear of branches for 20—30 ft. and the trunks are often bent or twisted and swollen at the base. They have a roughish bark on which often hangs a moss-like lichen of which cattle are very fond.

**Distribution**

The two tannin-yielding species of quebracho occur in a fairly well-defined region which extends from the Argentine province of Santa Fé to the northern limits of Paraguay. The belt extends roughly from 31° S to 21° S or a distance of some 760 miles. It is bounded on the east by the Parana and Paraguai rivers. The widest part of the belt is in the Argentine Chaco where it is some 200 miles across. It tapers to a width of only some 20 miles at the southern limit. In the northern or Paraguayan section the belt seldom exceeds 60 miles. It has been estimated that the whole area where quebracho occurs is about 200,000 square miles. The most important or extensive region is El Gran Chaco, a vast, flat, poorly-explored region of mingled jungles and open pampas, normally inhabited only by nomadic Indian tribes. Summer heat is sometimes intense and there may be quite severe winter cold—up to 10° frost.

Although *Schinopsis balansae* is widespread in northern Argentina, Paraguay and parts of southern Brazil the trees usually grow not in forests in the accepted sense of the word but singly or in small groups, mixed with other trees (termed ‘monte’) and separated from one another by the open spaces or grassland (‘campo’). Mixed with the tree vegetation may be vines, thorny bushes or scrub often forming an impenetrable mass. The campo is frequently
Distribution

Swampy and many different aquatic plants may occur as well as the coarse grass. In the monte the quebracho trees are usually taller than the other hardwoods and stand out above them.

Quebracho trees commonly reach a height of 50 to 75 ft. and trees reaching 100 ft. in height and 4 ft. in diameter do occur. The usual height, however, is from 20 to 40 ft. with a diameter of 1 1/2 to 3 ft. The tree is often bent and irregular and not particularly beautiful. A characteristic of the tree is the rather acute angle or upward trend of the main branches. The tree is subject to various insect or other pests indigenous to the region and it is common for the boles of the largest and oldest trees to be defective in some way. The density of the quebracho trees in the Gran Chaco and other regions may vary from 2 to 20 per acre, but is commonly only 5 or 6 per acre.

Owing to many years of felling, the stands of quebracho in the province of Santa Fé have been much reduced and unfortunately natural regeneration of the trees appears to be tardy or even quite absent. The fact that livestock are grazed in many of the areas and that they destroy the young trees is reputed to be largely responsible for this. It is considered that trees with a trunk diameter of less than a foot or 30 cm. should not be felled and that in any case seed trees should be left about every 100 metres and the area left undisturbed or ungrazed for at least five years to give seedlings a fair chance to become established. In practice this may be difficult to carry into effect. Trees under 40–50 years of age are regarded as not worth felling, either for tannin or for posts. Other provinces of Argentina where quebracho is exploited include Corrientes, Chaco, Formosa and Santiago del Estero.

In Paraguay it is mainly in the western part of the country in the areas served by the western tributaries of the Paraguai river that the quebracho industry is located. The factories are mainly on the right bank of the Paraguai river north of Concepcion. An idea of the growth of the quebracho extract industry in Paraguay is given by the fact that in 1913 about 12,000 tons of extract were exported from the country, while twelve years later, in 1925, some 64,000 tons were exported.

With regard to the occurrence of quebracho in Brazil, Horn states, 'Two species of Schinopsis occur in limited quantities on the flood-plain of the Paraguai River in the Territory of Ponta Porã in south-western Brazil. Quebracho Colorado (S. balansae Engl.), also called Quebracho Fêmea, yields 28% of tannin as compared to a yield of 18% for the Quebracho Macho (S. lorentzii Engl.),
QUEBRACHO

which is sometimes called Quebracho Cornillo. The trees of Quebracho Colorado are small, yielding only 400 to 500 kg. of heartwood as compared with average yields of 1,500 to 2,000 kg. for the Quebracho Macho. Occasional trees of the latter species yield from 10 to 20 metric tons of heartwood. The Quebracho Colorado is much less abundant than the Quebracho Macho and furnishes only 9% of the extract wood used by the two factories now operating in Brazilian territory. Brazilian extract factories therefore require 555 kg. of extract wood to produce the same quantity of tannin extract as the extract factories in Paraguay and Argentina produce with only 357 kg. of extract wood, which is largely S. balansae.  

Logging

In Argentina and the Paraguayan Chaco the felling of quebracho and the transport of the logs (termed 'rozillos' by the Argentinians) to the nearest depot, railhead, or extract factory is often beset with difficulties. The wood is heavy, with a specific gravity of 1·12—1·39, and being heavier than water cannot be floated as is commonly done in other logging operations, although suitable waterways are generally absent. The wood is so hard that it breaks the teeth of an ordinary circular saw. Many of the areas where quebracho occurs are low lying and liable to be swamped during the wet season. The trees are felled by means of heavy axes, and the bark and white sapwood are hewn off to reduce the weight of the logs and also to prevent the attack of beetles which deposit their eggs in the bark of down timber and fire-damaged trees. The resulting larvae will within six months completely riddle the wood with their galleries. The larger limbs are sometimes used for tanwood and the smaller ones are cut into firewood, if not too far from market. The logs are dragged by oxen through narrow paths to wider lanes, called "picadas", which had previously been hewn out from the rail-road. They are then loaded on heavy carts and hauled out, two or three tons at a time, to the narrow-gauge logging road where they are swung on to cars and drawn out to the extract factory by means of small wood-burning locomotives 149. Considering the hardness and toughness of the wood it may seem strange that it should be so subject to attack by borers.

The sapwood on quebracho logs is not extensive and varies from 1 to 3 in. in thickness. As it contains only about 3% tannin, as against over 20% for the heartwood, its removal constitutes
Plate VIII

Loading Quebracho logs after removal of the bark and sapwood

Off-loading Quebracho logs at the extract factory
By courtesy of the Forestal Land, Timber and Railways Co., Ltd.

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little or no loss in tannin extraction. The heartwood of quebracho, which darkens to a dark reddish brown after felling or exposure, is extremely hard and heavy and is considered one of the hardest of woods. It is also extremely durable, doubtless on account of its high tannin content, and is one of the best timbers for railway sleepers. Stipulations have been made in the past that new railways in the Argentine must be laid on quebracho sleepers. It has been estimated that some 3,600 km. of railway were laid down in Argentina expressly for the purpose of developing the quebracho industry\textsuperscript{41}. Large quantities of quebracho sleepers were exported at one time. In the first ten years of the present century the Santa Fé Land Coy. alone exported nearly a million railway sleepers. The timber has numerous important local uses and has been much used for such purposes as fence posts, telegraph poles, railway ties, bridge timbers, wood block paving, and general construction work. The timber is not generally used for planks on account of the difficulty of sawing and also because in the form of boards it has a great tendency to warp and crack. It is also important for fuel and the smaller timber (branches etc) has been much used for locomotives, small river steamers, power plants, and factories, as well as for domestic purposes\textsuperscript{140}. In recent years, with supplies of logs diminishing, the roots have also been used in extract manufacture.

**Extract Factories**

On arrival at the factory the logs are conveyed to the chipper, a powerful machine that reduces a log into small chips rather coarser than ordinary sawdust. A large quebracho log, which may have taken a hundred to two hundred years to grow, may be reduced to fragments by a machine of this sort in about a quarter of an hour.

A good and abundant water supply is important for the successful working of a quebracho extract factory, as large quantities have to be used. In many quebracho areas water may constitute a difficult problem for many months of the year. Fuel supply is also an important consideration.

After chipping, the fragments or chips are conveyed to the vats or extractors. Modern factories have 8 or 12 extractors made of copper and arranged for continuous counter current extraction under pressure (1.5—2 atm.) and 120—130° C. From the extractors, liquors with about 7% tannins are obtained and afterwards are evaporated in a regular triple-effect vacuum evaporator.
concentrating to 35 to 50% tannins. The liquid extract is then pumped into a vacuum evaporator equipment of special construction, where it is left for 16 or 18 hours until it reaches the desired density. When it becomes dense like resin, the black extract with a reddish shade is placed in double sacks (48–50 kg.) which are left for 48 hours until the extract is quite hardened. This hardened extract may now be stored. Before shipping, the extract must lie in storage at least 120 hours. This extract contains 62–63% tannins, 7–8% non-tannins, 7–8% insolubles, 20–23% water. Fifty hours is required to accomplish production. The spent chips from the diffusers are by no means a waste product. They are allowed to dry and are then used for fuel, a purpose for which they are well adapted. In recent years they have also been used to some extent in the manufacture of other products, e.g. lignin, active carbon, plastics and ethyl alcohol. Logs may be left lying about for some time with no appreciable loss of tannin content, but logs that have been exposed to the weather a long time are not popular owing to their greater hardness and difficulty in chipping.

In the late nineteen-thirties, some thirty extract factories were functioning in Argentina and Paraguay but at the time of writing the number is believed to have been reduced to about two dozen.

Quebracho Extract
Solid quebracho extract is dark brownish black and of a crystalline semi-transparent nature. As a tanning material it belongs to the catechol class. The extract will break with a vitreous fracture and is very similar to cutch in general appearance. There are two forms of extract, the ordinary or untreated extract, not very soluble in cold water, and the sulphited or ‘cold water soluble extract’. There is also the powdered extract with a higher tannin content (83–84%). The ordinary solid extract is marketed in bags with the trade mark and the name of the factory or maker printed in black letters. With the sulphited extract on the other hand the printing or the markings are in red.

One of the drawbacks of the ordinary or untreated quebracho extract is that much of the tannin is not soluble in cold water and becomes precipitated and wasted in the form of sludge in the tanning liquor, the sludge itself being a nuisance in the tannery operations. With the sulphited extract these difficulties are removed or greatly reduced.
QUEBRACHO

The so-called soluble, cold water soluble, or sulphited extract is prepared by heating a quebracho solution with sodium bisulphite and sulphite (about 8% on a solid matter basis) at a temperature of 100°C or somewhat higher for several hours. The sulphite process for quebracho was discovered by two Italian chemists (LEPITIT and TAGLIANI) and has been described as follows: 'Messrs. Lepitit and Tagliani, after long experimenting, discovered that the sulphurous salts of the alkali metals such as sodium sulphite, bisulphite or hydrosulphite, would so perfectly dissolve the reds of quebracho extract as to keep them soluble, not only in cold water, but in the acid liquor of the tannin vat. They found also that these salts so acted on the soluble tannins of quebracho extract as to prevent their precipitation in sour liquors; in short, they found that by treating quebracho extract with sodium bisulphite or other sulphites under suitable conditions, all loss of soluble tannin was prevented and all the insoluble or difficultly soluble tannins were made available by solution.

' The application of this discovery to quebracho extract eliminated all of its objectionable properties; made its use possible under all tanning conditions and in combination with the sour liquors of all other tanning extracts, thereby adding fully 25% to its value by saving and utilizing the tannins which had previously been precipitated and thrown away. In fact, it is not going too far to characterize this discovery as one of the most important ever made affecting the leather industry. . . .89

Ordinary (untreated) quebracho extract has a high pH value and low salts and acid content. It has been said in regard to it, 'However useful the limited solubility of ordinary quebracho might be when once it has been introduced into leather, it causes such practical difficulties as to restrict very markedly the use of this material. It can be used in comparatively high proportions in hot liquors, provided the temperature is maintained, but will cause difficulties if the run-off goes into cold liquors. Some 10% of ordinary quebracho can be used in blended liquors, but if the amount so used is near the maximum solubility at any particular temperature, the sticky sludge of quebracho will be formed if the temperature falls.'23

The sulphited or soluble extract also has a high pH value and a high salts content and a low acid content. Most of the quebracho used in tanning today is in the sulphited form. It tans more rapidly than ordinary quebracho but its use does not result in such high tannin fixation in the leather as does ordinary quebracho23.
Tanning Properties
A notable characteristic of quebracho or quebracho extract as a tanning material is the speed with which it tans. It tans leather in about one-third the time required by oak bark. Another of its merits is its weight-giving property which renders it of special value in the tanning of sole leather. In tanning, quebracho is commonly mixed with other tans such as chestnut, hemlock, mangrove, oak bark, myrabolans and sumac. It is one of those tanning materials which, with suitable modifications or adjustments, may be used in the tanning of most classes of leather. It is in consequence a universally popular tanning material producing a mellow leather and imparting good strength, toughness, and firm feel.

Valuable as the sulphited extract may be, especially in regard to its speed of penetration of the hide or rapidity of tanning and its complete solubility, certain precautions are necessary, for its unrestricted or unlimited use may lead to trouble. In Argentina the sulphited extract has been used alone in the tanning of sole leather with poor results. The resulting leathers have been light and lacking in firmness, 'short fibred', and with poor resistance to wear.

Future Supplies of Quebracho
The natural stands of quebracho trees in South America have now been heavily exploited for three-quarters of a century and fears are felt in informed circles that supplies will become exhausted fairly soon if the present rate of cutting and the present methods of exploitation are continued. Different observers have given very different and very divergent estimates as to probable supplies of wood still available as has been ably pointed out by Mezey. However, a recent estimate for Argentina, believed to be reliable, places remaining supplies at about 105 million tons, which, with the present rate of exploitation, should last 50—60 years. Some have considered the period to be not much more than 30 years. Naturally estimates of this kind are difficult to make with any degree of accuracy.

It is unfortunate that wherever man has appeared in the quebracho areas accompanied by his domestic animals (cattle) the natural regeneration of the quebracho trees has virtually ceased, for grazing animals destroy the young trees as has already been pointed out. Remedial measures to counteract this are difficult to apply in practice. It has been suggested that where an area has been worked for quebracho a certain number of 'seed trees'
QUEBRACHO

should always be left standing, and grazing animals should be excluded from the area for about five years in order that quebracho seedlings may reach a fair height and so pass out of the vulnerable early stages. It would seem that Argentina has at last become conscious of the dangers that threaten the quebracho industry for in 1950 laws came into effect prohibiting the cutting down of quebracho trees for firewood and stipulating that all quebracho trunks and branches with heartwood greater than 8 cm. in diameter must be used for tannin production and not for other purposes.114.

Cultivation

Large scale cultivation of quebracho does not appear to have been attempted anywhere so far, either in South America or in other countries. Reasons for this are (a) the relatively good supply of wood from wild trees that has been available in the past and (b) the slow-growing nature of the tree and the time taken to reach 'exploitable' size, with the consequent expense and time-lag before any return may be expected from man-made plantations. The trees are very slow in maturing and the age of trees yielding commercial quebracho is commonly from 100—200 years. It is generally considered that trees under about 40—50 years of age are not worth felling for tannin extraction. There is justification for this view as young trees or trees much under half a century old have a much lower tannin content of the heartwood than older trees. In this respect quebracho resembles the European chestnut, another important source of tannin.

Wood of a thirteen year old tree of Scluzopsis lorentzii from Réunion was examined at the Imperial Institute, London, in 1931. The age and identity of the tree, named from herbarium specimens sent to Kew, were established without question. A portion of the trunk, in the form of logs (4—6 in. in diameter), and of main branches, were received. The logs were covered with bark which was about \( \frac{1}{8} \) in. thick, fairly smooth and greyish brown externally, and dark reddish brown on the inner surface. The sapwood was buff coloured and the heartwood pale reddish brown. For purposes of comparison a commercial sample of Argentine quebracho wood was obtained for analysis at the same time. It was found that the heartwood of the thirteen year old tree contained rather less than half the percentage (7—9%) of tannin of the commercial Argentine sample. It is obvious that an examination of quebracho wood from trees of different and known ages, with a
view to obtaining the tannin content at various stages of growth and the average age at which it reaches its maximum would be of special interest. It should indicate the earliest age at which quebracho trees, if cultivated for tannin, could be exploited. There is some doubt as to whether the rings in a cross section of a quebracho trunk, only visible in a polished section, are really annual rings and a true criterion of age.

With regard to the rate of growth of quebracho trees in their natural habitat, records made in Argentina on a few trees (communicated by letter) are of some interest. Growth in the early years of the tree's life is normally fairly rapid, but later the rate of growth becomes slow. Some half dozen trees at Santa Felicia (Santa Fé) known to have been planted 15 years previously were kept under observation for six years. When the observations commenced the trees varied in height from 6·7 to 9·5 metres and the circumference from 35 to 66 cm. The average increase per year was—circumference 3·25 cm.; diameter 1·04 cm. The tree with the greatest rate of growth showed an average annual diameter increase of 1·42 cm., while the tree with the lowest growth rate had an average annual diameter increase of 0·57 cm. The difference in growth rate among individual trees was attributed in part at least to the presence of some pine trees in the area which may have affected the growth of some of the quebracho trees more than others. The proportion of heartwood in trees of this age is relatively small. By ascertaining the amount of heartwood with a drill, it was estimated that the two largest trees averaged approximately 13·5 kg. of heartwood. Cultivated trees now known to be 40 years of age exist.

Seed of quebracho (both *Schinopsis balansae* and *S. lorentzii*) has been sent to various parts of the world in the past with a view to establishing small trial plots or even a few specimen trees at botanic gardens or experiment stations, but there appear to be few accounts of trees having thrived. Probably lack of care and of interest accounted for many of the failures, and it may not always have been unsuitable climatic conditions that were responsible. During the last 20—30 years seed of *Schinopsis balansae* or of *S. lorentzii*, procured from South America, has been dispatched from Kew to the following countries: British Guiana, St. Lucia, Trinidad, India (Punjab), Ceylon, Mauritius, Sudan, Kenya, South Africa, St. Helena, Queensland, New South Wales and New Zealand.

At an arboretum near Nairobi, Kenya, plants were raised from seed sent from Kew (obtained from Janta in the Province of
QUEBRACHO

Santiago. After ten years’ growth the plants were reputed to have had the appearance of bushes rather than trees, with little indication of a main stem. The plot they occupied had the appearance of a dense thicket. The fact that the plants were partly shaded by other trees may have influenced their growth. The climate at Nairobi is relatively dry and the average rainfall about 34 in. In Trinidad and Singapore plants were established but failed to thrive, which would suggest that the wet tropics may be unsuitable for quebracho as might be expected, although at St. Lucia (Réunion Experiment Station) and at St. Kitts (Old Botanic Station) healthy young trees were raised. In South Africa young trees have been established in the Midlands of Natal, but early trials in Zululand and the Transvaal were not successful. However, at Hanglip in the Cape Province some healthy young trees were established. At seven years of age they had reached a height of 8—12 ft. and the opinion was expressed that they seemed to prefer a certain amount of shade. At Calcutta and at the Cinchona Plantation at Mungpu young plants failed to thrive.
URUNDAY

Urunday and urunday extract, obtained from the wood of a South American tree (Astronium balansae) are now well known as tanning materials and are very similar in many respects to quebracho, the trees yielding these two tanning materials being related and belonging to the same family (Anacardiaceae).

The genus Astronium consists of about a dozen species, mainly medium-sized to large trees that occur from southern Mexico (and the West Indies) through Central and South America into Argentina. The woods are valued for their durability and strength and their handsome appearance and are favoured for furniture and cabinet work. They are also used for railway sleepers, bridge timbers, posts, building and construction work, also for axles for heavy vehicles. The woods are very similar, and are almost indistinguishable anatomically from those of Schinopsis or quebracho. They are, however, more ‘oily’ to the touch, have a more regular grain and a sharper differentiation between sapwood and heartwood than does quebracho.

Astronium balansae occurs in Brazil, Paraguay and Argentina, but it is mainly in Argentina that it has been exploited as a tanning material. It may range in height from 30—60 ft. with a trunk diameter of anything up to 4 ft. It occurs largely in fairly dry areas (the Chaco) which accounts for the smaller dimensions being the more usual. It is called ‘urunday’ in Misiones, ‘urunday pardo’ in Corrientes and ‘urunday-pichai’ in the Chaco. It may also be referred to as ‘urundai’ or ‘urundel’. The name ‘urunday’ may also be applied in South America to some trees not used in tanning. There is relatively little sapwood in the trunk of Astronium balansae and sapwood and heartwood are sharply defined. The heartwood is reddish brown in colour and darkens on exposure to light.

In northern Argentina Astronium balansae is reputed (Parado) to cover an area of about 80 square kilometres (between 55° and 60° longitude and between 24 and 28° latitude) in the districts of S.W. Misiones, N. Corrientes and Santa Fé, and E. Formosa. It commonly occurs along with quebracho (Schinopsis balansae). In general, the trunk is not so stout as that of quebracho but the tree is taller. The bark contains about 12% tannin or three times as
URUNDAY

much tannin as that of quebracho and has less ross. The abundance or density of the trees in Argentina varies considerably in different areas, from one tree per hectare where the trees are sparse to 61 trees per hectare in the richest stands (according to Pardo), the overall average working out at about 35 trees per hectare.

The exploitation of urunday and the production of extract is a very much more recent development than the production of quebracho extract. Preparation of the extract follows the same lines as that of quebracho. Production in the Argentine has averaged about 2,600 tons of extract a year, which is only a fraction of that of quebracho extract. An output of 816 tons in 1935 had increased to 5,256 in 1938, a peak year. Subsequently production declined.

The tannin content of munday wood (heartwood) is usually 11—12%, but may reach as much as 16% (soluble non-tannins 2—3%). It is therefore appreciably lower than that of quebracho (about two-thirds). The tannin content of the sapwood is only 1—2%.

A hundred pounds of urunday wood may be expected to produce twenty pounds of solid urunday extract containing 63—65% tannin, 6—7% soluble non-tannins and 5—8% insoluble matter. Commercial urunday extracts may contain rather less tannin and more non-tannins than quebracho extract.

The tanning properties of urunday extract are rather similar to those of quebracho. It is a tanning material of very high pH value and moderate salts content. The acid content is low. Both urunday and quebracho belong to the catechol group of tannins. The untreated and the bisulphited extracts of urunday possess a more intense colour than quebracho. Leather tanned with urunday is said to darken more on exposure to light than that tanned with quebracho. The two are similar in regard to speed of penetration, but urunday is claimed to produce a leather of greater weight and firmness.

It is believed that some of the so-called urunday extracts on the market may be mixtures of urunday and other materials.

The opinion has been expressed in Argentina that reafforestation with urunday would be easier than with quebracho and that whereas the quebracho tree reproduces only by seeds and under ideal conditions the urunday reproduces readily through shoots. From this it would seem that, unlike quebracho, the urunday tree may be easily grown from cuttings.
CHESTNUT

The extensive use made of chestnut and quebracho wood or their extracts in tanning is rather remarkable when it is remembered that less than a century ago woods were quite unknown in tanning, for barks were mainly used, particularly oak bark in Europe and hemlock bark in North America. In France and certain other European countries the exploitation of the common or European chestnut (Castanea sativa) for tannin assumed very large proportions in the latter part of the nineteenth century and the early part of the present century, as did the exploitation of the American chestnut (Castanea dentata) in the United States before the catastrophe of its virtual extinction through disease (Oriental chestnut blight).

History of Chestnut Tanning
It is stated that the tanning properties of chestnut wood were first brought to notice by Michel, a French chemist of Lyons, in about 1820. His property happened to be enclosed with chestnut fencing or chestnut stakes, and he noticed the black discoloration after rain where the wood had been in contact with metal. He conceived the idea of reducing chestnut wood to small chips and boiling them in water, subsequently concentrating the decoction to an extract. This he used for dyeing silk and found it gave a fine, fast, blue-black colour, and also appreciably increased the weight of the silk. Michel also used finely chipped chestnut wood as a substitute for ground oak bark in tanning or preparing leather. About 50 years later Koch used the wood extract, as distinct from the finely chipped wood itself, for tanning. At first the extract was used only for tanning heavy hides, but its use as a tan became more general after 1878, when GORDOLA discovered a method of removing the colouring matter which stained the hide.

About the same time that Michel became interested in chestnut wood in France, interest in chestnut for tanning in America began to develop. For in 1819 William Sheldon communicated to the American Journal of Science his discoveries and views on the 'Application of Chestnut Wood to the Arts of Tanning and Dyeing'. Sheldon maintained 'that the chestnut wood contains twice as much tannin as ross'd oak bark' (presumably an American oak is intended) and that he had uniform success with it in a great
variety of experiments in tanning and dyeing. It was not until many years after Sheldon's experiment that chestnut wood was used on a large scale in the United States. Chestnut bark had been used in England for tanning as a substitute for oak bark long before the wood attracted attention as a source of tannin, and was known to tan very much quicker than oak bark but to yield an inferior leather.

The European Chestnut
The European chestnut tree (Castanea sativa), known also as Spanish or Sweet Chestnut and of importance mainly for its nuts, is widespread in Europe in both the wild and cultivated states. As it has been cultivated for so long and has become quite naturalized in many parts of Europe, it is now difficult or impossible to indicate with any certainty its natural range of distribution, particularly in the more northerly areas of its occurrence. The tree occurs wild or apparently wild throughout the whole of southern Europe, in Algeria, Tunis, Asia Minor, the Caucasus and northern Persia. Some of the best stands or groves of chestnut are to be found in Italy, France, Spain and Corsica, where the nuts may constitute an important source of food for man and beast. It is in these countries, where the trees are very prevalent, and particularly France and Italy, that preparation of the tanning extract from the wood has been mainly developed. Other extract-producing countries in Europe are Spain, Yugoslavia and Switzerland. In France the tree is particularly common in Provence, Dauphiné, the Cévennes, Périgord, Limousin and all the central plateau. In the north of Spain, where the tree appears to attain its maximum development and to be truly wild, extensive forests occur, especially in Galicia, Asturias and Vizcaya.

The tree reaches 100 ft. in height and may develop an immense girth. It is more fastidious with regard to soil than most forest trees, and rarely thrives in those areas that are of a chalky or limy nature or in stiff clay or peaty soil. The bark of the young stems is at first smooth and olive green, but soon becomes greyish white, and after 15—20 years develops into a thick brown bark deeply fissured longitudinally. The tree lives to a great age but the timber deteriorates, due to the development of shakes or decay in the heartwood, at a comparatively early period, long before the tree approaches the end of its life span. The wood does not appear to develop a sufficiently high tannin content to warrant exploitation until the tree is about 30 years old. It is usually considered that
Chestnut Trees in Italy (Lanzo Valley, near Turin). Italy is the world's largest producer of chestnut wood extract for tanning

By courtesy of Sig. E. Durio, Fabbrica Nazionale Estratti Tannici, Torino

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Chestnut trees for extract manufacture should be not less than 50—70 years old. The wood of trees grown in the more northerly areas or colder climates has been found to have an appreciably lower tannin content than wood from trees farther south where warmer conditions prevail. This has also been found to hold with the American chestnut (Castanea dentata) in North America. In southern Europe it is considered that trees from the mountainous districts are better for extract manufacture than those from the plains.

Tannin Content
The bole or trunk of a mature chestnut tree consists of about 8% bark, 30% sapwood and 53% heartwood. The heartwood is richest in tannin but the sapwood, being fairly rich in tannin, is not separated from the heartwood in the preparation of the extract. The bark, however, is removed, for it has a deleterious effect on the extract. Its presence imparts a darker colour, and it is also much richer in sugars (4.7% as against about 1% for the wood), which results in a higher soluble non-tan content in the extract.

The usual tannin content for the wood of chestnut trees grown in northern Europe is 7—8%, and that for southern Europe 10—11%13. A tannin content of 12—13% or higher is not unusual in Italy, Spain and Corsica41, and as much as 20.5% tannin has been recorded from a sample of air-dry wood from Corsica13. Rotten or decayed wood is undesirable, for apart from a lower tannin content it yields an excessively dark coloured extract. The tannin content of decayed wood may be only half that of sound wood, the loss due to decomposition being so great. The wood does not appear to attain its maximum tannin content until trees are at least 30 years old.

Some interesting observations have been made on the effect of the age of the tree on the tannin content of the wood. An 8 year old tree contained only 1.3% tannin, an 11 year old tree 3.5%, a 16—18 year old tree 6.3%, a 37 year old tree 10%, and a 71 year old tree 10.7%. The tannin content of the bark, however, is not dependent upon age in this way. An 8 year old tree was found to contain about 12% tannin, or roughly the same percentage as 16, 37 and 71 year old trees83.

The bark of mature trees may be considered to have an average tannin content of about 10% tannin, although tannin content may vary from 8% to 14%. The bark has been used as a substitute for oak bark in tanning, but is regarded as inferior to it.
One of the advantages of the wood for extract manufacture is the low percentage of soluble non-tans present. The chipped wood may be used direct in tanning, but it is more usual and more satisfactory to employ chestnut in the extract form. In America samples of the root bark of the American chestnut (from stumps) have been found to contain over 30% tannin and root wood over 17%. Living or freshly-felled trees contain much lower percentages. Dead or fallen chestnut leaves have a comparatively high but variable tannin content, and have been considered as a source of tannin. The dried prickly husk of the chestnut fruit contains 10—13% tannin, and the brown outer skin enclosing the kernel 7—9%.

The European Chestnut Extract Industry
The phenomenal and rapid growth of the French chestnut extract industry in the latter part of last century may be gauged from the fact that in 1886 there was only one factory in operation, but thirty years later some forty factories were operating with an output of about 100,000 tons of extract per annum, the factories being situated mainly in Savoie, Lyonnais, Limousin and Corsica. Proximity to good stands of chestnut, to a water supply and to rail or other transport facilities naturally played an important part in the location of extract factories. One of the largest factories (operating near the station Cornil not far from Tulle in Corrèze) used some 34,000 tons of wood annually and produced 8,500 tons of extract or about one-twelfth the total production of France. Before the war some three dozen extract factories were in operation in France, handling in all about 800,000 tons of chestnut wood a year. In recent years, the yearly output of chestnut extract, expressed on a basis of metric tons of pure tannin, has been 24,000—26,000 tons for Italy and 22,000—24,000 tons for France, while Switzerland produces only some 2,000 tons. It is interesting to observe that in these countries the percentage of chestnut extract in the total amount of vegetable tanning material used is as follows: Italy 95%, France 66%, Switzerland 57%. In contrast to this the figures for the United Kingdom were only 2—3% and for Germany 17%. In European countries chestnut extract is now frequently blended with oak wood extract before use in tanning, this combination having proved very satisfactory.

The Italian chestnut extract industry has made great strides in recent decades. There are more extensive stands of chestnut in Italy than in any other European country. During the Second
Chestnut logs in one of the yards of a large Italian Chestnut extract factory

Ground Chestnut Wood after leaching or extraction of the tannin: it is used as fuel in the factory furnaces

By courtesy of Sig. E. Durio, Fabbrica Nazionale Estratti Tannici, Torino
World War and the years immediately following, much chestnut wood had to be used as fuel which might otherwise have been used for tannin extract manufacture. There are over three dozen extract factories in operation. These are situated mainly in northern Italy, especially in north-western Italy near the French border. A good account of the chestnut extract industry has been given by Bravo.

A well-developed chestnut grove may have 100 trees to the hectare, spaced at 10 metres or 70 trees spaced at 12 metres. With the latter spacing, each tree would yield about 5 steres or cubic metres of wood, or 350 cubic metres to the hectare, equivalent to about 131 tons in weight. A similar yield could be expected with the closer spacing. Although the trees would be smaller there would be more of them. Some French chestnut plantations have been known to yield over 500 cubic metres per hectare, while others do not exceed 200. It is considered that 100 tons of wood would yield about 17 tons of liquid extract (27—30% tannin) or 8.5 tons of solid extract (60—63% tannin).

In the early days of the French extract industry much ruthless felling of good nut-yielding trees and over-exploitation in general took place. It was argued that felling should have been restricted to old trees—trees past their prime. The excessive cutting out of the more readily accessible stands of chestnut and the spread of chestnut bark disease or 'maladie de l'encre' (Mycelophagus castaneae or Blepharospora cambivora) were largely responsible for the rapid decline of the French extract industry that subsequently took place.

The extract factory owners generally worked through agents in the chestnut districts who would contact the owners, large and small, of stands of chestnut trees in their areas. Small proprietors would often sell their trees at very low prices in order to obtain ready money. After felling, the trunks and larger limbs would be cut into lengths and those of large diameter split with wedges. The chipping or rasping of the logs is carried out by specially designed heavy machinery at the factory, and is always across the grain of the wood. The chipped or fragmented wood is then placed in a series of large copper or wooden vats and treated with successive charges of hot water at about 70°C, which extracts the tannin. The liquor circulates from one vat to another and is finally separated, filtered and evaporated down to extract. The evaporators are somewhat similar to those used in sugar factories. Extraction in some factories is carried out under pressure. This
method has the advantage of giving a higher total yield of extract, but the extract is generally inferior, for under pressure a certain loss of tannin occurs and more non-tans are extracted. The extract obtained is darker than that obtained by the open vat method.

The methods used by different factories for decolorizing the extract are said to be largely kept secret. The colouring matter or dye obtained in the process has been used for dyeing silk. The extracted wood may be put to various uses, such as fuel for the furnaces, for briquettes, charcoal and the manufacture of wood alcohol.  

The American Chestnut Extract Industry

The development of the American chestnut extract industry took place a little later than the development of the French industry, but was even more rapid. In the early part of the present century production was in the neighbourhood of 140,000 tons of extract per annum, and chestnut extract constituted two thirds of all the tannin used in the United States. To the American tanner the new extract had many advantages over the various barks which had hitherto been mainly used, and could be much more economically and expeditiously handled. In an hour and a half, a tank-car of the liquid extract could be automatically emptied into the storage vats, this amount of extract being equivalent to twelve car-loads of bark, which would normally take two men four days to handle. Furthermore, the extract would be ready for immediate use, whereas the grinding and leaching of the bark would take a week. The development of chestnut extract brought about many fundamental changes in the American tanning industry.

The preparation of the extract was largely confined to the southern states, particularly Virginia and North Carolina. Trees in the northern states were found to have an appreciably lower tannin content and to be less profitable for extraction than those in the south. The American chestnut was widely distributed, being found from southern Maine westwards to Indiana and Michigan and southwards along the Alleghany Mountains to Alabama. It probably attained its finest growth on the western slope of the southern Alleghanies. As with the French industry, factories were established in good chestnut areas and where suitable transport and water facilities existed. The industry is one requiring considerable quantities of water. Every cord (160 cubic feet) of wood leached in open extractors requires some 1,400 gallons of water. The yield of 25% liquid tannin extract from a cord of
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Wood is stated to be from 700—900 lb. Most of the extract imported into Great Britain in the past has been in the liquid form, the American product containing 29% tannin and the French and Italian 27%.

In American factories the wood is said to be less finely chipped, or not reduced to such small fragments as is customary in French factories. The machine commonly used and termed a 'hog' would grind about 5 cords of wood per hour. Some factories employ disc chippers similar to those used in a wood pulp reduction plant. The factories making chestnut extract are complicated and specialized and require considerable capital for their establishment.

The decline of the American chestnut extract industry has been due, like the French industry, to reduced supplies of wood, caused mainly by the wholesale destruction of trees, both mature and immature, from disease. The destruction of the American chestnut by the Oriental chestnut disease or 'chestnut blight' (Endothia parasitica) is well known, and may be regarded as one of the major tragedies of the plant world. Owing to this widespread destruction of the growing trees, use has been made of the dead trees and of stump and root wood for tannin.

**Tanning Properties**

In tanning, chestnut extract is rapid in its action on hides and skins and gives a firm leather. Used alone, however, it has disadvantages and may give a more reddish colour to the leather than is generally desired. It is generally used in combination with other tanning materials, such as quebracho, mimosa, myrabolans and valonea in the preparation of sole leather. Chestnut, especially in the form of warm strong liquors, has been valued for giving uptake and fixation in the final stages of heavy leather tannage.

The extract is marketed in both the solid and the liquid form, products of different makers varying somewhat in tannin content. With the solid extract (in block or powder form), the tannin content is generally from 56—76% (non-tans 5-5—9.5%) and the liquid extract 29—49%, according to concentration (non-tans 5—10%). The American extract is generally darker in colour than the French.

The chemical nature of the tannin in chestnut wood does not appear to be clearly understood. The tannin is of the pyrogallol class and possesses a low pH value and salts content and a rather high acid content. It has points of similarity with oak.
CHESTNUT

tannin but is not identical with it\textsuperscript{153}. On hydrolysis with dilute mineral acid, ellagic acid, glucose, gallic acid and quercetin have been obtained, and it would seem that the tannin in the wood is of a mixed nature. A marked difference in the nature of the tannin of young chestnut leaves and of old chestnut leaves has been found to exist. What is known of the chemistry of chestnut tannin has been discussed by Balfe, Gnamm, Rottsieper, Nierenstein and others.

Other Chestnuts as Tan Sources

Other chestnuts or species of Castanea are known to have fairly high percentages of tannin in wood or bark, but for various reasons have not been exploited. Some are not prevalent or occur in remote regions, while others do not attain large dimensions. In the Dutch East Indies the wood of Castanea (Castanopsis) argentea has been shown to be rich in tannin and to give good results in small tanning trials\textsuperscript{171}.

In India and Burma the wild chestnuts belong to a different, though closely allied, genus, Castanopsis. The two most promising species investigated appear to be Castanopsis tribuloides and C. argyrophylla in Burma, the wood of which has been found to contain respectively 16\% and 12\% tannin. The bark of these species is also fairly rich in tannin: 13—19\%. Small-scale tanning trials with these materials proved satisfactory\textsuperscript{13}. In Burma, wood collected in the winter months is richer in tannin than that collected in the summer. The same has been found to apply to oaks in Burma.

The Chinese chestnut (Castanea mollissima), of interest on account of its edible nuts and its resistance to 'chestnut blight', has been shown to be fairly rich in tannin. Trees grown in the United States of America have been shown to contain 8\% tannin in the wood at 16 years of age and 12\% with 25 year old trees, which compares favourably with the European chestnut. However, on account of the long time necessary to produce commercial stands, the prospects of development with this species are not considered very promising in the United States\textsuperscript{161}. 

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The use of oak bark, from the two common European oaks *Quercus robur* and *Q. petraea*, in the tanning of leather is very old and goes back hundreds of years. In contrast to this, the use of oak wood on a large scale for tanning purposes is comparatively recent. Oak wood is never used as it is in tanning, the percentage of tannin being relatively low (compared with woods like quebracho and chestnut) and it is only the extract prepared from the wood that is used in the tannery.

**Kind of Oak Wood required for Extract**

The sapwood and the wood of young oak trees or trees under 20 years of age contains very little tannin (under 2% and often less than 1%) and is quite unsuitable for tannin extract manufacture. For the making of extract the wood must contain not less than 5% tannin. Only the heartwood of middle-aged or old trees contains sufficient tannin (usually 6—9%) for extract manufacture. Such wood, however, long famous for its durability and strength, is valuable as timber and much sought after for all manner of purposes. In the form suitable for usable timber or lumber it is far too valuable for use in extract manufacture and normally it is only where waste wood is available in quantity, as in the making of furniture, parquet flooring, oak barrels etc., that sufficient waste heartwood becomes available for the making of extract. This applies in various Continental countries and especially in central Europe. In the British Isles the manufacture of oak wood extract has not so far been undertaken.

Oak wood extract is said to have been first prepared at Zupanja in Yugoslavia as long ago as 1883 but manufacture did not become general until very much later. This may have been because the early extracts were of a very inferior nature with large proportions of insoluble matter (causing much sludge in the tanning liquor). Very great advances have been made in the technology of oak wood extract manufacture and the present-day extract is greatly superior to that manufactured formerly. Countries where the extract is now manufactured include Russia, Yugoslavia, France, Sweden and the United States, different species of oak being used in the latter country. It is in Russia that the manufacture of the extract...
OAK WOOD

has been most intensively developed. Very extensive forests of oak occur in that country. In the central part of European Russia it is mainly the pedunculate oak (*Quercus robur*) that is used and in the southern districts the sessile or Durmast oak (*Q. petraea*). As with oak bark and its tanning properties, there appears to be no discrimination made between the pedunculate oak and the sessile oak with regard to the use of the wood in extract manufacture.

*Distribution of Tannin in Oak Wood*

As the trunk of an oak tree increases in size with age, the proportion of sapwood decreases and the amount of heartwood steadily increases. As the heartwood develops, the amount of tannin present in it slowly increases. The percentage of tannin present in the heartwood appears to be greatest in the outer portion or periphery (the part next the sapwood) rather than in the central part of the heartwood or the centre of the trunk. In an investigation carried out by PAETZLER, with a tree over 100 years old, it was found that the sapwood contained only 1.1% tannin, the outer zones of the heartwood 9.3—9.8%, the middle zones 8—9% and the central zones 6.8%. Other investigators have had similar results. Whether the percentage of tannin in the heartwood alters appreciably with height from the ground seems open to question. The tannin present in oak wood does not seem to be much affected by the death or felling of the tree, and timber that has long been in use still retains its tannin. This is in rather marked contrast to oak bark where the tannin may be much reduced if the peeled bark is exposed (underside uppermost) to the weather and to rain.

*Oak Wood Extract Manufacture*

The bark, if still present, is removed from the wood before it is reduced to small fragments by mechanical means, as with quebracho and chestnut wood. Various different types of power machinery are in use for this. The comminuted material is then subjected to hot water treatment on the counter-current principle as practised with other tannin extracts—usually in batteries of 6—8 units. In modern factories the final liquors are clarified, freed of insoluble matter, and often sulphited—especially in Russian factories—before concentration and evaporation.

In the early years of oak wood extract manufacture, the extract was usually marketed in liquid form (tannin content about 26%)
but for some years it has been mainly prepared in the solid form (tannin content 60—65%). A still more recent development has been the preparation of the extract in the powdered form—with a still higher tannin content. The quality of the extract is now largely judged by the tan/non-tan ratio and colour, apart from insoluble substances which have been reduced from about 18% in extracts manufactured 40 years ago to 5—4% in present-day extracts. Improvements of similar magnitude have been made in regard to colour and tan/non-tan ratio, Russian factories in particular having been said to have gone to great pains to effect these improvements.

Oak wood extract yields a somewhat darker coloured leather than oak bark. It is employed mainly for the tanning of sole leather and other heavy leather, for it has good weight-giving properties. It is usually mixed with other tanning materials in order to obtain modification of colour. Oak wood extract is a tannin of the pyrogallol class. It has a rather high pH value for a tanning material of this type and possesses a moderate salts and acid content. It is not completely soluble at low temperatures.
CUTCH

The name cutch was formerly used only for the solid extract obtained from the heartwood of *Acacia catechu*, a common tree of India, Pakistan and Burma. This extract is used for dyeing, for medicinal purposes and, in the East, for chewing as a constituent of the betel quid. It is only used to a limited extent in tanning. The name cutch has, however, come to be used for other extracts among tanners in Great Britain, particularly those prepared from mangrove barks. In the following discussion the name is used only in its original sense.

*Early History*

The use of cutch in India is believed to go back as far as history relates. There was also a trade in it with China from the earliest days of seaborne trade, the product changing hands at Malacca. Among European writers one of the first to mention cutch was BARBOSA (A.D. 1514) who refers to 'cacho' being exported from Cambay to Malacca. The name 'cacho' or 'kachu' is that used in Kanara for cutch and may account for the present name 'catechu'. GARCIA DE ORTA (1574) gave an account of the tree and the method of preparing the extract. Cutch became known in Europe in the seventeenth century. By the early nineteenth century it was of some importance commercially and was much used in France. The first cutch to reach European countries had been re-exported from Japan and was termed 'terra japonica', being thought at that time to be a natural earth or of mineral origin. It was about the same time that gambier (see Chapter 31) became known in Europe. It was also called 'terra japonica'. Both were much used for medicinal purposes in Europe but later cutch was largely supplanted by gambier, for gambier proved to be usually a purer and more uniform product.

*Botanical Sources*

*Acacia catechu* is widely distributed in the Indian Sub-continent, and occurs also in some of the adjoining countries and in tropical East Africa, but cutch is not prepared from it in Africa. The tree is widespread in its distribution and may be gregarious or sporadic. It is deciduous, thorny and usually only of moderate
EXTRACTION AND PREPARATION

size. The grey or greyish brown bark peels off in strips which may hang from the tree. The pale yellow flowers are in cylindrical spikes and the pods thin and strap-shaped up to $3\frac{1}{2}$ in. long with 5—6 seeds. The wood is very hard, the sapwood being yellowish white and the heartwood light or dark reddish brown. It seasons well and is very durable, being much used for agricultural implements, rice pestles, oil and cane mills etc.

Three distinct varieties or forms of the tree have been distinguished by PRAIN\textsuperscript{142}, as follows:

(a) *catechu* proper: Calyx, petals and rachis covered with spreading hairs. This is the most northern form and is the 'kath' or pale-cutch-yielding form of Kumaon (referred to later). It occurs also in the Punjab, Garhwal, Behar, Ganuam and the Irrawaddi valley of Pegu and Upper Burma.

(b) *catechuoides*: Calyx and petals glabrous but the rachis puberulous. This is the common cutch-yielding form of Burma and the source of the exported product. It is commonly known as 'sha'. It also occurs in Assam, Bengal and other parts of India.

(c) *sundra*: Calyx, petals and rachis, all glabrous. This, the southern and western form, and the source of cutch in the Madras and Bombay Presidencies, is very common from Coimbatore northwards to the Deccan, Kanara and the Konkan. It has also been recorded from northern Burma.

In some parts of India *Acacia catechu* is reputed to yield very little cutch. Natives felling trees for cutch commonly make a practice of chipping a piece out of the bole and inspecting the heartwood to see if it shows white spots. If these are present the tree is considered to be one that will give a good yield of cutch and worth felling, otherwise it may be left. Experiments as far back as 1890 (by Dr. Worth) to test this belief showed that the spotted wood of Indian and Burmese origin does give more extract as well as more catechin than the unspotted heartwood\textsuperscript{96}. The white specks are due to deposits of a whitish substance in the vessels.

*Extraction and Preparation*

Although the details of cutch manufacture may vary to some extent from one district to another, the same general principles are observed. Trees of fair size with well-developed heartwood are felled and the trunk and main branches cut into lengths. The sapwood, which contains little or no cutch, with the bark, is removed. The heartwood is then reduced to chips, commonly 1—2 in. broad, which are placed in earthenware pots of water—
CUTCH

holding 3—4 gallons—and boiled for several hours. The pots are commonly arranged in a series from a few in number to 2 or 3 dozen according to the size of the outfit. After several hours boiling, the liquor becomes much reduced in volume and dark coloured. The liquor from several pots is then poured into a single large metal cauldron or pan and further boiled and stirred until it acquires the consistency of a thick syrup. It is then poured into wooden moulds lined with leaves, where it sets on cooling into a brick-like mass. The leaves used are commonly the large leaves of *Dipterocarpus tuberculatus*. Sometimes the cutch is moulded while still soft into rounded balls, flat cakes, or other shapes. In some districts the liquor, after the first boiling, is poured on to a fresh lot of chips and again boiled, but this is not usual. By these methods the yield of solid cutch is from 3—10% of the weight of the wood. Sometimes the chips are boiled down a second time but very little cutch is extracted with the second boiling.

It is common for three men to work together. One man cuts down the trees and uses cattle to drag them to the site of the furnace. The second man removes the sapwood and chips the logs into small pieces. These are taken over by the third man who attends to the furnaces and boilers.

With this traditional method of preparation, much of the cutch present in the wood is not extracted and so is wasted. Experiment has shown that, if the wood were to be reduced to a finer state of subdivision before boiling, a much higher yield of cutch would be obtained. Experiments with wood in the form of the usual chips and in the form of sawdust and shavings (as produced by a carpenter’s plane) showed that when ordinary chips yielded 3·8% of extract the sawdust yielded 12% and the shavings 15·1%. It has also been shown that 10 parts of water to one of wood or chips is ample for extraction and that the first boiling need not exceed half an hour.

Kinds of Cutch

The method of preparation already described yields the common dark catechu or Pegu cutch used for industrial purposes. Pale catechu or ‘kath’, a pale cinnamon coloured biscuit-like substance of a crystalline nature, is a much more valuable commodity which is used throughout India in betel chewing and for medicinal purposes. It is simply the crystalline portion of a concentrated decoction of *Acacia catechu* wood. Crystallization is generally hastened by placing twigs in the decoction, the crystals that form
on the twigs being removed and pressed together into cubes or cakes to constitute the 'kath' as marketed. Filtering through sand in a crude fashion may be employed to separate the crystals, but this naturally tends to contamination with sand.

A third form of cutch is that commonly known as 'keersal' or 'khersal', a naturally-occurring deposit in the wood of *Acacia catechu* that is sometimes present in cavities in the wood. When found by woodcutters, in small crystalline pieces, it is generally carefully collected, being valued by the Hindus as a medicine and fetching a high price. Like kath it consists chiefly of catechin.

Dark catechu consists mainly of catechu-tannin with but little catechin, while pale catechu or kath consists mainly of catechin with but little catechu-tannin. It has been pointed out by Puran Singh that a pure form of catechin or kath could be obtained by first treating wood of *A. catechu*, preferably in the form of shavings, with wood alcohol, the catechin being completely soluble, and then evaporating off the alcohol. The catechu-tannin remaining in the shavings could then be extracted by the ordinary native method.

In the past, ordinary cutch or dark catechu has been marketed in many different forms, being generally known in the trade by the area from which it originates. Burma was the chief producer. Half a century ago a large trade existed in it but this declined as cutch was replaced by cheaper materials—mangrove bark extract and aniline dyes. It is considered unlikely that the trade in cutch is ever likely to resume its former proportions.

*Nature and Uses of Cutch*

Cutch as imported is in broken, irregular, dark brown or blackish masses with a dull, rusty brown external surface. Often fragments of the leaves used in the moulds are still attached. When fractured, the surface is glossy although small air holes may be present. The material is hard and very brittle, odourless with a bitter taste and sweetish, astringent after-taste. It is only partly soluble in cold water, giving a brown magma, but almost entirely soluble in boiling water. It consists mainly of catechu-tannic acid (25—35%), catechin (2—10%), quercetin and catechu red. The chemistry of cutch has been dealt with by Nierenstein, Perkin and Everest, and Rottsieper.

As a tanning material used alone, cutch gives a harsh leather, often showing a yellow stain, and is not regarded as very satisfactory. When used for leather, it is usually with heavy leathers
A primitive tannin extract factory: the preparation of cutch (Acacia catechu)
in India

where a dark reddish brown colour is desired, its use being as much that of a dye as a tan. It has been freely used in the past in the leather industry, especially the English and Italian leather industries. It is extensively used for treating fishing nets to impart long life which it does in a highly satisfactory manner, a fast dark brown colour being imparted at the same time. It is also used for other fabrics liable to be in contact with water, such as sails, tents, canvas for travel goods etc. Another use for cutch has been for combating deposits in boilers. Formerly cutch was much used for dyeing, particularly cotton and silk, but was later replaced by aniline dyes. In medicine, cutch may be used in the same way as gambier, being a powerful astringent.
In the south-western portion of Western Australia open, park-like forests of the wandoo occur (Eucalyptus wandoo syn. E. redunca var. elata). They occupy the low-lying country to the east of the jarrah belt or the eastern escarpment of the Darling Range. The wandoo trees commonly reach 50—60 ft. in height with an average girth of about 6 ft. at breast height. Both the bark and the wood are used as commercial sources of tannin, a solid extract ('myrtan') being prepared from them in regions where they occur. At first, extract was made only from the bark, but later bark and wood were used simultaneously. The tannin in the bark may vary from 13—21% and in the wood from 8—13%. In the wandoo forests, 30—35 tons of raw material suitable for extract manufacture (i.e., wood and bark) may be obtainable per acre, the larger branches or limbs being used as well as the trunks. Single trees may yield up to 6 or 7 tons.

Plate XI b. A modern tannin extract factory: the preparation of Myrtan or Wandoo extract in Western Australia: logs of Wandoo (Eucalyptus wandoo) in foreground

By courtesy of Paul Popper Ltd.
WANDOO EXTRACT.

Extract preparation is similar to that with chestnut and quebracho wood, except that the material is dealt with in the fresh or green state and not dried first as with chestnut. Heavy-duty rasping machines reduce the material to a pulp, in which form it is fed to autoclaves and the tannin leached out by the counter-current press leach method. The liquor is then concentrated in triple-effect evaporators to a concentration of 18—20 % moisture and run into gunny bags (approximately 1 cwt.) to cool and harden, in which form it is exported, as with wattle extract.

The preliminary work with ' wandoo ', ' myrtan ' or ' redunca ' was carried out in the early nineteen thirties. In 1935, 1,400 tons of extract were exported. This had increased to 8,500 tons in 1941 when three extract factories were functioning, one at Belmont on the Swan River and two at Boddington; later a fourth was established. Only a small proportion (less than 5 %) of the extract produced is used in Western Australia, the remainder going to the eastern states of Australia or for export. The approximate composition of the commercial extract, as exported, has been given as follows: tannin 60—63 %; non-tans 17—20 %; insolubles 1.5—2 %; moisture 17—20 %. Colour, estimated by means of a Lovibond tintometer on standard solution of the extract, gives 3—4 reds; 10—14 yellows. A powdered extract with a higher percentage of tannin (69—70 %) and a moisture content of 9—10 % has also been manufactured.

In tanning properties, wandoo extract or myrtan is somewhat similar to chestnut extract, but produces a firmer leather. With the shortage of chestnut extract it has proved a welcome substitute in many quarters. It is well suited for blending with other tanning materials, especially in sole leather tannage. It gives a somewhat paler leather than chestnut extract but penetrates more rapidly. On exposure to light, the colour of the leather darkens. The extract consists mainly of tannins of the pyrogallol class with a small proportion of catechol material. It yields more sludge than is the case with many tanning materials. As a retanning agent for chrome-tanned leather it is claimed to possess many advantages, such as ' smooth and strong grain, good colour and break, as well as a round feel '.

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TIZRA

**TIZRA (Rhus pentaphylla)** is a well-known tanning material of Morocco and of other parts of North Africa. Its use in tanning, especially in Morocco, is considered to go back to very early times, and it has long been used in the production of Morocco leather. The roots and the heartwood of this shrub or small tree are the parts that are richest in tannin, and which are mainly used.

![Figure 4. Tizra (Rhus pentaphylla): the heartwood has long been used for tanning in Morocco and other parts of N. Africa; it has been used in the production of Morocco leather](image)

Tizra, or 'tizrah', also referred to as 'tizerah', 'tisra', 'tesera', 'tazad' or 'seqqoum', has a fairly wide distribution. It occurs more or less throughout the whole of the western portion of North Africa, in the Canary Islands, in Sicily and other countries bordering on the western Mediterranean. It exists in fairly large quantities on the lower slopes of the Atlas mountains in Morocco and in other parts of that country. In parts of Algeria and Tunisia it is also common. It usually occurs as a much-branched shrub or small tree, generally not more than 10—12 ft. in height, and in general appearance not unlike the hawthorn. The branches are greyish in colour and stout, woody spines or spinous branchlets are present. The leaves are rather small and narrow and divided into 3—5 segments. The flowers, which are unisexual, are small and
somewhat inconspicuous, and are produced in small panicles or bunches in the axils of the leaves. The fruits, which are about the size of a large pea, have a single large seed. They are reddish yellow when ripe, and are sometimes produced in great abundance. Each fruit bears three peculiar small tubercles near the apex.

A notable characteristic of the tizra shrub is its slow rate of growth. It has been said that plants that are considered a good
or suitable size for cutting may be as much as 200 years old. This extremely slow rate of growth unfortunately militates against the cultivation of the tree on plantation lines as a source of tannin. The stems or trunks need to be about 6 cm. in diameter for use as a source of tannin, for it takes some time for heartwood, which alone is rich in tannin, to develop. The tree is well adapted for withstanding arid conditions, and has been used in Morocco in soil erosion control. In some areas the trees have been largely cut out or over-exploited, with the result that supplies of the wood for local tanning are more restricted than formerly and have to be obtained from the less accessible areas.

The wood of tizra is extremely hard and heavy (sinks in water) and is capable of taking a high polish. It has been used to some extent in cabinet making when obtainable in suitable sizes. The sapwood is yellowish in colour and the heartwood reddish brown. There is often very little sapwood. The trunk and the main roots and branches are chopped into small pieces for use in local tanneries. The twigs and branches chopped up may also be marketed, but are of less value as they possess an appreciably lower tannin content. The leaves are also a trade commodity and have been referred to as 'Morocco sumac'. They are known to have been used as an adulterant in ordinary or Sicilian sumac (Rhus coriaria).
The leaves contain some tannin, but are used mainly in Morocco
and North Africa, in the dry and pulverized form, as the source of
a yellow dye.

The tannin content of tizra wood is of somewhat the same order
as that of quebrach0 wood. The heartwood generally contains
20—23 % tannin, while the sapwood has a low tannin content
(2—3 %). The soluble non-tan content of the heartwood is quite
low (2—3 %). The roots may have a tannin content as high as
28—29 %.

The tanning properties of tizra wood (or its extract) are also
very similar to those of quebrach0. It may be used in tanning for
all the purposes for which quebrach0 is normally used. In fact, it
is said that leather tanned with it alone is very difficult to distinguish
from that tanned with quebrach0. Tizra tannin, which is of the
catechol class, resembles quebrach0 tannin very closely in chemical
properties as well as in tanning quality. It is claimed, however,
that tizra has a rather deeper colour, and that it is difficult to
reduce this colour to a satisfactory degree. Tizra extracts lend
themselves to solubilization by means of bisulphitation, contrary to
some reports.

Owing to the rather restricted supplies of tizra for tanning
purposes and the likelihood of cultivation being improbable, due
to the slow growth of the tree, it is unlikely that large-scale develop­
ments in the production of tizra extract will take place.

Prior to the Second World War, tizra was exported to some
extent, mainly from Morocco, to France and Germany. Exports
from Morocco in 1937 were—1,500 tons to France, 600 tons to
Germany and 200 tons to Algeria. In earlier years much larger
quantities were apparently exported.
FRUITS
Plate XIII

Myrobalans as imported from India for tanning

Myrobalan trees (Terminalia chebula) on the Pachmari Hills, Madhya Pradesh (Central Provinces), India
MYRABOLANS

Myrabolans are the dried fruits of certain Indian trees, species of Terminalia, and are much used and much esteemed in the tanning industry. In addition to their extensive use in Indian tanneries, large quantities are exported annually to other countries. The dried flesh of the myrabolan fruit, which surrounds the single seed, is rich in tannin, averaging 30—32%, but the percentage varies a good deal with different grades of myrabolans or material from different geographical or botanical sources.

The name myrabolan may be spelled in various ways and any of the following renderings are to be seen in the literature and in leather-trade journals: ‘myrobalan’, ‘myrabolam’, ‘myrabalam’, ‘myrobolan’, ‘myrabhalam’ etc. The name here used is in common use and complies better with the everyday or colloquial abbreviated form ‘myrabs’ employed by users than does myrobalans. There seems to be some doubt as to which may be the correct form of the word etymologically.

Use in Tanning

Myrabolans have been used by the natives of India for tanning from time immemorial. They were first exported in large quantities to other countries in the latter half of last century. In the tanneries of European countries they superseded to some extent sumac and plant galls, being cheaper and possessing similar tanning properties. They are one of the most important tanning materials of the pyrogallol class, the tannin being of a mild type and penetrating hides very slowly indeed. Used alone, a soft mellow leather is produced. Myrabolans are well suited for blending with other tans and are generally so used.

One of the principal virtues of myrabolans, from the tanner’s point of view, lies in their acid-forming properties, for they contain a much greater quantity of sugary matter than most tans, viz 3—5%. Consequently fermentation takes place readily in the tan-liquor and satisfactory plumping of the hide or skin is obtained in the early stages of tanning. Another advantage of myrabolans in tanning is that they contain a large proportion of ellagitannic acid and are therefore one of the chief bloom-yielding tans and are especially useful in the production of sole leather. Used alone,
MYRABOLANS

myrabolans have certain definite drawbacks. Apart from their slow penetrating power they are prone to produce a spongy leather of poor wearing quality. They are also not a good weight-giving tan-stuff, for the amount of tannin that actually combines with the leather is small compared with other tans. For these reasons myrabolans are usually blended with other, astringent, quickly penetrating tans such as wattle, quebracho or mangrove. So used, they have a neutralizing effect on the often excessively red colour produced by such tans and produce a brighter, more satisfactory colour. Mixed tannages of wattle bark or extract and myrabolans have been much used. The myrabolans supply the acidity lacking in the wattle and have altogether a mellowing effect giving a brighter colour to the leather and reducing the tendency to become red on exposure to light.

In Indian tanneries, myrabolans are often blended with babul, avaran or mangrove bark, when they have a similar effect. They may also be used as a bleaching agent for Indian kips (half-grown or small cattle hides) at the end of the tannage. Among tanners generally, myrabolans are greatly favoured as an acid producing body and are much used where sour liquors are required.

Species Exploited

The myrabolans of commerce are derived mainly from *Terminalia chebula*, but other species, notably *Terminalia bellirica*, are also involved. The terms ‘chebulic myrabolans’ and ‘beleric myrabolans’ are sometimes used to distinguish the fruits of the above two species, but they do not now appear to be in general use. A summary of what is known of other species in India and Burma has been given by M. V. Edwards who states: ‘Detailed investigations into what passes as chebulic myrabolans showed that they come from other species than *T. chebula*, for *T. pallida*, *T. travancorensis*, and probably *T. citrina* all yield fruit known as myrabolans.

*In Burma the myrabolan tree was originally described by Kurz as *Terminalia tomentella*. Kurz confined *T. chebula* to Chittagong, but Hooper and Brandis united *T. tomentella* with *T. chebula* as one species and so they have remained ever since. Blatter (1929) admits *T. tomentella* as a form of *T. chebula* and also *forma tomentosa* in India and *forma villosa* in Bihar. There seems little doubt that for tanning value the Burma form or species is entirely distinct.

‘Other Burma species are *T. foetidissima* and, *T. argrophylla* (doubtful). As a result of the Report on the Trade in Indian Myrabolans, an investigation into some of these forms was carried
TERMINALIA CHEBULA

out at the Forest Research Institute and the Imperial Institute, and it appeared that the tannin content of myrabolans from various parts of India varied greatly, and that *T. travancorensis* fruits might be worth making into a separate variety of myrabolan, that fruits of *T. citrina* are probably inferior to those from the other species and also that a new botanical investigation into all the *Terminalia* species of the section *Catappa* (whose fruits are of the myrabolan type) would be necessary to determine which species are really distinct. This would involve considerable research which it has not so far been possible to carry out. The difficulty lies in the fact that all the varieties merge imperceptibly into one another and lines of distinction are therefore hard, if not impossible, to draw. 3

*Terminalia chebula*

This tree is widely distributed in India and Burma in mixed deciduous forests and occurs on a variety of geological formations including clay and sandy soils. It ascends to elevations of 5,000—6,000 ft. and may grow in dry regions where rainfall is scanty. In the drier, rocky situations at the higher elevations it may be quite a small tree, but in the valleys or in moist, mixed forests where it sometimes occurs it grows to a large tree. It has a thick bark with vertical fissures and a hard durable heartwood. The tree is a light-demand but withstands and may even benefit from slight shade when young. It is drought-resistant and fairly hardy against frost. It also has good powers of recovery from burning, and coppices fairly well.

Trees are usually leafless by February or March and leaves may commence to fall in November in some areas. New leaves appear from March to May and with them the spikes of greenish white flowers. Fruits ripen and fall from November to March according to locality. The fruit is a hard drupe 1—2 in. long, usually ovoid in shape, yellow to orange brown and sometimes tinged with red or black. It becomes five-ribbed when dry. The solitary stone or seed is generally about 2 in. long and ½ in. in diameter. About 35—45 fresh fruits or 60—75 dry fruits weigh 1 lb.179

The Indian forms or varieties of *Terminalia chebula* are stated to be different from the Burmese and in extreme cases look like different species. They pass one into the other. Even allied species such as *T. argyrophylla* and *T. pallida* may be regarded as scarcely more than forms of *T. chebula*. GAGNEPAIN in the *General Flora of Cochin-China* regards *T. citrina* as a variety of *T. chebula*. The
wide degree of variation in morphological characters in *T. chebula* is very obvious. Leaves show all stages of pubescence from densely hairy to quite glabrous. The fruits vary much in size, shape and degree of angularity.

The germinative power of the seed is reputed to be poor, but the reason for this is not known. There are said to be areas where natural regeneration is very meagre, which might in time affect

*Figure 5. Myrabolan (Terminalia chebula): the dried fruits from India have long been a much favoured tanning material and are commercially one of the most important tanning materials of the pyrogallol class*

the myrabolan industry. The fruit itself is much subject to the attacks of insects, rats and squirrels. In India the seedlings also have many enemies. Besides rats and squirrels, creatures such as porcupines, crabs and peafowl will devour the young cotyledons as soon as they appear above ground. Experiments at artificial reproduction have been carried out at Dehra Dun in India. Seeds sown in mounds, patches or trenches gave very indifferent results. The most successful method of raising plants in a nursery was found to be by first drying the seeds thoroughly, removing the hardened fleshy covering and sowing the fruit stones in boxes before the rainy season and watering them regularly. With this method 20% germination was obtained.
The rate of growth of the seedling and of the tree is comparatively slow. Seedlings normally attain a height of 4—8 in. at the end of the first season increasing to 1—2 ft. by the end of the second. Once established, the young trees grow readily and require little attention other than protection from livestock, goats and cattle being partial to the young leaves. In the Madras Presidency considerable damage is said to be sometimes done to the leaves of the tree by the bagworm moth (Kophene moorei or Acanthopsyche moorei). It is interesting to observe in this connection that a bagworm is also the most troublesome pest with the wattle in South Africa.

*Terminalia bellirica*

Like *T. chebula* this is a well-known and widely distributed species in India and has a fleshy drupaceous fruit. It occurs also in Ceylon and Burma and extends to Malaya and Java, often intermixed with important timber trees such as teak and sal. The tree attains larger dimensions than does *T. chebula* and may reach 120 ft. in height and 10 ft. in girth, the best developed specimens being found in the moist river valleys.

The tree, commonly called ‘bahera’, is deciduous and matures its fruits in the dry season. When these ripen and fall they do not as a rule remain intact on the ground or the forest floor, for the fleshy outer portion is a favourite food of various wild creatures, including monkeys, squirrels, pigs and deer. The germinating power of the seeds is considerably better than that of *T. chebula*.

As a tanning material, the fruits, sometimes called beleric myrabolans, are definitely inferior to those of *T. chebula* (chebulic myrabolans) and have a lower tannin content. However, they are often collected and frequently used for village or local tanning in India. The dried fruits are usually rounder and less prominently ribbed than those of *T. chebula* and covered with a furry coat. The species is variable and varietal forms exist. It is also thought that climate, soil and the age of the fruit may affect its tanning value. The fruits are also used in native medicine.

**Collection**

The collection of myrabolans in India is carried out in both Government forest reserves and from private forests, villages and waste lands, the latter being considered to yield about five times the total from forest reserves. The following forest divisions are stated by Edwards to have a considerable export of myrabolans from forest reserves:
MYRABOLANS

Madhya Pradesh (Central Provinces) and Berar—Balaghat, North and South Mandla, South and North Raipur, Chhindwara, Melghat, Betul, Jabulpore and Amraoti.

Madras—Upper Godaveri, Vizagapatam, Madura, Vellore, also Tinnevelly, North and South Guddapah, North Coimbatore, Kurnool, the Nilgiris and Salem.

Bombay—Belgaum, Poona, Satara, East Thana, Kanara West, East and West Nasik and Kolaba.

Bihar—Singhbhum and the Sonthal Parganas.

Orissa—Parlakimedi.

Supplies from the Punjab and Uttar Pradesh (United Provinces) are used locally and not exported. Bengal, Assam and the dry north-west part of the Sub-continent do not produce much.

The usual method of collection is for a myrabolans contractor to purchase the right to exploit a certain area for the season. He arranges with villagers to collect the fruits, commonly termed 'hirda', which he sells to merchants who in turn sell to tanneries or exporters. In Government reserves, departmental collection with paid collectors has been tried, but this method does not appear to compete successfully with contractors for whom women and children often do the collecting. The fruits may be picked from the trees or beaten down with sticks or are simply picked up from the ground. If not too large the tree may first be shaken.

When received at the depot, the fresh fruits are immediately spread out in a single layer on a bare piece of ground, previously swept. They are turned every second or third day to facilitate drying. The contractor usually erects temporary sheds to house the myrabolans in the event of rain, for rain soon lowers the quality of the product. Sometimes the fruits are regularly put under cover at night during the drying process. In drying, the fruits shrink to about half their former size and become ridged. When dry, the pericarp becomes very hard—too hard to cut with a knife. Sound fruits kept dry and properly stored do not deteriorate. During drying, in a small percentage of the fruits, the fleshy part does not dry hard but becomes black and powdery. Such fruits are preferred for ink making.

The time of year when the fruits are collected has a bearing on their tannin content or their value for tanning. In some districts the custom is to pick only the ripe or nearly ripe fruits whereas in others they may be picked green. January is considered to be the best month for collection in many areas. There has been some controversy as to the best stage in the fruit's development for
CRUSHED MYRABOLANS

collection when required as myrabolans for tanning. Some consider the best stage to be just as the fruits approach maturity (when greenish yellow) and before they become fully ripe. At this stage they are still strongly astringent and contain a higher tannin content than do the fully ripe fruits or those less mature.

With regard to yield, little concrete information appears to exist. Yields of up to 20 lb. of fruit per tree have been recorded.

Commercial Grades

Myrabolans are graded by appearance for the export market and for some tanneries in India. It has been pointed out that the present method of visual grading is far from ideal and that to grade by tannin content, if this were practicable, would be far more satisfactory from the user’s point of view. Grading generally consists of simply picking out the inferior fruits to constitute ‘twos’, the remainder being ‘ones’. In the trade myrabolans are usually known by the place of origin. The following kinds are recognized:

- Bimlies (Bs) exported from Bimlipatam, Madras.
- Jubbulpores (Js) exported from Juppulpore, Madhya Pradesh (Central Provinces).
- Rajpores (Rs) exported from Kolhapur State, Bombay.
- Vingorlas (Vs) exported from Bombay forests.

Myrabolans of fair quality from any area may be marketed without grading as ‘FAQ’ (fair average quality). A special ‘picked’ grade is sometimes sorted out. The myrabolans from the Salem District of the Madras State are regarded as the best in India for colour and tannin content, but are mainly used in India and not exported.

Crushed Myrabolans

Crushed myrabolans, from which the stones are removed, have become a regular article of trade and offer advantages over ordinary myrabolans as a tanning material. The fruits are easily stoned by hand with a wooden mallet, or they may be crushed in roller grinders. The removal of the seed or stone, which contains comparatively little tannin, results in a much higher tannin content of the product and a considerable saving in freight. The tannin content is usually from 45–52% as against 30–35% for most commercial samples of whole myrabolans. The main drawback of crushed myrabolans is that they are a product easy to adulterate and adulteration is unfortunately practised. This
MYRABOLANS

has prejudiced users. If purity could be guaranteed, an increased
demand for crushed myrabolans would doubtless soon take place.
Rotten fruits and earthy matter are common adulterants in crushed
myrabolans. Myrabolans were first exported from India in this
form in about 1911 and were at first principally used by Continental
tanners. During World War I, owing to wartime difficulties
in Europe, increased quantities were shipped to Britain.

Extract

Myrabolan extract has been prepared in India for over 30 years
and it is said to be the only tannin extract the manufacture of
which has so far proved a success in India. At one time a lack
of uniformity and standardization in the product proved a draw­
back in overseas markets. In the years before World War II, annual exports from India varied from 1,500—3,500 tons. The
extract is manufactured at a factory at Raniganj, near Asansol,
Bengal and at Kharappur. The composition of the extract is
approximately 55% tannin, 30% soluble non-tans, insolubles 3% and moisture 12%. The powdered or 'spray dried' extract has a
higher tannin content (~60%). At the present time some of the
extract is exported and a good deal finds its way to the large
commercial tanneries of India, notably those of Cawnpore. The
solid extract is generally prepared in blocks and packed in bags,
cases or kegs weighing about a hundredweight each. In tanning,
the extract is said to be somewhat inferior to the fruits themselves,
particularly in regard to the formation of acid liquors, the deposition
of bloom, and in improving the colour of the leather.

SUNTHANKAR and JATHAR have studied the optimum condi­
tions for the extraction, clarification, and decolorization of tannic
acid from myrabolans, and applied them to large-scale experiments.
Most of the tannins are extracted by water at 70° C with open-vat
extraction. Cooling the extract to 15° causes the separation of a
good deal of colloidal matter without appreciable loss of tannins.

Trade

It is not possible to assess the total annual production of myrabolans
in India as large quantities are used locally for which no figures
are available. Apart from small-scale or village tanning, consider­
able quantities go direct from private forests to Indian tanneries.
In recent years, annual exports from India have been in the neigh­bourhood of 60,000 tons, the United States and Great Britain being
the main importers.
TANNIN CONTENT AND NATURE OF TANNIN

The yield or crop of myrabolans in different districts in India varies greatly from season to season, weather or climate being an important factor.

Other Uses of Myrabolans
In addition to their use as a tanning material myrabolans are employed in the making of ink and to some extent in dyeing, more especially in India. In dyeing, they may be used as a mordant for the basic aniline dyes. Their yellow colouring matter, however, renders them unsuitable for certain bright shades on cotton and silk. They are commonly employed for the weighting of black silk.

The use of myrabolans for the making of writing ink is centuries old in India, and has been applied in other countries. In the commercial manufacture of inks there is a good demand for the purified tannic acid prepared from myrabolans. The properties of inks made with myrabolan extract and purified myrabolan tannic acid have been studied by Sunthankan and Jathar from the point of view of corrosion, stability, washing and fading tests. The results compared favourably with the properties of well-known inks on the market.

From the earliest times, myrabolans have been freely used in India for medicinal purposes and employed for many ailments. For this purpose they are usually picked green and dry black, several kinds being recognized, according to size, in Indian medicine. Chopra has stated that in the Punjab 'there is hardly a household which does not stock “harar” fruit for some purpose or other. Sanskrit writers describe the fruit as a laxative, stomachic tonic and alterative; and the practitioners of Ayurvedic medicine use it for fever, cough, asthma, diarrhoea, urinary, skin and heart diseases, for enlarged spleen, liver etc. Dried and powdered, the fruit pulp is also used as a dentifrice, to cure bleeding and ulceration of gums, its paste for sores and ulcers and a lotion as a cooling bath for the eyes'. The bark, leaf galls, and kernel oil also have medicinal uses. Myrabolans have been used in European medicine on account of their mildly purgative, carminative and tonic properties.

Tannin Content and Nature of Tannin
The average tannin content of good commercial samples of myrabolans is about 32%. It has been shown, however, that the figure may vary from 12%, as in the case of low grade Burma myrabolans, to as much as 49% (10% moisture basis) for the best
quality Indian (Salem) myrabolans. The extent to which the tannin content may vary with samples from different districts is well illustrated by an investigation carried out at the Imperial Institute when it was found that fruits from Madras (several samples) had a tannin content of 26—49%, from Bombay 31—36%, United Provinces 20—30%, Punjab 26—36%, and from Central Provinces (Madhya Pradesh) 30—37%.

The tannin of myrabolans is of the pyrogallol class with low viscosity, medium pH value and salts content and a very high acids content as has been already pointed out. This sets a limit to the amount that may be used in warm tanning liquors. It is considered that salts derived from some of the acids content along with salts already present may assist penetration of tannin in the early stages of tanning. The tannin of myrabolans contains chebulinic acid and a fairly high proportion of ellagitannin. On fermentation, the latter produces ellagic acid which is technically termed or commonly known as 'bloom'. It is this that accounts for the value of myrabolans in mixed tannages for sole leather.
Valonea, often written ‘vallonea’ or ‘valonia’ by English and American writers, is an international name for a much-esteemed tanning material that consists of the dried acorn cups (or cupules) of the valonea oak (Quercus aegilops and allied species) which occurs in the eastern Mediterranean region and Asia Minor. In Turkey, which is the main producer of valonea, the common name for it is ‘palamut’. There is doubt as to the origin of the name valonea. Some consider it is derived from the Greek word for acorn, ‘balanos’ or ‘valanos’, in modern Greek. Others think the name may owe its origin to the Albanian town of Valona (or Avlona), a centre of export of this tanning material in Albania. Other renderings of the name valonea are ‘velani’, ‘velandida’ and ‘wallonea’. Another name that has been used is Turkish— or Levantine—knopper, the word ‘Knopper’ (German) being generally used for oak galls, particularly those on Quercus cerris. This may be confusing.

It does not appear to be known when valonea first became generally used as a commercial tanning material in Europe but its use probably goes back a considerable time. It was a trade product in the eighteenth century. Valonea has long been used by the Turks in tanning and its use in Greece for medicinal purposes and as a dye goes back to very early times.

In recent years, a good deal of attention and scientific study has been devoted to the valonea industry in Turkey for it constitutes one of the main exports of that country. Proper grading of the product, under state control, has been established and is in operation at various centres. Several extract factories are also functioning. In Greece also, special attention has been given to the valonea industry in recent years.

The Valonea Oaks
There has been and still is much confusion regarding the botanical sources of the valonea of commerce. Most of it is undoubtedly derived from Quercus aegilops, a variable species with many varietal forms. Some of the more distinctive of these varietal forms have been raised to specific rank by some botanists, e.g. O. Schwarz. There are also intermediate or hybrid forms.
which cause much difficulty or confusion in classification. All
the valonea-yielding oaks of Turkey belong to Schwarz’s section
Valonea. They are all deciduous and characterized by the fact
that their fruits require two years to develop and ripen. Besides
Quercus aegilops, which is by far the most important source of valonea
in Asia Minor, the following species may also be sources of valonea:
Quercus tournefortii, Q. ehrenbergii, Q. ungerii, Q. pyr am, Q. ithabwensis,
Q. oophora and Q. graeca. 40, 183. Q uercus aegilops is also the important
source of valonea in Greece and throughout the Greek islands. Two
varieties of this species, viz macros epsis and cretica, are also important
in some areas.

The true or typical valonea oak (Q. aegilops) somewhat resembles
the common English oak in general appearance but is smaller.
The tree is not evergreen as has often been stated in the older
literature. The dentately-lobed leaves, with bristle-tipped lobes,
and acute sinuses, are also smaller than those of the common oak.
The young branches are covered with a dense grey covering which
persists in the second year. The bark is deeply divided into small
scaly plates. The acorn cup or cupule is quite different from that
of the English oak and often striking on account of its remarkable
size—up to 2 in. in diameter internally and 1 in. deep—or as large
as a medium-sized apple. The cups are also covered with the
characteristic beard or ‘drillo’. This consists actually of modified
leaves or elongated scales. These appendages as they might be
called are generally about 1 in. long, but shorter at the base of
the cup, and are bent over the developing acorn in the early stages,
thereby affording some degree of protection. Scales may be flat
or ribbon-like with a broad base, or else three-angled or cylindrical.
They may also be only slightly or else very much recurved. They
sometimes become quite woody. Some observers (CAHIT ONGU
and VON HAYDAR BAGDA) have classified the different forms of
cup or cupule into three or four basic groups depending upon the
size, shape, and woodiness of the appendages but this appears to be
purely an arbitrary classification. The size of the fruits varies from
one district to another and with different varieties or forms of the
tree. With some trees they never become very large. The acorns
themselves are usually larger than those of the common English
oak and have thicker shells. They are commonly eaten by the
local inhabitants. They may be more or less ovoid in shape or
cylindrical. Sometimes those that are ovoid in shape are scarcely
exerted from the cup, while those that are long and cylindrical
may project $\frac{3}{4} - 1 \frac{1}{2}$ in.
Plate XIV

Turkish Valonea—cups of the Valonea Oak (Quercus aegilops)—as imported for tanning

A bag of Valonea as received for use at an English tannery (together with Myrabolans, Oak Bark and shredded Wattle Bark). Some acorns are still present in the Valonea.

From the Common Ground filmstrip 'Tanner'

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The massive bearded fruits are perhaps the most characteristic feature of the tree. In describing a visit to the valonea district of Smyrna (Turkey) a well-known authority on tanning materials (Dr J. Gordon Parker) stated: 'The thing that strikes one first on seeing the valonea tree is the size of the valonea cup. It is a deep golden yellow in colour, tinged with green. It is comparatively speaking soft, and about two or three times the size of the cup as it arrives on the English market.'

The fact that the acorns and the cups of the valonea oak take two years to reach maturity, not one year as with most oaks, is important for it may have a bearing on yield as will be seen later (see Harvesting).

**Distribution**

*Quercus aegilops* occurs in many parts of Asia Minor, and in Greece and the islands of the Grecian Archipelago and Aegean Sea. The tree thrives in the area from the Dardanelles and Ankara southwards to the Mediterranean Sea—just north of Cyprus. The area about Izmir (Smyrna) has long been one of the main centres of the valonea industry. The tree also occurs in Syria and Israel (Palestine) but a trade in valonea in these countries has never reached large proportions.

The trees do not occur in extensive or closed forests but usually in groups or scattered with distances of about five to ten paces between the trees. Quite often they are on cultivated land. Natural regeneration takes place from the acorns that fall in the autumn. In Turkey, the trees appear to thrive on most soils from low-lying rich alluviums, where they attain their greatest height (50—60 ft. or more) to poor sandy soils or mountain sides (up to 4,000 ft.) where they may not exceed 20—30 ft. Throughout the range of distribution of the tree in Asia Minor a considerable degree of variation in the climate exists. In the south, the winters are often mild and the heat of the summer is tempered by sea breezes but on the plateau the summers are very hot and the winters extremely cold. In Israel, where *Q. aegilops* exists in several varietal forms, it is considered (von Haydar Bagda) that its distribution is limited to localities with high insolation—where strong sunlight is felt. In areas of lesser insolation *Q. aegilops* commonly gives way to another species, *Q. calliprinos* (East Mediterranean Kermes Oak).

In Turkey, there are good districts and poor districts for valonea. Among the former, the following have been included: Manisa,
HARVESTING AND PREPARATION OF VALONEA

Salihli, Dikili, Bergama, Alasehir, Nazilli, Davas, Gördes, Armut-Ova, Bodrum, Canakkale, Akhisar, Datca, Fethiye Feferihisar, Altinova, Bürhaniye, Demirci, and Odemis. Areas in the south such as Antalya, Silifke and Karaman have in general a poor reputation for their product. 'Caramanian valonea' (or Karamanian) has long been indicative of poor quality in overseas markets.

In Greece and the Aegean Sea, important areas for valonea are the islands of Mytilêne, Khios (Chios), Krêtê (Crete). Other areas (as given by Cahit Oncu) are Venitas (Vonica), Yition, Mesolongi, Resmo, Preveze, Alêksandrupoli, Isparta, Ayios, Evstratios and Filiate.

Harvesting and Preparation of Valonea

The acorns and acorn cups of the valonea oak ripen in the autumn and harvesting usually takes place from mid-August until mid-September, but the time varies with the season and the altitude. In Turkey, the best and brightest qualities of valonea are collected in August, before the danger of rain arises. That collected in late September or October may be spoiled or darkened in colour by rain. When ripe, the cups change from green to golden. Those on the lower branches are plucked by hand and those out of reach knocked off by means of sticks or light poles. After collection, they are placed in a thin layer in the sun to dry and are turned over periodically. Sheds may be used for drying if the weather is damp. If acorns are present in the cups, they usually become detached during drying and are removed and fed to pigs or other animals. During drying the cups shrink to half their original size. Their weight is also halved. The colour changes from golden to grey—the colour of the commercial valonea. Thorough drying is essential, otherwise deterioration (fermentation and discoloration) takes place in storage. The work of harvesting and drying is generally carried out in Turkey by women and children. The use of sticks or rods for beating off the cups out of reach from the ground may cause quite considerable damage to the trees. Branches become broken off which may be carrying a number of female flowers or immature cups. These if left would be fully developed and contribute to the harvest of the following year. As it is they are lost. Rain in the autumn can cause difficulty in drying and reduction in the value of the harvest. Poor quality valonea, spoilt by rain, is referred to as 'rufus' in Turkey. Fine sunny weather as the cups ripen and are harvested is therefore desirable.
The yield of cups or valonea varies a great deal from one tree to another, even among trees of similar age and size growing together. There is also periodicity in yield. Trees may give a good crop one year but yield nothing or next to nothing the following year. It is said that a single large tree may yield up to 200—400 kg. of fresh valonea but the usual yield is much lower. Trees do not produce profitable crops until about 15 years of age and may live for 150 years.

In the spring of each year it is common for some of the half-developed or one-year-old cups to fall from the trees on to the ground, these being commonly termed 'koruk' in Turkey. They are rich in tannin, even richer than the mature cups, and are esteemed in tanning.

**Grades and Grading**

When in the hands of merchants and before shipment, valonea is usually hand-picked to remove impurities such as sticks, stones, leaf fragments or acorns. Small stones, lumps of soil and dust (carrying with it iron) are liable to contaminate the product during drying. Grading for size may also be carried out, the work being generally done by women. In assessing the value of commercial valonea special attention is paid to colour, a light grey or ash colour being desired, and to the thickness and bulkiness of the individual cups. The two basic or well-known types of valonea entering world commerce are ‘Smyrna’ (Turkish) and Greek valonea. The Turkish is usually superior to the Greek, the cups being larger and of a better or lighter colour than the Greek. Included in these two main basic types are numerous other grades, which have varied from time to time in the past, and which are often named according to the place of origin.

In Turkey, there are state grading stations or depots at Izmir, Antalya and Istanbul. Grading is on a purely physical basis according to appearance but is considered satisfactory and is in fair accordance with tannin content. A similar, purely physical type of grading applies of course with mimosa or wattle bark in South Africa and is also satisfactory. The six Turkish grades now recognized in order of superiority are: (1) Krible (best grade), (2) Birsu, (3) Naturell I, (4) Naturell II, (5) Engin I, and (6) Engin II. This grading ensures a standard product with an average tannin content of 27—28%. Some of the finest qualities of valonea from Turkey in the past (known as ‘mezzaa’) have been those from Nash (or Nazilly), Gunei, Demirji and Borlu. The name
VALONEA EXTRACT

'camata' may be used for immature valonea, i.e. when the acorn shows but cannot be removed and the name 'camatina' when the acorn is completely enclosed and is not visible. These grades are favoured for light colour and are also used in extract factories.

Among the better known grades of Greek valonea are those that have been known by the names of 'prevesa', 'patrasso' and 'dragomestra'. The island Mytilene has long been known for its high quality valonea. Well-known kinds of Albanian valonea include 'Golfo', 'Durazzo', and 'Eamattina'.

Last century, there were many more kinds of valonea entering commerce than there are now. One writer (H. Mendel) listed no less than sixty123.

Commerce

There is less valonea entering world commerce at the present time than there was half a century or more ago. Considering the keen demand that still exists for valonea this may well seem strange. Several factors may be involved, the disinclination of peasants to collect valonea being one of them. Compared with most other tanning materials, valonea is more troublesome to collect and prepare and requires much hand labour. A good analogy may be the collection of gum Arabic in parts of Africa where the inhabitants will collect the gum only when their personal economic considerations are sufficiently compelling. Just before the Second World War, the annual imports of valonea to Great Britain were in the neighbourhood of 5,000 tons or about a quarter of what they were at the turn of the century. In 1885 some 30,000 tons were imported.

The total annual export of valonea from Turkey is now considered to average about 50,000 tons, whereas half a century ago it was 70,000—80,000 tons. The total production of valonea for the country is difficult to assess as there is no record of the amounts used in the numerous small tanneries throughout Turkey which are considered to exceed 2,000 in number10.

Peasants also use valonea in the production of their own primitive kinds of leather, i.e. 'carik', 'dagarcik' and 'tulum'. The average annual export of valonea from Greece is considerably less and is about 15,000 tons.

Valonea Extract

For many years valonea extract has been prepared in both Turkey and Greece, the Turkish industry being older and on a larger scale
than the Greek. In Turkey, extract manufacture is carried out mainly in Izmir (Smyrna). In addition to ordinary valonea, the beard or trillo (Turkish 'tirnak' or 'fingernail') is also used, possessing as it does a much higher tannin content.

Manufacturers use both the ordinary valonea or cups ('kaba') and the beard or trillo. The use of the beard, with its much higher tannin content and relatively lower soluble non-tan content, not only gives a higher tannin content in the extract but also imparts a lighter colour. The usual process of preparing valonea extract is similar to that for preparing other tannin extracts. The material is first sifted to remove sand and earthy matter, and iron is separated by means of electromagnets. It is then ground, and extracted with water at a moderate temperature. The extract is rapidly concentrated in vacuum evaporators and finally run into jute sacks or gunny bags. It may be marketed in the familiar solid, vitreous form and also in powder form—with a moisture content of 4—7 %. With the better methods of manufacture, little or no decomposition takes place and the leather produced is reputed to be of the same colour as that yielded by ordinary valonea. The extract is marketed under various proprietary names, e.g. 'Valonex' and 'Valex' (Smyrna), 'Sens' (Mytilene, Lesbos), 'Tanoval' (Eleusis). Solid valonea extracts may contain 64—68 % tannin and 21—25 % soluble non-tans.

**Tannin Content**

The tannin content of valonea cups may vary from 25—31 %. There appears to be little or no correlation in the matured cups between size and tannin content although the immature cups—that fall from the tree before they are fully ripe—commonly have a higher tannin content. The beard or 'trillo' is considerably richer than the cup in tannin, the tannin content being usually about <0 % but may be a good deal higher. The amount of beard still attached to the cup in commercial samples is therefore likely to affect the tannin content quite appreciably. The tannin content of the acorn is commonly only 6—7 %. The presence of any quantity of acorns in commercial valonea is therefore undesirable.

**Tanning Value and Uses**

Valonea is generally considered one of the best and most useful of tanning materials, being a tan of the pyrogallol type. It is of value chiefly in the production of high-grade heavy leather, such
CULTIVATION

as sole leather, where weight and water-resistance are important. The leather obtained with it is usually of firm texture and light coloured. The weight-giving properties of valonea are due to the large amount of ellagitannic acid present, giving 'bloom' to the leather and causing it to be dense and heavy. For heavy leather, valonea may be ground and employed as a dusting material between the hides in the pits. It may be left in contact with them from one to six weeks. Used in this way the maximum amount of 'bloom' is deposited in the hide and not in the solution where much would be lost. In the manufacture of dressing leathers, however, valonea may be used in the form of a liquor in admixture with other tanning materials or extracts.

Experience in Britain suggests that, on the whole, Turkish valonea has better weight and 'bloom'-producing properties than the average Greek product and may also be superior with regard to colour. The beard or trilla of Turkish valonea, used alone, may give a greyish leather similar to that obtained with sumac. Poorer quality beard may yield a dark fawn coloured leather.

Valonea has a rather high pH value for this type of tan and a moderately high acid and salts content. Its viscosity is also rather high and in strong solutions it is probably better suited for slow tanning processes than the comparatively rapid hot-pitting processes that have arisen in the present century.

Cultivation

In Asia Minor and the eastern Mediterranean region where valonea is gathered, collection takes place entirely from wild trees and so far no attempt appears to have been made at large-scale or systematic cultivation. In some districts undergrowth may be cleared round the trees but this is only to facilitate collection of the cups. The fact that this oak requires 10—15 years to come into bearing and does not give an appreciable yield until considerably older may have accounted, in part at least, for the lack of any attempt at large-scale planting.

The valonea oak has been introduced to various other countries and individual trees grown for ornament or as specimen trees in botanic gardens or by persons especially interested in trees. This oak appears to be fairly adaptable with regard to soil and climate, which is not surprising considering the varied conditions under which the tree thrives in its native land. The valonea oak has been grown in the south and west of England and is quite hardy. It is reputed to have been first introduced in 1731 (Loudon). Although
VALONEA

fruits are formed, acorns do not usually mature or mature properly. Ripe acorns are obtained in some seasons in some parts of the country. At Kew, the tree grows quite well and, although fruits form, the acorns rarely ripen. This may hold for many other countries where similar climatic conditions prevail. Doubtless the tree needs more summer heat than is available in the average English summer. Trees have also been grown in Ireland, Munich, and the Jardin des Plantes in Paris. The oak has also been cultivated on the North American Continent mainly between latitudes 30° and 40°, but is not hardy in the more northerly areas.

Early attempts to introduce the tree to Australia, where it might well be expected to thrive, were not successful, the acorns failing to germinate. It is now known that acorns of this oak soon lose their viability. Seedlings and germinating acorns imported in Wardian cases from Smyrna were successfully introduced to Victoria in 1879 by George Cunnack, an enthusiastic tanner, currier and leather merchant of Castlemaine. Plants were sent to various parts of Australia and grew well in several places. These began producing acorns after about 15 years, which were used for further planting. In spite of the early efforts of Maiden and others to stimulate interest in the exploitation of the tree on a commercial scale valonea has never been produced in Australia, either for local consumption or for export. Considering the length of time required for trees to come into profitable bearing and the large amount of hand labour that would be required in handling the crop, this may not be surprising, especially as hand labour has always been at a premium in Australia. A revival of interest in the possibilities of valonea in New South Wales took place before the Second World War. More plants were distributed and it was considered that parts of the table-lands and southwestern and central-western slopes offered the best possibilities for successful cultivation of this oak.

The tree is reputed to have been introduced to Algeria in 1860 and to have thrived, but no commercial development appears to have taken place in that country.

The valonea oak may be found to grow well in many countries where a low rainfall, poor soil and cold winters reduce the number of crops or trees that may be profitably grown.
DIVI-DIVI

The pods of certain species of *Caesalpinia*, a large genus of trees and woody climbers scattered throughout the tropics and subtropics, are rich in tannin and have been used as commercial sources of tannin\(^{100}\) (Plate XV, p. 186). The best known and most important is divi-divi (*Caesalpinia coriaria*).

‘Divi-divi’ or ‘libi-dibi’ is both the commercial and the local or native name used in Colombia and Venezuela for a small tree (*Caesalpinia coriaria*) or its dry pods, which have long been a commercial tanning material. The tree has a wide range in the American tropics for it is also indigenous in many parts of northern South America, in central America including Mexico, and parts of the West Indies. It has also been introduced or become naturalized in many other parts of the tropics. In its natural habitat the tree occurs mainly in open or semi-arid country especially on the dry outskirts of the tide belt. Other native names for the trees are: ‘nacacol’ (Costa Rica, Salvador, Nicaragua), ‘cascalote’ or ‘nacascalotl’ (Mexico), ‘nacascalote’ (Guatemala), ‘agallo’ (Panama), and ‘guatapana’ (Cuba)\(^{149}\).

**History**

Divi-divi pods appear to have been used by the inhabitants of central American countries from very early times for local tanning and for dyeing. In Honduras they are known to have been employed with iron sulphate from naturally occurring deposits in preparing a black dye\(^{183}\). The Spaniards were familiar with the use of divi-divi in leather manufacture as far back as 1769, for it was first imported into Spain from Caracas in that year\(^{94}\). During the next hundred years its use in European countries steadily increased and by the end of the nineteenth century its employment as a tanning material had become well established and it had acquired the somewhat misleading name of ‘American sumac’, its tanning properties being rather similar to those of sumac. It has also been used to some extent in black dyes for fabrics.

Prior to the First World War, Germany was the largest consumer of divi-divi and imported a large proportion of the total production of central American countries. It was not until the First World War that the United States became an important user. Then

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Caesalpinia Pods that may be used in tanning

1. *Divi Divi* (C. coriaria), Venezuela
2. *Algarobilla* (C. brevifolia), Chile
3. *Guayacán* (C. melanocarpa), Argentina
4. *Al Tamarindo* (C. corymbosa), Ecuador
5. *Pai-pai* (C. paipa), Peru
6. *Teri* (C. digyna), India
7. *Jure* (C. ferrea), Brazil
the war-time demand for leather made it necessary to use all available sources of tannin. American imports for 1915 were fourteen times as great as they had been previously. By 1919 they were ninety times as great as the 1913 level\(^84\). The United States has continued to be the chief importer of divi-divi.

The Divi-Divi Tree

In its natural state, divi-divi is either a shrub or poorly formed tree from 15—30 ft. high. It usually has a short bole, often crooked, which may reach 16 in. in diameter but is usually smaller. The tree is thornless, has feathery bi-pinnate leaves and bears sweetly-scented cream or whitish flowers in axillary or terminal panicles up to 2 in. long. The mature pod is oblong in shape, 2—3 in. long and about \(\frac{3}{4}\) in. broad and \(\frac{1}{8}\) in. thick. It is smooth and shiny and normally dries a chestnut brown in colour. In the commercial article the colour of the pod may vary from pale brown to almost black, conditions of collection and storage being liable to affect the colour. Pods gathered under damp conditions are prone to be dark. A notable feature of the pod is the twisting or curling it undergoes on reaching maturity, being often S-shaped. The number of seeds present varies from 2—8, but is usually 2—4. They contain little or no tannin and constitute about 10% of the weight of the pod. The tannin is located mainly in the spongy inner tissue, notably the white powdery tissue immediately below the epidermis. If the epidermis of a ripe dry pod be ruptured this powdery matter falls away and is lost. Because of this, divi-divi should be, and generally is, packed in bags of close mesh in order to prevent wastage in transit. For the same reason it is desirable that pods be damaged as little as possible in collection and handling.

The divi-divi tree does not usually exceed 30 ft. in height but is long lived, attaining an age of 100 years according to some writers\(^84\). It generally commences to bear fruits at about the seventh year but may flower and bear a few fruits at an earlier age. The tree does not yield full crops of pods until considerably older—about 20 years. Mature trees commonly yield 80—100 lb. of pods in a season. Well-grown trees under favourable conditions may yield as much as 300 lb. of pods in a season. From the results of cultivation in other countries it would seem that where there is a high annual rainfall and high humidity the production of pods is likely to be less than in a drier climate. At the Singapore Botanic Gardens, trees were found to grow well and to flower but to give a poor yield of pods\(^88\).
DIVI-DIVI

The divi-divi tree has been grown for ornament to some extent in other parts of the tropics, as its spreading umbrella-shaped habit, mimosa-like foliage and sweetly scented flowers make it very decorative. It is often employed as a hedge plant, for it makes an attractive hedge and is easy to grow. The flowers are visited by the honey bee for nectar. The wood of the mature tree is reddish brown and very hard but seldom available in good dimensions.

Main Producing Countries
The divi-divi of commerce is derived almost entirely from tropical American countries for only small quantities have been exported from other countries—notably India and Jamaica.

Venezuela—Venezuela has always been the most important source of the divi-divi of commerce, annual exports having varied during the present century from about 3,000 to 10,000 tons. It is considered that the production of divi-divi in Venezuela could be very much higher if the full crop were harvested and collection were more thorough. Usually only that part of the crop most readily available or accessible is collected and marketed.

Divi-divi is a relatively expensive commodity to ship, and freight is an important factor in determining its price to the overseas consumer. It is a bulky material per unit of weight, requiring approximately 100 cubic feet per ton. The high costs of transportation during the 1914–18 war and the desire to eliminate all possibility of waste led to the establishment of extract factories in Venezuela, the first to be erected being at the ports of Porlamar and La Guaira. It is reported that a patented process, without the use of heat, was used for extracting the tannin which was pressed into tablets or cakes containing an average of 80% tannic acid.

Colombia—Colombia stands next in importance to Venezuela as a producer of divi-divi, production having fluctuated between 1,000 and 7,500 tons per annum. Most of the crop is obtained from the Goajira Peninsula. In past years, a considerable quantity of divi-divi has been exported through the port of Rio Hacha to the island of Curacao for trans-shipment.

West Indies—The Dutch West Indies are also commercial producers of divi-divi, notably the islands of Curacao, Bonaire and, to a small extent, Aruba. Production is less now than formerly, an export tonnage of 2,057 tons in 1911 having fallen to rather less than half this in the years preceding the Second World War. The divi-divi tree is wild in the islands mentioned and is the most

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common tree in places. It may also be cultivated or cared for in a primitive fashion. In wind-swept situations it may be rather dwarfed with a much-twisted trunk and the lop-sided habit of growth often to be seen with trees in maritime situations. The development of the petroleum industries in Curacao and Aruba affected divi-divi collection adversely by affording more attractive employment for local inhabitants. A certain amount of Colombian divi-divi finds its way to Curacao and is re-shipped as 'Curacao divi-divi'. According to Rowaan, the quality is usually inferior to that of the divi-divi produced in Curacao (lower tannin content and inferior colour) and its export as 'Curacao divi-divi' is likely to be harmful to the local product. The export of divi-divi from the Dutch West Indies is mainly to the United States.

The question of reducing ocean freight charges of Curacao divi-divi by various means has been considered, notably by the use of pressed bales, by the production of extract or by exporting only the tannin-rich powder in the pods. As divi-divi extract is liable to deteriorate rapidly, much more so than other extracts, it was considered the export of the powder offered the best possibilities. The powder is easily separated by partially crushing the pods. It was found, however, that the powder, as extracted from the pods, was to some extent hygroscopic and inclined to cake badly unless packed in sealed containers. The powder, to which the name 'casumo' has been applied, contains approximately 60% tannin as against 40-50% for the whole pod and is readily extracted in water. A hundred pounds of pods yields approximately 64 pounds of powder. The proportion of soluble non-tans in the pods is high, the average being about 18%.

The export of divi-divi from Jamaica in the past has been very erratic. Compared with the other countries mentioned, production has been small, usually between one hundred and two hundred tons annually.

Commercial supplies of divi-divi have also been obtained in the past from the Republic of Dominica. Exports have exceeded 2,000 tons per annum, almost entirely produced on the arid lands of the Province of Monte Christi. At one time, output was said to be seriously affected by an orchid infecting the divi-divi trees and often killing them.

India—The divi-divi tree has long been introduced to India and thrives in a cultivated or naturalized state in many parts of
DIVI-DIVI

the country. The pods are used in Indian tanneries and have also been exported to some extent—two hundred to four hundred tons annually.

Tanning Value
The advantages of divi-divi as a tanning material are (1) the high percentage of tannin present (~0.45%), (2) the ease with which it may be leached out by the tanner, and (3) the light colour of leather obtained with it. Its tanning properties somewhat resemble those of gambier and sumac for which it may be used as a substitute. Used alone as a tan, divi-divi possesses certain outstanding disadvantages. The leather is inclined to be affected by atmospheric conditions, being soft and spongy in a damp atmosphere and lacking pliability in dry weather. Owing to the amount of sugary matter present in the pods, fermentation in the tan-liquor takes place very readily—in fact too readily. This sometimes causes reddish stains in the leather, but this may be controlled to some extent by antiseptics. For these reasons divi-divi is usually mixed with other tanning materials and not used alone. It is commonly employed in leather dressing and in the rapid drum tannage of light leathers. Sometimes its use with leather is mainly as a dye. Divi-divi has also been used in the past as a textile mordanting agent. The tannin present is of the pyrogallol class, similar to that of algarobiilla (*Caesalpinia brevifolia*) but with a rather higher pH value and salts content and lower acids content.

Cultivation
The divi-divi tree has been introduced and found to grow satisfactorily in many other tropical countries, but only in India has the actual production of pods in bulk for tannin taken place. It was introduced at an early date to islands in the West Indies and is now apparently wild in places (*e.g.* Antigua). Other countries to which the tree has been introduced and found to grow satisfactorily include the Sudan, East and West Africa, Southern Africa (Botanic Gardens, Durban), Mauritius, Seychelles, New Guinea, Java, Queensland and Ceylon. When the tree was first introduced to East Africa (Tanganyika or German East Africa), it was found to thrive at the coast (Dar-es-Salaam area) but at the higher altitudes (over 900 m.) it was slow to come into flower and gave only small yields of pods.

Divi-divi was introduced to India about the year 1834 by Dr. Wallich at the Botanic Garden at Calcutta. By 1840, ripe pods
were obtained from the young trees that had been raised and the tree was introduced to various Government farms and experimental stations throughout India. It soon became widely distributed, as much interest was taken last century in its cultivation in various parts of the country. Cultivation was subsequently mainly developed in Dharwar, Belgaum, Bhadgoan, Kanara, Bijapur and to a less extent in the North Western Provinces and in Bengal and Burma. The tree later became naturalized in places, the soil and climatic conditions of many parts of south India closely resembling those of the tree’s natural habitat. In some parts of India, hot winds and frost in the cold weather were found to destroy young seedlings, but once seedlings reached 3 ft. in height no harm was felt. Watering in the early stages was also necessary in some areas. In Mysore and Coorg the tree was used with some success as a shade tree for coffee. One of the largest of the earlier plantations was a private one at Perambore, Madras.

The seed of divi-divi germinates readily, in about a week if kept moist, and may either be sown in situ, in nursery beds or bamboo pots or baskets, the advantage of the latter being the absence of check at transplanting. When planted in situ several seedlings may be allowed to grow in a clump, as this gives greater resistance to wind, but these are thinned at a later stage to leave only one. The seedlings need careful weeding in the early stages to prevent their being smothered. Where conditions are dry, watering may be necessary while the seedlings are small or after transplanting. Once the young trees are a few feet high they are able to look after themselves and to withstand long periods without rain. A certain amount of pruning in the early stages may be desirable to ensure a good habit. Goats can be very destructive to young trees. In Queensland, the tree has been found to do well in old ‘worn out’ lands and areas where ‘nut-grass’ (*Cyperus rotundus*) is troublesome.

The recommended planting distances are 10 or 15 ft., spacing being altered to 30 ft. as the trees approach full size. Under favourable conditions, trees commence to bear in 3 to 4 years from transplanting, when they may yield about 5 lb. of pods per tree. As the trees develop, their yield steadily increases and profitable quantities of pods are produced for 25 years or more. In South America the yield of pods from well-grown trees has been given at 40 to 80 lb. per tree. In India, trees in full bearing have yielded 100 lb. of pods per tree, which, with 135 trees to the acre, constitutes a theoretical yield of about 6 tons of pods. It has
DIVI-DIVI

been found that 22 lb. of dry pods will yield 2 lb. of seed. The best quality divi-divi is considered to be that which is harvested as soon as the pods are ripe and from which the seeds have been extracted. The best pods are those which are thick and fleshy and of a pale colour. Pods which are dark or with black spots or blotches often owe their condition to having been collected in a damp state or to having been stored under bad conditions. The pods are considered fit to pick as soon as the seeds rattle.
ALGAROBILLA

ALGAROBILLA is the name used for a tanning material from Chile which consists of the dry pods of the shrub *Caesalpinia brevifolia* (see Plate XV, page 186). The word is a diminutive form of 'algaroba', used in Spanish-speaking South American countries for shrubs whose pods show some sort of resemblance to the Carob (*Ceratonia siliqua*), notably species of *Prosopis*. An alternative rendering of the name is 'algarrobito'. It would appear that algarobilla has been used locally in Chile as a tanning material and as a dye from remote times and that it first became known in commerce as a tanning material about the middle of last century. In Great Britain it was attracting attention in 1875, being known botanically at that time as *Balsamocarpum brevifolium*. In France it was first used for tanning at Lyon in 1859. Trade supplies appear to have been erratic and irregular and at no time have large quantities of the material been shipped from Chile.

The Shrub

In its natural habitat the algarobilla shrub may reach about 6 ft. in height and be much branched, often with relatively thick branchlets and small pinnate leaves (1—1½ in. in length) with minute pinnae (2 or 3 pairs) about 1 in. long. The shrub is intensely prickly with sharp slender spines, up to 1 in. long, usually in threes on the stem. The yellow flowers are in compact inflorescences at the ends of the branches. The pods, which are straight or nearly straight and not twisted as in *divi-divi*, are from 1—2 in. long and 1—3 in. in diameter. In colour they vary from yellow to dark brown and may have reddish markings. From 2—6 seeds may be present and there may or may not be constrictions between the seeds. The seeds are surrounded by a fibrous network and a yellow or light brown mealy substance which contains the bulk of the tannin of the pod.

Distribution

In Chile the algarobilla shrub occurs only in the provinces of Atacama and Coquimbo, between the rivers Copiapo in the north and Coquimbo in the south, and between 27° 10' and 30° S in a belt roughly 100 km. wide and 26,000 sq. km. in extent. Within
this area the shrub occurs very freely in some places. In others it is sparse or absent altogether. On stony thin soil the shrub is stunted in growth. It is most abundant 20—50 km. from the coast. It is not found more than 80 km. from the sea and reaches an altitude of 2,000 m. The excessive moisture of the coastal districts (up to 25 km. inland) is considered to be the cause of the shrub fruiting poorly. The most favourable conditions are the high plains where there is moderate moisture from light rains and a deep soil. In the eastern areas of distribution, which approach the Andes, insufficient moisture adversely affects growth.

Natural regeneration of the shrub is said to have been poor in many areas in the past. This is attributed to a too thorough collection of the pods, due to the prevailing high prices. Furthermore, chinchillas and rats take heavy toll of what pods escape the collectors. High prices paid for fox skins resulted in increased trapping and shooting of foxes with the result that rats multiplied considerably. Damage to existing stands of the shrub has also occurred through the shrub being used for firewood and for charcoal by collectors, but steps have been taken by the local administration to prevent this. The yield of pods varies from one year to another and is highest in seasons of normal climatic conditions.

Tanning Properties
As a tanning material, algarobilla is rather similar to divi-divi but less prone to cause discoloration of the leather. It also has the advantage of giving better weight and greater firmness to the leather. With the best grades a light coloured liquor is obtained which only slightly colours the leather, giving a light reddish yellow tint. After fermentation an exceedingly bright coloured leather is obtained. Used alone it is not satisfactory for sole leather and is generally blended with other tanning materials. It is a good substitute for gambier. Penetration is rapid. It has been freely used in the tanning and dyeing of furs and fine skins. The extremely light colour it imparts to leather has led to its finding favour with leather for fancy work and fancy articles of various kinds. The tannin present is of the bloom-forming pyrogallol class. It has a rather low pH value and salts content and a rather high acids content.

Commercial samples of algarobilla pods vary in their tannin content, and figures ranging from 45% to 65% have been given. This wide range may have been due in part to different methods of investigation having been used by different workers but it is
safe to assume the tannin content is commonly 45–50%. SAGOSCHEN gives an average tannin content of 44% and soluble non-tans 20% (filter method). According to ROTTSIEPER, pods are said to consist of hull (21% of the pod) with 31% tannin, powder (37% of the pod) and 57% tannin and of seeds (42% of the pod) with no tannin. The tannin seems to have great similarity to that of divi-divi. It contains free and combined ellagic acid, both in large quantities, as well as combined gallic acid. Also here it is not known whether gallic acid liberated on hydrolysis forms part of the ellagitannin or not. Red and yellow colouring matters are present with the tannin in the pods.

Trade
The total annual production or export of algarobilla from Chile in past years has generally been 2,500–3,000 tons, which is considered an average crop. Prior to the Second World War, Germany was the main importer, the final destination of the product being said to be mainly Leipzig. Great Britain and other European countries imported smaller quantities. In more recent years the United States has become the most important consumer.
ALGAROBILLA

Cultivation

The keen demand that has existed in the past among tanners in Great Britain and elsewhere for algarobilla for special tanning processes, and the uncertainty of supplies from Chile, has led to the possibility of cultivating the shrub in other countries being considered. As far back as 1875, seed was dispatched from Kew to Australia, the Bahamas, Barbados, Bermuda, South Africa and India. In 1910 seed was again sent to South Africa and India as well as to Rhodesia, Uganda, Kenya and Cyprus. Since then consignments of seed have been distributed to various countries from time to time, but nowhere does successful cultivation appear to have resulted.

It is possible that the climatic requirements of the shrub may be peculiar or rather specialized. In its natural habitat it appears hardy and drought-resistant and the winters may be cold with frosty nights and some snow. Four inches of rain or its equivalent in snow in winter may be enough to ensure a good crop of pods, but a dry summer is desirable. Probably a high rainfall and high humidity are inimical to the growth of the plant. Experiments at cultivating the shrub at Serena in Chile, which is on the coast, were not successful. Plants flowered freely but pods failed to form. It was assumed that the humid conditions of the coast were responsible.
TARA

TARA is the name commonly given to a fairly well-known tanning material which consists of the dried pods of Caesalpinia spinosa, a tree or shrub widely distributed in north western South America (Plate XV, p. 186). The pods are a similar type of tanning material to divi-divi and algarobilla, all three being members of the same genus (Caesalpinia). It has in fact been called 'divi-divi' or 'Bogota divi-divi' and also 'algarobilla'. Tara pods are often to be seen for sale in the native markets in countries where the tree occurs, especially in Lima, and may be used locally for tanning, dyeing and making ink. For many years they have been exported, usually sporadically or in relatively small amounts, and used in European countries and North America in tanning.

As early as 1707—12 mention was made of 'tara' in the valley of Lima by Feuillee in his observations on the coast of South America. He described it as a shrub reaching a height of more than 12 ft. and gives a fairly good botanical description of it. Feuillee mentions having made a good black ink by boiling the pods with a small quantity of alum.

The tara shrub or tree has been known by various other botanical names in the past, e.g. Caesalpinia tinctoria, C. pectinata, and C. tara. There are many forms or varieties which may differ in their growth characters, ranging from shrubs a few feet high to trees 20—30 ft. in height. As a rule the plant is thorny, but is sometimes thornless. The leaves are pinnate with usually 5 pairs of pinnae, each leaflet being up to 1 1/2 in. long. The yellow flowers are in dense terminal inflorescences up to 1 ft. long. The pods are generally 3—4 in. in length and 3/4 in. broad, rather flattened, reddish brown in colour, soft and easily broken with the fingers when dry. They may be distinctly tinged with red when fresh but may darken with age. Two to six dark brown, flattish seeds are present in each pod.

Tara is perhaps best known in Peru, but the tree (or shrub) is widely distributed and occurs also in Chile, Bolivia, Ecuador, Colombia and Venezuela. It is also recorded from Cuba but is doubtless an introduction in that island. It is regarded as an introduced or cultivated plant in Chile, being often cultivated in gardens at Valparaiso. 'Guarango', or 'guaranga' are names recorded for it in Ecuador and Colombia. In Peru, especially in
TARA

the district round the town of Urubamba, tara is often planted for hedges, a well-grown hedge keeping out cattle, pigs or goats as well as human intruders. In the Urubamba valley, between Ollantaytambo and Torontoy, it is abundant in the wild state at an altitude of 2,400—3,000 m. In Ecuador it occurs in the dry sandy valleys of the Rio Chota and in the valleys of the Andes at 1,800—2,400 m.172

Tara pods appear to have been also known in trade as 'cevalina' or 'carabin', but these names may not be in general use. Tannin content is variable and figures ranging from 35—55% have been given by various writers48, 69. The main value of tara pods is in the tanning of light leathers. Under certain conditions they may be used as a substitute for sumac or gambier to produce light coloured leathers, for they impart but little colour to the leather. The tannin present is of the pyrogallol class. It is somewhat similar to, but more astringent than, sumac tannin. ROTTSEIPER153 states: 'Probably only the existence of a comparatively high percentage of diffusion-inhibiting mucilaginous matter has prevented the tannin from wider application and has also discouraged investigation of its chemical nature of which very little is known'.

During the Second World War when the United States of America was deprived of usual supplies of sumac, valonnea and myrabolans, the tara industry of Peru received a distinct stimulus. An export of 490 tons in 1939 had risen to nearly three times this amount in 1941. Since the war the annual export from Peru has fluctuated around 2,000 metric tons (equivalent to 1,000 tons of tara powder) which is not a large amount. The United States has taken the bulk of the quantity exported. Other post-war importing countries are the United Kingdom, Belgium, Japan, Mexico and Panama.

Tara has been cultivated experimentally in various other parts of the world. As far back as 1802 a shrub 5—7 ft. high is reputed to have existed in the Royal Garden at Madrid, having flowered for the first time in July of that year172. The shrub has been cultivated in southern Italy, Sardinia and in former Italian Colonies180. In many parts of North Africa it has been found to grow well, especially in Morocco. It has also been tried in Tunis (Hamma), Egypt, the Sudan, Uganda and Tanganyika. At Amani in Tanganyika, trees that flower and fruit have been in existence for many years. Trees have also thrived at Arusia from seed obtained in 1936 'despite overshadowing by tall and indigenous trees'. In 10 years trees had reached a height of 20 ft.
or more and fruited freely, usually twice a year (letter from Mr G. Collins). In some parts of Morocco (e.g. Rabat) tara has grown particularly well and small plantations for proposed commercial exploitation established, but it is doubtful whether these still exist. As in East Africa, two crops of pods are produced in the year (February and August), five year old trees producing 10—12 kg. of pods, eight year old trees 25 kg. and matured trees 50 kg.

Peruvian tara is often found to be contaminated with oxide of iron from the soil which adheres to the pods when they are collected. In Morocco this difficulty has been remedied by sieving the pods and removing the earthy matter before grinding. Sheepskins tanned with such purified material were of a fine white colour which allowed dyeing in the lightest of shades.

Other South American Caesalpinias

The pods of several other South American Caesalpinias are known to be rich in tannin and in some instances they have been used in tanning (Plate XV, p. 186).

The thick black or brownish black leathery pods of *C. melanocarpa* are fairly rich in tannin—about 22%. They were being imported into London for tanning in 1881, a sample imported at this time being in the Kew Museum. The tree is common in many parts of the Argentine where it is known as 'guayacan' or 'ibirabera', being very prevalent in the quebracho forests of the region known as Gran Chaco. It may have a bole 2 ft. in diameter, free of branches for 20 ft., yielding a valuable, hard and durable timber. In tanning, the pods are reputed to resemble divi-divi, but both the tannin content and the purity of the extract are lower. The tannin is of the pyrogallol class. The wood is also fairly rich in tannin—about 13%.

Another species whose pods have been used in tanning from early days is *Caesalpinia paipae*. Pods were being imported for tanning to Great Britain from Peru in 1867, according to notes on Kew specimens. The pods are blackish in colour, rather long and slender (4—4½ in. long, ¾ in. wide) and similar to some *Acacia* pods. They are used in Peru under the name of 'pi-pi' for tanning and dyeing.

Other species with tannin-rich pods are *Caesalpinia corymbosa* (Guayaquil), with rather thick woody pods, and *C. cacalaco* (Mexico). According to NIERNSTEIN the latter have been marketed under the name of divi-divi. They are used in Mexican cities.
for tanning by a process which is similar to the English 'bottle' method of tanning sheepskins. Used alone they produce a light leather, but the liquor is prone to fermentation. Another species with pods known to be rich in tannin which has attracted attention in the past is *Caesalpinia ferrea*, known in Brazil as 'juca' or 'ymirá-ita'.
TERI PODS

This Indian tanning material, not to be confused with tara of Peru, consists of the pods of Caesalpinia digyna, a scandent thorny shrub that occurs in India and some adjoining countries (Plate XV, p. 186). It first attracted attention as a possible material for large-scale tanning in 1847 (through a Mr. Sconce of Chittagong), but for half a century after that little or no notice was taken of it. It was used by natives in some areas in the local preparation of leather, and for dyeing. The plant also has native medicinal uses and the large pea-like seeds are sometimes eaten after roasting.

Caesalpinia digyna is a common plant in many parts of Burma and occurs also in Chittagong, Assam, Bengal, Ceylon, Siam and the northern part of the Malay Peninsula. In Burma it is said to favour low-lying situations along streams, but not areas subject to flooding. It is also common on waste land near villages and deserted village sites. It seldom exceeds 10 ft. in height. Its scandent habit and prickly nature renders collection of the pods difficult. The branches are glabrous or slightly downy, and the leaves pinnate with 8-12 pairs of pinnae, each leaflet being up to 2 in. long with a pair of stipular thorns at the base. The yellow flowers, tinged with red, are in simple axillary racemes 8-12 in. long. The pods are fleshy when fresh (1/2-2 1/2 in. long and 3/4 in. broad) and 2-4 seeded. They dry to a dark brown with constrictions between the seeds. The shrub flowers profusely in the rainy season and fruits in the cold season. Seeds require hot-water treatment or fracture of the seed-coat to ensure good germination.

The seeds are spherical (about 1 cm. in diameter), dark greenish brown in colour and very hard. As large quantities would be available if the pods were used extensively in tanning, the properties of the seeds have been investigated. They possess a thick hard seed-coat, equal in weight to the kernel, which is difficult to separate from the kernel on cracking. The kernel itself, which is sweetish in taste, would appear to have high nutritive value (oil 25.9%, protein 14.8%, starch 41%). The thick seed-coat militates against profitable use of the seed, the oil expressed on the basis of the whole seed being about 13%. The seeds represent a considerable proportion of the weight of the whole pod and their removal before using the pods for tanning has been advocated. The seeds
TERI PODS

are usually removed by hand but it is considered they could be readily extracted by mechanical means.

Although the pod is dark brown externally, the inner tissue is whitish and, freed of the seeds, grinds readily to a light coloured powder. There is no granular or mealy matter present, that is so characteristic a feature of divi-divi and algarobilla pods. The tannin content of the husk (dry pods freed of the seeds) of several samples examined at the Imperial Institute was found to be about 52%\(^\text{19}\). As the large seeds contain little or no tannin, the tannin content of the whole pod (husk plus seed) is considerably lower (22—27%). Leather tanned with the husks is reputed to be equal in colour to that tanned with the best sumac and not to darken appreciably on exposure to light. Like other tanning 'pods' the infusion is inclined to rapid fermentation, but not so rapid as with divi-divi. In other respects, its tanning properties resemble those of divi-divi. The opinion has been expressed that if regular supplies of the de-seeded pods were available they would be well received by European tanners. The pods do not appear to be used extensively in India for tanning. Probably the thorny nature of the plant (sharp recurved thorns on the stems) is a limiting factor in the large-scale collection of the pods.
SANT PODS

The pods of *Acacia arabica* are a well-known tanning material in India, Egypt, the Sudan and parts of west tropical Africa. Common names for them are: 'babul' or 'babool' (India); 'sant', 'garad', 'babla' (Sudan); 'neb-neb', 'gonaki' (Senegal); 'gabaruwa', 'bagaruwa' (N. Nigeria). The tree has a wide distribution which extends from South Africa to India, being very abundant in some places such as the western and eastern Sudan. In India it is often cultivated as a source of timber, fuel and tanning material, the bark in addition to the pods being rich in tannin (see Babul Bark, Chapter 9). The tree is usually small to medium sized with a spreading crown, or umbrella-shaped, but may reach large proportions (2½ ft. in diameter and 80 ft. high) in favourable situations near rivers and water courses. There are many forms or varieties of the tree. These show marked differences in the degree of constriction of the pod between the seeds and in the pubescence present. Some of the more extreme forms have been regarded as distinct species. The bark, branches and twigs are dark coloured, and thorns up to 3 in. long, in pairs, are present. The leaves are bipinnate, and the flowers in yellow balls. The pods are straight or sickle-shaped, up to 6 in. long and ½ in. wide, with a wrinkled surface and generally densely covered with a whitish bloom. They develop rapidly. The hard, brown seeds, 10—12 in a pod, are slightly embossed and about ⅝ in. in diameter.

Sant pods are considered to be one of the oldest tanning materials of northern Africa and to have been used by the Ancient Egyptians. Dioscorides and Pliny described a preparation, Akakia, made from them: 'the juice expressed from the leaves and fruit of the tree Kardh or Sant'. They are still much used in native tanning, especially in the Sudan, and are a common commodity in native markets. They have been exported from the Sudan to Italy in the past, also from Senegal to France, but do not appear to have been regularly imported into Great Britain. Although sant or garad pods are usually the fruits of *Acacia arabica* the pods of various other species of *Acacia* may appear under these names, among which are: *Acacia farnesiana*, *A. senegal* and *A. seyal*, all widespread species.
SAN'T PODS

In Northern Nigeria the pods of *Acacia arabica* are the main tanning material used in the preparation of Kano leather (rather similar to ‘Morocco’ leather), an account of which has been given by BEATON. The dried pods are first roughly ground in a mortar, although the seeds are not crushed. About a pound of ground pods are then used for each gallon of water, and the goat skins, after preliminary treatment, immersed for about 6 hours. After squeezing and scraping, the skins are immersed for another 24 hours, then again squeezed, washed and hung in the sun. When dry they are rubbed with groundnut oil and worked to make them soft. Very young green pods are said to yield a pale, almost milky, leather, older green pods a pale fawn, and ripe dry pods a darker leather of a more or less reddish colour. A somewhat similar method of tanning with sant pods is employed in the Sudan.

Sant pods from the Sudan have been found to consist of the following: seeds 33\%, inner pod coat 12\%, outer pod coat 23\%, resin-like grains (occurring between the pod coats) 32\%. The seeds contain little or no tannin but much sugar. They are troublesome to the tanner for they are the cause of early fermentation and deterioration of the tan-liquor. It will be noted that they constitute about a third (by weight) of the whole pod. Their removal, preferably in the country of origin to save freight charges, is therefore desirable.

The tannin content of the pods varies a great deal. On an average, African deseeded pods contain about 30\% tannin, while Indian may contain only 18—27\%. Deseeded pods from ten different parts of Africa were found to have an average tannin content of 33\%, the highest being 41\%, and the lowest 19\%. This wide difference in the tannin content of African and Indian pods is considered to be due to climatic reasons, for trees grown experimentally in India from African seed produced pods with the low tannin content typical of the normal Indian product.

A product known as “Sant grains” has been prepared in the Sudan by crushing the pods and removing the seeds and most of the shell or pod-case by sifting. The Sant grains so produced, amounting to about one-third of the entire pod, contain from 50 to 60\% of tannin, depending largely on the extent to which the fibrous matter has been removed. In tanning, this product produces a soft, plump, very light coloured or pinkish leather which may subsequently be dyed very delicate shades without any deadening appearance. The material is considered to be a
good substitute for gambier and capable of replacing sumac for both tanning and retanning processes. Native-produced leather from Sant pods in Africa has a high reputation for durability, even in the United Kingdom, and especially for bookbinding.

The Sant grains may be sifted from the crushed pods by hand or by mechanical means, but little advantage seems to be derived with the latter from experience so far gained. A drawback with Sant pods or Sant grains is the relatively high proportion of mineral matter (and iron) they are liable to contain. This is due to soil or dust that clings readily to the somewhat furry pods. This mineral matter has been shown to contain a high proportion of iron (including magnetite). Nevertheless, trouble with iron spotting of leather does not seem to take place to any appreciable extent, either from experiments in Britain or in tanneries in the Sudan and Nigeria. However, it is felt that difficulty in the marketing of Sant grains in Britain is due to the fear of spotting among tanners with a material containing such a high percentage of iron.

The tannin present in Sant pods is considered to be of a mixed nature (both pyrogallol and catechol tans) and to consist probably of five different tannins. The high percentage of sugar present in infusions made with the whole pods accounts for the rapid fermentation that takes place. In India it was found that 0.3—0.5% crude carbolic acid on the weight of the pods was sufficient to retard fermentation. The pods are considered to contain too high a percentage of soluble non-tannins to be of any value for making extracts.
LEAVES
SUMAC

SUMAC consists of the dried leaf or ground dried leaf of certain species of Rhus, mainly Rhus coriaria from the Mediterranean region, and in more recent times the dried leaf of various American species. The leaves of Rhus coriaria ('Sicilian sumac') constitute one of the oldest and best known of the vegetable tans. The tannin present in the leaf is of the pyrogallol class, sumac being used mainly in the light leather industry and the manufacture of sheepskin leathers.

The word sumac or 'sommacco' (Italian) is believed to be of Arabic origin from the Arabic word 'sommaq'. Throughout the Mediterranean basin Rhus coriaria has been used for tanning from the earliest times, often in conjunction with the rind of the pomegranate fruit (Punica granatum). It is referred to by some of the classical writers (Theophrastus and Pliny) as being used by the leather dressers of their day. The Latin name 'coriarius' was later adopted in the botanical name of the plant.

Sumac furnishes a much favoured tan where white or light coloured, soft and supple leathers are required. Consequently it is much used in the tanning of Morocco leather, skivers, roans, and leather for gloves, upholstery and fancy articles. An advantage of the leather produced from sumac is that it does not darken on exposure to light and is less liable to decay than leather produced by many other tannages. It is of special value for the production of light leathers for dyeing and for brightening leathers of darker tannages such as wattle. Retanning with sumac may be carried out with some classes of leathers after stripping with borax and washing. This helps to clear the grain of the leather and effects a partial bleaching, thereby serving as a good ground for the production of light shades.

In spite of its special value for certain classes of leather, the use of sumac as a tan has declined in recent decades. This has been due in part to the development of other cheaper tans such as wattle, quebracho and myrabolans for general tanning and also perhaps to the adulteration that has so often been a feature of commercial sumac from the Mediterranean region.

The commercial sumac derived from southern European countries is the product of Rhus coriaria, often referred to as Sicilian
SUMAC

sumac, or European sumac, to distinguish it from American or Indian sumac. In Sicily, the main producing country, the sumac prepared is from cultivated plants. Other European countries where sumac has been produced from *Rhus coriaria* are Italy, the south of France, Spain, Portugal and Greece. The plant occurs wild also in many parts of North Africa and Asia Minor, also in Madeira (up to 2,500 ft., being termed 'sumagre'), the Canary Islands and Azores. It extends eastwards into Afghanistan. The so-called Trieste, Venetian or Turkish sumac that has sometimes appeared on European markets is the product of *Cotinus coggygria* (syn. *Rhus cotinus*). This species also extends eastwards and is well known in north western India (see Indian sumac, p. 217). Another European sumac that has been exploited to some extent in Europe in the past, mainly in France, is *Rhus myrtifolia* (syn. *Coriaria myrtifolia*), known as French, Montpellier, or Provence sumac, also termed 'myrtle' by early sixteenth century writers. Both of these species are inferior to *Rhus coriaria* in that the leaves generally contain less tannin and yield a darker coloured leather. They do not appear to be regularly exploited in Europe for large-scale tanning.

The Sicilian Sumac Plant

In the wild state *Rhus coriaria* is a shrub reaching about 3 ft. in height and often inhabiting dry rocky situations or mountain sides. It bears pinnate leaves with 6—8 pairs of small oval leaflets about an inch long, and small white flowers in terminal inflorescences. These are followed by the more conspicuous reddish coloured, one seeded fruits (drupes) about 5 mm. in diameter and acid and astringent to the taste. They are exported from Persia to India for use medicinally (as an astringent) by Mohammedans. The species is a variable one and forms showing marked variation in size of leaf and degree of hairiness exist.

The sumac plant thrives best under relatively dry, warm conditions and in light, well-drained soils, preferably those of a calcareous nature or volcanic origin. The plant will not tolerate excessively damp conditions and is ill-suited for damp, compact soils or soils prone to become waterlogged. In the richer soils the plant may grow more vigorously or have more luxuriant foliage, but the leaves are believed to have a lower tannin content. In Sicily the plant thrives from sea-level to elevations of 2,000—3,000 ft. There is a winter rainfall with little or no rain from June to September during the hot, dry summer. The plant is drought resistant,
but in some seasons the plants may suffer from hot or scorching winds, which have an adverse effect on yield. Severe winters or spring frosts may also affect yield. Good winter rains are conducive to good yields. The plants are normally fairly free from pests and diseases, but in some years a certain amount of defoliation through insect attack takes place.

In Sicily, *Rhus coriaria* occurs both wild and cultivated. It has been commonly stated in the past that two distinct forms or varieties are cultivated in Sicily known locally as 'sommacco mascalino' (or 'sommacco forte'), and 'sommacco femminello' and that the former is cultivated in the provinces of Girgenti and Trapani while 'sommacco femminello', which is an inferior sort with lower tannin content, is obtained from the east side of the island. According to the views (unpublished) expressed by the late Dr T. F. Chipp (formerly Assistant Director, Royal Botanic Gardens, Kew), who was interested in sumac and visited the island in 1929—views
alleged to have been confirmed by members of the staff of the Orto Botanico at Palmero at that time—there is only one form of sumac cultivated throughout Sicily, and that the so-called 'masculine' and 'feminine' forms exist only in the minds of peasants. What one peasant would call 'sommacco masculino' another would term 'femminello', the terms being used quite indiscriminately and applied according to the grower's fancy—influenced by the growth of the plants and the yield of leafy shoots. One writer states that 'femminello' or 'marine' constitutes the wild sumac of Sicily which has smaller leaves than the cultivated kind and is inferior as a tanning material.

Cultivation
The older accounts of the cultivation of sumac in Sicily give the impression that the crop received more careful attention at the hand of the cultivator last century than it does at the present time, and that it was grown as a sole crop in quite large stands. It would appear that sumac now invariably takes second place in cultivation to other crops such as cereals, pulses, vegetables and the vine. It is usually planted on the steeper slopes or where cultivation ceases on the hill or mountain sides. The plants are commonly relegated to the very stony patches or the margins of fields where they are planted in irregular fashion, 2—3 ft. apart, rather than systematically or in regular rows. They also receive a minimum of cultivation. In general, sumac is grown incidental to other crops to fill odd corners, rough patches and mountain sides too poor or unsuitable for any other cultivation.

Propagation
Propagation is by means of rooted suckers, easily obtained from established plants as suckers are very freely produced. The best suckers are obtained from plants in full vigour rather than those that have passed their prime. They are usually planted in December or January and cut back to a height of 6—8 in. In very stony ground a pick may be used for making the holes. Sometimes a short, shallow trench some 2 ft. in length is made instead of a hole and a sucker planted at each end—as a labour saving measure. In spring the early growth of grass or young weeds may be purposely left for a time and used for fodder before cultivating the plot with the 'zappa', a type of draw hoe. Further cultivation or weeding with this implement is carried out at intervals as required. Plants may be raised from seed, but it is
not customary to use seed owing to the longer time required by seedlings to reach a profitable size.

Harvesting
Harvesting usually takes place in June or July and there may be a second harvest in September. Growers know instinctively when the crop is ready for harvesting. According to Chipp some growers contend that this may be judged by clasping leaves and shoots in the hand. If ready for harvesting, the leaves remain pressed together on releasing the hand, but if not ready the leaves immediately separate. The leafy branches are cut with a special heavy curved knife which has a blade rather like an English pruning or slashing hook and is termed a ‘roncone’. They are then left in loose bundles in the field to dry. Cutting is carried out close to the main stem and to the ground. When growth after the first cutting in June or July warrants a second harvesting in September the leaves are simply stripped off with the hand. After repeated coppicing, the sumac stumps bear a marked resemblance to vines. At one time a method of harvesting practised to some extent was to strip the leaves from the lower halves of the branches and the remaining leaves about a month later. Naturally this involves a good deal more labour but is theoretically the better method. It has been shown by experiment 46, involving extensive tannin analyses throughout the season, that the tannin content of the leaf is at a maximum when the leaf attains full size, but diminishes as the leaf ages. If the lower leaves remain until the upper leaves are fully developed they suffer a reduction in tannin content which may be as much as 8%. The ideal times of harvesting in Sicily are considered to be late June for the lower leaves, and late August for the upper ones. If harvesting is carried out too soon there is not only a reduced yield but also reduction in quality and tannin content. If harvesting is postponed too long, the older leaves may drop from the stems and be lost.

Threshing
When the bundles of cut leaves and branches are dry, which usually takes 3—4 days, they are taken to the threshing floor, termed an ‘aja’ or ‘aria’ and threshed with a flail or ‘bovillo’ (little ox) before being sent to the mill or factory. A specimen of one of these Sicilian sumac flails in the Kew Museum has a stout handle 8 ft. long and 1—1½ in. in diameter, with a notched head of similar diameter and 2 ft. in length, the latter being attached.
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to the handle by heavy hide loops. The weight of the complete flail is 4 lb. Threshing is often undertaken by middlemen and not the cultivators themselves. Sometimes the freshly cut branches are placed in a thin layer directly on the threshing floor and forked over two or three times daily until dry. The coarse stems and branches separated after threshing by means of wooden forks are used as fuel. The threshing floor is usually located on a site protected from wind for the threshed leaves are very light and easily blown away. For the same reason a calm day is always chosen for threshing. Normally threshing is carried out in the full heat of the midday sun when the leaves, being bone dry and brittle, readily crumble and break away from the stalks. As they are destined for the mill it does not matter how finely they break up. However, when the whole leaf is required for sale or export as such, threshing is done earlier in the day when the leaves are not so brittle and come away whole from the stalks. The earth or dust loosened by the flail on an earth threshing floor, and which is mixed with particles of leaf, was formerly regarded as a legitimate source of profit and deliberately mixed with the threshed sumac. The buyer could not object to this for it was regarded by all as a custom of the trade!

Milling

Most of the mills for processing sumac in Sicily are at Palermo, doubtless on account of its being a convenient centre for export and as a rail head. The dry leaves and small twigs are ground in stone mills of the edge runner type—two wheels revolving in a trough. The process involves a system of sieving and regrinding of the coarser material. An important process ‘ventilation’ for the removal of impurities is also carried out. This consists of blowing the ground material by fans, which blow the light leafy matter away leaving behind sand, stones, earthy matter or any particles of metallic iron that may be present. The ground leaf is finally packed in sacks of 75 kg. for export. When the leaves are exported whole they are compressed in hydraulic presses and are shipped in bales usually weighing 250—300 kg. The whole leaf is employed largely in making extract. Sticks and twigs separated from the leaves are used as fuel for the engines.

A sumac mill in operation is generally accompanied by a dense cloud of powdered dust or leaf, and the interior is described as being 'as dark as the most intense London fog. One comes out saturated with fine powder. The odour is not unpleasant, something between snuff
and chamomile. Workmen all wear a handkerchief over the nose and mouth, but it is said to be rather wholesome than otherwise.\footnote{193}

**Adulteration**

Sumac is a commodity that has been much subject to adulteration with both organic and inorganic adulterants. The leaves and hairy twigs of the plant naturally collect a certain amount of dust in the field. When threshing is carried out on the bare earth instead of a stone-flagged threshing yard, stones and earthy matter may become mixed with the broken leaf to a considerable degree, as already pointed out. If the soil is of the red type, containing much iron, this is an additional source of iron impurity, so undesirable in a tanning material. Iron in sumac, even a very small percentage, may be exceedingly harmful. For when such sumac is used in the tannery the skins come out showing small black specks. These can only be removed by bleaching with oxalic acid which damages the leather.

The leaves of various plants have often been deliberately added to sumac, a common adulterant being the leaves of *Pistacia lentiscus*, a common evergreen tree in Mediterranean countries and the source of mastic. At one time large quantities of this leaf were imported to Palermo for mixing with sumac! As it contains 12—19\% tannin it may not be so undesirable as other leaves sometimes used. These include *Ceratonia siliqua* (carob), *Cistus salvifolius*, *Ailanthus altissima* (tree of heaven), *Arctostaphylos uva-ursi*, *Tamarix* and *Rhus* spp. Such adulterants may usually be detected or distinguished by microscopical means as may the leaves of *Rhus cotinus* and *Rhus myrtifolia*.\footnote{183}

**Yields**

With sumac cultivated as a sole crop in full bearing and under favourable soil and cultural conditions, an average yield is considered to be 2 quintals 35 rotoli of leaf per 'tumulo' or approximately 1,500 lb. per acre.\footnote{102} Yields generally increase steadily from the first to about the seventh year, after which the yield gradually decreases. Plants usually become exhausted or cease to be profitable after about the fifteenth year.

**The Sumac Trade**

In the years immediately preceding the 1914—18 war the annual export of sumac from Sicily was in the neighbourhood of 30,000 tons. By 1921 the total export had fallen to half this amount. It
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has remained at a relatively low level compared with the figures for
the earlier part of this century and the latter part of last century.

The annual export of sumac from Cyprus has not been in excess
of 1,000 tons and in most years has been considerably less than
this. The best markets for Sicilian sumac in the past have been
the United States, Great Britain, France and Germany.

Sumac in Cyprus

The sumac plant, _Rhus coriaria_, occurs freely in the island of Cyprus,
and flourishes especially among the vineyards on the mountain
slopes in the southern part of the island. A local name for it is
'reoudhi'. What sumac is collected is entirely from wild and not
from cultivated plants. Good samples of Cyprian sumac compare
well in quality and tannin content with superior grades of Sicilian
sumac, but very often Cyprian sumac is of poor quality and low
tannin content because the leaves are collected before they are
fully mature.

In a leaflet issued by the Agricultural Department in Cyprus on
sumac collection, it is strongly urged that collection should not take
place in the lowlands (under 3,000 ft. altitude) until the middle of
July, and at the higher elevations (above 3,000 ft.) not before 1st
August. It is also strongly urged that stone-flagged threshing
floors instead of the bare earth should be used. For many years
sumac was exported from Cyprus to Egypt and Syria. Milling of
the leaf with stone mills on the island commenced in 1905, and in
1923 a modern factory yielding a good product was established.
It is considered by those who have studied sumac in Cyprus that
the only means of substantially increasing the production of sumac
from the island would be by cultivating the plant instead of relying
on wild supplies.

Among other Mediterranean countries small amounts of sumac
have in the past reached world markets from Tunisia and Morocco.

Sumac in Other Countries

_Rhus coriaria_ has been grown experimentally in countries outside
the Mediterranean basin where suitable soils and climatic conditions
exist. As far back as 1863, sumac had been grown in Australia,
for Australian grown plants were shown at an exhibition at that
time (Kew Bull. 1895, p. 293). There are reports that the
plant grows well in the dry plains of the Wimmera district of
Victoria. In South Africa plants have grown satisfactorily and
fruited at the Botanic Gardens, Kirstenbosch (near Cape Town).
Indian Sumac

Here the climate, with a winter rainfall and relatively hot, dry summer, is not unlike that of Sicily. So far, however, cultivation does not appear to have been taken up on a commercial scale anywhere outside the Mediterranean region.

Tannin Content

Good quality commercial sumac appears on the market as a light, yellowish green powder. The tannin content is usually 26—27% but the figure may vary from 25—30%. Badly prepared or adulterated material may have a lower tannin content. The presence of an unduly high percentage of stalk also lowers the tannin content.

The tannin present is of the pyrogallol class and is very mild in character, penetrating leather slowly. It is readily decomposed if boiled with water, and for this reason the leaf is not extracted with boiling water in practice, the best temperature for sumac extraction being considered to be 50—60° C. If boiled for half an hour, at least 25% of the tannin is destroyed. Tanning liquors made from sumac are liable to vary in composition, probably more so than most tanning materials. Sumac has in general a higher pH value than other materials of its class; also a very high acids and salts content, a large proportion of the salts being of weak acids. This may be partly the reason why sumac is favoured for the tanning of leather that has to withstand prolonged exposure to an acid atmosphere, e.g. bookbinding leathers.

Indian Sumac

The name ‘Indian Sumac’ has been applied to Cotinus coggygria (syn. Rhus cotinus), a shrub or small tree allied to Sicilian sumac (Rhus coriaria) that is fairly widely distributed in north west India, and much used locally as a tanning material. This species also occurs in western Asia and China, and extends westwards through Afghanistan and Persia to central and southern Europe where the leaves are also used in small-scale tanning, especially in the Tyrol. The dried leaves have also entered commerce in the past as a tanning material under the names of ‘Turkish’, ‘Venetian’, ‘Hungarian’, or ‘Tyrolian’ sumac. However, in India the leaf appears to have been used only in local or village tanning and not in the large tanneries, nor does it appear to have been collected systematically for export.

In India this sumac occurs in the lower reaches of the western Himalayas and the Suliman Range at altitudes from 3,000 to
6,000 ft. It is chiefly found in the underwood of forests, particularly those of chir pine (*Pinus roxburghii*). The shrub usually grows gregariously rather than in dense stands. It has a thin reddish brown bark and a dark yellow, mottled heartwood often streaked with brown or greenish grey. When of sufficient size the heartwood may be used for ornamental work, being very decorative. It has been employed in Europe for inlaid and cabinet work. Well-known common names for the tree or shrub are ‘páán’, ‘bhan’, ‘manu’, or ‘tung’ (Punjab). Branchlets, petioles and undersides of the leaves are covered with a soft pubescence. The small entire leaflets, often shorter than the petiole, are strongly aromatic. Fertile flowers in the large feathery panicles are few. After flowering the pedicels of the numerous sterile flowers elongate and become hairy, forming a feathery bunch. On account of the striking inflorescence and the attractive autumn foliage, the shrub is often cultivated for ornamental purposes in Europe and America. Venetian sumac and Smoke tree are common horticultural names for it, the latter name being due to the resemblance of the flowers to smoke when seen at a distance. Cultivated forms exist, one of the most esteemed having a purplish coloured inflorescence.

Throughout the area where it occurs, the leaves, bark and wood of the shrub all seem to be used locally in dyeing and tanning. At one time the wood was used for dyeing in Europe, mainly for yellow or orange colours in woollen materials. Both the bark and the leaves are used by native tanners in India.

An investigation of the tannin content of the bark and leaves from various parts of India and collected at different seasons was carried out by Puran Singh. The tannin content of the bark varies from 10 to 23% (dry material) with an average of 16% for 9 samples, that collected during the rainy season having the highest tannin content. With regard to the leaves, material collected in the spring and summer contained from 7—14% tannin, while that collected in the autumn yielded from 21—26%, and in one case, 31% (leaves from the Kulu Division of the Punjab). These figures indicate forcibly how the tannin value of the leaves may vary according to the time of year or the locality from which they are collected. They also indicate that in India the leaves of *Cotinus coggyria* should be collected in the autumn after the rains for maximum tannin content, when they may not compare unfavourably with Sicilian sumac. It was found, however, that the colour of the tannin or its infusion darkened appreciably towards the end of the autumn.
There are several wild sumacs or species of *Rhus* native to North America, especially in the eastern United States. All are known to contain tannin to a greater or lesser degree, but only three or four are of interest from the point of view of tannin production or have actually been used in commercial tannages. They have only been used to a small extent, and sporadically, in the past. The three main species, all of which are deciduous shrubs or small trees with large compound leaves produced in abundance, are as follows:

**Dwarf Sumac (Rhus copallina)**—Known also as mountain sumac, black sumac or shining sumac. This deciduous shrub is widely distributed in the eastern United States and varies much in the wild state. It may attain the dimensions of a small tree, but is generally a shrub a few feet high. The branchlets are covered with a fine reddish down and the rachis of the pinnate leaves is winged between the pairs of leaflets in a characteristic manner. The small unisexual flowers are in dense panicles 4—6 in. long. The fruits are bright red. These, combined with the reddish purple autumn colour of the foliage, afford a good colour combination and account for the shrub being sometimes cultivated for its ornamental value.

**White Sumac (Rhus glabra)**—Also called smooth sumac, scarlet sumac or red sumac. This shrub, which may reach 10 ft. or more in height, although rarely, is also indigenous in the eastern United States of America and is characterized by smooth leaflets and branches. In some areas it is so common as to be almost a weed. It has large pinnate leaves, turning a rich red in autumn, and red fruits resembling those of Staghorn sumac—a species which it closely resembles. It is sometimes cultivated as an ornamental foliage plant and is attractive with the bluish-white bloom on the branches and undersurfaces of the leaves.

**Staghorn Sumac (Rhus typhina)**—Known also as hairy or velvet sumac. This species is also native to eastern North America and is well known in cultivation as a fine foliaged summer shrub and for autumn effect. If unpruned and allowed to grow as a small tree it reaches 25 ft. or more in height and has a somewhat gaunt habit and flat top. The thick branchlets are densely covered with...
short hairs. In autumn the leaves assume a red shade, suffused with orange or crimson. The female plant has the added advantage as an ornamental plant of having the fruit clusters thickly covered with crimson hairs. This species has been cultivated in England since the reign of James I and grows admirably in the murkiest of London suburbs.

For many years the leaves or leafy twigs of these species have been collected in a desultory and mainly unsatisfactory manner and sold in small quantities for use by tanners or tannin extract manufacturers. The amounts collected in this way and used for tannin do not appear to have exceeded 1,000 tons in most years. The material has usually been gathered from the wild plants in a careless fashion, often by inexperienced collectors or those temporarily out of work and urged to acquire a little ready cash. Before it reaches the user it is frequently allowed to ferment partly or overheat through being left in heaps, or packed improperly dried. This causes it to be dark in colour and in no way to resemble commercial Sicilian sumac. The presence of too much stalk and twiggy matter which has a deleterious effect on the extract has also been characteristic.

The American sumacs have attracted some attention as desirable plants for certain classes of soil erosion control work because of their shallow spreading root system and soil binding propensities. They are sometimes among the first plants to colonize eroded areas.

Tannin Content and Tanning Properties

For tanning purposes dwarf sumac (R. copallina) is superior to both white sumac (R. glabra) and staghorn sumac (R. typhina). It contains a higher percentage of tannin and yields a lighter coloured leather. White sumac is also superior to staghorn sumac. The average tannin content of several samples of the dried leaf of these three species has been given as follows: dwarf sumac 32%, white sumac 27%, staghorn sumac 25%.

Dwarf sumac is the commonest species in the south eastern United States and is the one that has been mainly exploited in the past, chiefly in Virginia. A survey of wild sumac over 12,000 square miles in southern Virginia indicated that some 43,000 tons (dry leaf) could be collected there annually.

It has been found that while the leaves, leaflets and flowers of the wild American sumacs are rich in tannin the other parts of the plant have a low tannin content. The fruits and seeds, mature
or immature, contain little tannin. As they are a cause of dark colour in the extract or in tanning, their admixture with the leaves should be avoided if possible. The leaves of male plants of dwarf sumac (*R. copallina*) had an average of 3·3% more tannin than those of female plants. Leaves grown in shade averaged 2·8% less tannin than similar leaves that had grown in full sunlight. Tannin content varies appreciably with the season, being highest in the summer. The position of the leaves on the plant, i.e. their height from the ground, also affects tannin content quite appreciably, the leaves nearest the ground being richest in tannin. With *Rhus copallina* and *R. glabra* this was found to average 0·6% for each foot in height of the plant.\(^{50}\) Deblossoming of seedling plants was found to result in an increased tannin content of the leaves, although this may not be of much practical significance. Genetical factors have an important bearing on tannin content. Some progress has already been made in the development of superior strains (especially with *Rhus copallina*). These are likely to be closely associated with large-scale cultivation should it develop. Much experimental work on the American sumacs has been carried out in the United States in recent years, the complete cessation of supplies of Sicilian sumac during the Second World War having stimulated interest in the possible development of the domestic product.\(^{50}\)

American sumac, like ordinary sumac, is not well adapted for general use in the tanning of heavy leather for it lacks the weight-giving properties of the usual heavy leather tanning materials. However, it is very well adapted for light leathers and when properly prepared produces pale coloured, soft, durable leathers of good feel.\(^{151}\)

In the past the plumping qualities of American sumacs have sometimes been found to be inferior to imported Sicilian sumac and the colour produced in leather has frequently been appreciably darker. This is due to low quality of the sumac so often caused by bad collection and drying, or to a high proportion of stalk. It has now been conclusively shown\(^{151}\) that sumac of acceptable commercial quality and tannin content may be produced from American species provided correct methods are employed in harvesting and drying.

In a series of commercial tanning tests with some 4,000 sheepskin skivers, employing properly prepared material of *Rhus copallina*, *R. glabra* and *R. typhina*, it was shown that all three species produced satisfactory leather that was approximately equal to that yielded
by Sicilian sumac. The proportion of soluble non-tannins present in these species is high (18—20 %).

**Cultivation and Yield**

From the cultivation trials that have been carried out in the United States the conclusion has been reached that three species of wild sumac may be worth cultivation, *viz* R. copallina, R. alba and R. typhina (already mentioned), and also possibly fragrant sumac (*Rhus aromatica*). The last mentioned is a low spreading shrub of the eastern United States, 3—5 ft. high, with leaves that are aromatically fragrant when bruised.

The wild sumacs will grow on a variety of soil types. Propagation does not present any special difficulty and may be effected by seed or cuttings (root cuttings). Quite often seed may not be produced very freely or the percentage of viable seed may not be very high. This appears to vary much from one clone (or race) to another. Treatment with sulphuric acid may improve germination. Harvesting size is reached in about three years. Three year old plants, grown from seed, were found to yield at the following rates, the figures being expressed in pounds per acre: *Rhus typhina* 2,250, *R. copallina* 975, *R. glabra* 592, *R. aromatica* 416. Midsummer collection of the leaves gives the best results. Leaves collected later on, with the approach of autumn, may have commenced to turn red. They are undesirable for tanning in this state because of the darker colour they impart to leather. In general, cultivated plants appear to have a lower tannin content than wild plants and plants growing in rich soils a lower tannin content than plants in poor soils.

A power driven mechanical harvester is said to have been developed for American sumac. It is suitable for plants in the wild or cultivated state and under favourable conditions is capable of harvesting about three tons of green material per day—the equivalent output of ten men harvesting by hand in a day. Mechanical methods of drying and of separating leaf from stalk are also under trial. As the presence of stalk greatly detracts from the value of the sumac, its removal in an economical manner is very desirable.

It is considered that mechanical harvesting and handling could be much more easily and more profitably carried out with sumac as a cultivated crop than with wild plants. Furthermore, high quality strains could be grown. Cultivation would also result in more uniformity of the product and greater reliability of supplies.
CULTIVATION AND YIELD

It is also thought that sumac should prove a good crop for poor land and should fit into soil conservation programmes because of its value in controlling soil erosion.

The cultivation of Staghorn sumac (R. typhina) as a possible source of tannin has received attention in European countries, notably Czechoslovakia and Germany, and has been favourably reported on but has been inclined to give a dark colour to leather, compared with Sicilian sumac. The ease with which the plant may be grown, its high yield of leaf and its tolerance of hard pruning or pollarding are doubtless points in its favour.
GAMBIER

Gambier or gambir is the name given to the solid extract prepared from the leaves and stems of Uncaria gambir, a shrubby plant that occurs both wild and cultivated in the Malayan region. For tanning, this extract is used much less now than formerly in European and American tanneries. Nevertheless it is still of commercial importance, especially in the East where it is much used as a masticatory in combination with betel. Indonesia, notably the East coast of Sumatra, Malaya and Borneo, are the main producing countries.

Early History
Gambier has been prepared in the Malayan region since at least the seventeenth century and probably several centuries before that. There are definite records to show that gambier boiling was being practised on both sides of the Straits of Malacca at this period. The fact that the gambier plant is only cultivated in the wetter parts of Malaysia where the plant is also wild makes it often difficult to determine whether the jungle plants are really wild or are escapes from earlier cultivation. It would seem, however, that gambier has not been a cultivated plant over a long period, and that it is not of age-long cultivation like many tropical economic plants. The fact that the cultivated gambier is identical with the wild plant and that there do not appear to be established varieties or forms in cultivation supports this view.

Cultivation in and around Singapore for export to oversea markets commenced in the early part of last century. It was taken up by immigrant Chinese who grew it along with pepper, using the spent or extracted leaves as manure for the pepper vines. As fuel became scarce, the gambier growers moved to the mainland having, it is stated, devastated Singapore island agriculturally during a period of 40 years. By 1883 there were 4,000 gambier factories in Johore. In 1892, gambier is reported to have ranked second among the vegetable products of the Malay Peninsula (rubber having not yet become established). Annual exports at that time were valued at $4,600,000. Subsequently, the demand for gambier in Europe grew less, owing to the development of other vegetable tans and partly perhaps to the gravely adulterated
nature of most of the gambier that appeared on the markets. As a consequence, cultivation and production in Malaya and the Dutch East Indies declined. Nevertheless a considerable amount was still produced to meet the local demand for chewing and for export to other Asiatic countries. In 1926 there were 8,000—9,000 acres in cultivation in Malaya, but by the outbreak of the Second World War this had dropped to 3,000—4,000 acres.

**Figure 8.** Gambier (Uncaria gambir): the solid tannin extract is prepared from the fresh leaves in the Malayan region; its main use in the Far East is as a masticatory

*The Gambier Plant*

The genus *Uncaria* (family Rubiaceae) to which the gambier plant belongs consists of some four dozen species of woody climbers or scandent shrubs that occur in most parts of the tropics, the greatest concentration being in Malaysia. They are characterized by the peculiar grapples (modified inflorescence stalks) with which they climb, and by their astringency. The leaves of some species, other than *Uncaria gambir*, are known to be used for chewing, such as *U. longiflora* and *U. tonkinensis*, although only *U. gambir* is used for making extract. A gambier extract, inferior to the normal product, has been made experimentally from the Malayan species *U. jasminiflora*.  

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In the natural state (unpruned) *Uncaria gambiri* is a strong shrubby climber with rather leathery, opposite leaves and numerous small flowers in globular heads. The inflorescences occur singly in the axils of the leaves and are peculiar in that the stalks later become modified. They are sensitive to continual contact and after clasping enlarge and become woody. They increase in length and thickness and form the grapples or curved hooks by which the plant climbs. Sometimes these hooks are produced without first bearing flowers. The numerous seeds produced by the small fruits are minute and bear a transparent tail at each end.

In the seedling stage the plant is somewhat delicate and requires adequate moisture and some degree of protection from continuous sun. When past the seedling stage, growth is rapid and unchecked. The plant soon requires much space or climbs over other vegetation. It thrives best where rainfall is more or less continuous throughout the year and it will not withstand dry periods or drought conditions. Its length of life probably depends to a large extent upon environment but there are records of plants reaching 60 years of age and attaining large dimensions. Under cultivation the plant maintains a more or less shrubby, erect habit due to the continuous pruning.

The plant occurs wild only in the wetter parts of western Malaysia, *i.e.* Malaya, Java, Sumatra, Borneo and many of the smaller islands. It does not occur at the higher altitudes or in the drier areas and is essentially a plant of humid lowlands and high rainfall. If grown at the higher elevations the leaves are smaller and there is a marked reduction in total leafage.

*Cultivation*

For field cultivation gambier is propagated either by seed or cuttings. In Malaya seed is usually used but in Sumatra cuttings of ripe wood may also be employed. These are planted during the rainy season, *in situ*, the same day that they are cut and are kept protected from the hot sun until rooting has taken place. It has been stated that plants from cuttings grow with less vigour than those from seed.

Gambier is usually cultivated as a catch-crop with other slower growing plantation crops, such as Hevea rubber and the African oil palm, and is popular with native cultivators on account of the ease of cultivation and early maturity of the crop and the small outlay. In Malaya its cultivation has been mainly in the hands of Chinese. In Sumatra, the largest producer, it has also been grown largely by Chinese and small-scale cultivators, although
many of the larger estates under European control took up the crop at one time.

In Malaya the seed is sown in specially prepared beds which are lightly shaded as soon as germination takes place, and kept shaded until the plants are strong enough to withstand direct sunlight. The seed germinates in about a fortnight. One picul (133\(\frac{1}{3}\) lb.) of seed capsules is said to produce enough seed to plant 100 acres\(^88\). The small seeds do not retain their viability for long and germination is often irregular. When about 3 in. high and 3—6 months old the seedlings are planted out in the field and kept shaded until established, any that die being soon replaced. Spacing varies according to the main crop that is being interplanted, and plants may be set at 6 ft. apart or at greater distances. Some consider gambier undesirable as a catch crop for oil palms as it is inclined to smother the young palms and subject them to undue root competition. The best soil for gambier is considered to be virgin jungle land, varying from a sandy to a medium loam. The plants will not tolerate stagnant soil conditions or thrive on land subject to flooding.

Harvesting commences when the plants are about 15 months old and consists of cutting off the side branches in lengths of about 2 ft. A knife is used for this purpose, but it is considered that secateurs would have advantages\(^89\). The cut branches are loosely tied into bundles and transported to the factory. Cutting is repeated at intervals of 3—6 months according to the rate of growth. Usually about three-quarters of the total leafage of the plant is removed at each cutting, the weight of prunings (leaves and stems) from a single plant being generally 6—10 lb. Native cultivators in Sumatra sometimes cut back the main stem of the plant or weight it with a stone or piece of wood to induce the development of vigorous basal shoots which render cropping easier\(^91\). Harvesting is not carried out under wet conditions or while dew is on the plants. If the leaves are stacked for even a short time in the wet condition, rapid deterioration takes place with consequent deterioration of the prepared gambier. One labourer is able to harvest the crop from half an acre in a day on a well-developed gambier plantation\(^88\).

It is realized by producers, and has been confirmed by experiment, that a minimum of delay should take place from the cutting of the twigs and leaves to their processing in the factory. For with undue delay chemical changes take place in the leaf which result in a reduction in yield and quality of the extract\(^60, 80\).
The life of a plantation varies with soil conditions and with the treatment the plants receive. As a sole crop, the plants are likely to be at their best at 8 years and to produce well for 15 years or longer. As a catch-crop much depends on the main crop with which it is grown. With rubber the shade from the rubber trees seriously affects the gambier yield after 5—8 years.

No serious diseases of the crop appear to have been recorded, and insect pests are mainly of a minor nature.

**Yields**

In Malaya a fair yield of gambier (as extract) when grown as a sole crop is considered by one authority to be 8—10 piculs (1,060—1,330 lb.) per acre per annum, or, if interplanted with another crop, about a third of this amount. Another writer estimated a yield of 18 piculs (2,400 lb.) in the first year, 5 piculs (666 lb.) in the second, and 4 piculs (533 lb.) in the third year in an area where young oil palms were interplanted with gambier.

About 10 piculs of fresh leaf are required to produce 1 picul of extract.

**Manufacture**

Although the basic principle of gambier manufacture is the same throughout all the gambier producing areas, i.e. boiling of the leaves and twigs in water and concentration of the resulting liquor by heat, details may vary a great deal from one district to another. They also vary somewhat according to the form of gambier required.

The Chinese or native-operated factories are usually of simple design and constructed within easy reach of a good firewood supply and of water. In Malaya the factories are usually built of round timber, have earth floors and are enclosed on two sides only with plank walls. They have a steeply sloping thatched roof and rafters in the upper part serve to hold the trays of prepared gambier to accelerate drying from the heat of the fires below. Boiling is carried out in circular iron or (preferably) copper cauldrons 4—5 ft. in diameter and 1½ ft. deep set over furnaces of beaten clay sunk in the floor. A wooden funnel-shaped extension fits the top of the cauldron, at the back of which is a long wooden chute on which the extracted leaves are put to drain. Metal chutes for this purpose have been found unsatisfactory. A factory may have any number of cauldrons according to its capacity.

Freshly cut leaves and twigs from the plantation are placed in the cauldrons of boiling water and boiled with frequent stirring.
for 2—3 hours, when they assume a yellowish colour. They are then placed on the chute to drain and are washed with water to remove what extract may be adhering to them. All leaf or stem fragments are removed from the boiling mass in the cauldron by means of a coarse meshed sieve of rotan canes. The presence of leaf fragments in the final product is not only undesirable in itself but such fragments impede setting or crystallization of the final product. The liquor in the cauldron is subjected to further boiling until it assumes a deep brown colour. It is then baled out to cool, often into small wooden tubs 8 in. high and 14 in. in diameter. When partly cool, setting is accelerated by stirring with a short piece of wood in a special manner, and the contents are then poured into flat moulds if required for cube gambier.

When cool, the flat slabs of solid or semi-solid gambier are cut into cubes or rectangular pieces by means of a knife or piece of hoop iron. If bale or block gambier is required, the extract is left to cool and set in the tubs. It is then removed, cut into large blocks, placed in the sun or in the racks to dry and finally pressed together and packed in grass matting or boxes ready for the market. Drying is usually carried out first in the sun and finally in the factory in racks over the furnaces. The block gambier usually retains a higher moisture content than does the cube form.

Experimental work in Malaya has shown that the temperature of extraction has an important bearing on the character of the extract and that a temperature of about $80^\circ C$ is theoretically the most desirable. Higher temperatures lead to decomposition (oxidation) of dissolved matter which could be reduced by the use of closed vessels in place of the open pan method. The acidity of the liquor also affects the proportion of solid matter that remains soluble, that represented by $\text{pH} 5$ giving the best results. Evaporation of the extract at low temperatures, as has been practised by European estates in Sumatra, is also desirable and gives a product of high quality and good colour.

For local consumption or chewing gambier, the product may be moulded into various shapes, the disc or biscuit form being common. The various shapes have been described and figured by Temminck Groll. It is a common practice to add rice bran to cube or disc gambier, usually to the extent of 10—25%. This has advantages when the gambier is used for chewing, although it is naturally reprehensible to the tanner. For chewing, it adds porosity to the product and makes it easier to break off a small piece. It also makes it easier to mould the product in pieces of uniform size. Regularity
of size is important in Eastern markets or bazaars where pieces may even be retailed singly.

In some areas, especially in Sumatra, factories on more modern lines have been established. In these the leaves are exhausted by diffusion in cylinders of the type used for sugar. The quantity of water and heat are closely controlled, and concentration is effected at a reduced pressure. This procedure yields block gambier of high and unvarying quality. Gambier of this sort, well packed in wooden or plywood containers, has sold at a premium on European and American markets.

The Gambier Trade
As a tanning material, gambier is now of far less importance than it was in the earlier part of the present century or the latter part of last century. This has been due largely to the increased production and use of other tannin extracts, notably wattle and quebracho. Nevertheless, under normal conditions considerable quantities are still prepared in the East both for local consumption and for export.

In a survey of the industry made by Rowaan and Van de Koppel the average export from the Dutch East Indies, the main producer of gambier, for the five years preceding the Second World War, was 6,215 tons. Of this quantity, 4,040 tons represented gambier in block form for use by oversea tanners and 2,175 tons was in the small cube or disc form as required for the betel quid and for consumption in the East. The bulk of the latter was destined almost entirely for Singapore, from whence it may have been shipped together with Malayan gambier to various countries, including India and the Far East. These figures do not, of course, take into account the large amount of gambier consumed locally in the Dutch East Indies. The main buyers of East Indian block gambier during this period, in order of importance, were: the United States, Great Britain, Singapore (for re-export), France and Holland.

Rowaan and van de Koppel estimated that the total quantity of gambier consumed annually in the East for betel chewing was some 10,000—12,000 tons and the quantity exported to Western markets (mainly used for tanning) about a third of this amount. A certain amount of cube or disc gambier may be exported from Singapore to Western markets. The total annual export from Singapore before the disruption of the Second World War was about 2,000 tons, a third of which went to India and Burma.
COMPOSITION AND USES OF GAMBIER

The gambier trade and gambier prices have fluctuated a great deal in past years. This is attributed, in part at least, to the fact that gambier has been grown largely as a catch-crop with other plantation crops and the acreage under gambier has therefore been dependent upon the acreage being planted with crops such as rubber and oil palm. The demand for gambier in tanning has also been influenced in the past by the amount of adulteration practised, Chinese producers and dealers being often guilty of heavy adulteration with earthy or other matter.

The fact that gambier requires much fuel for its preparation has had an important bearing on cultivation and production. Shortage of fuel was one of the reasons for cultivation being relinquished on Singapore Island at quite an early period. The transfer of cultivation from Java to Sumatra that has largely taken place may be due to similar causes.

Composition and Uses of Gambier

The extract gambier, also known as catechu, pale catechu or terra japonica, is usually dark reddish brown or greyish brown externally and a lighter colour internally. It is friable and porous and microscopically is seen to consist chiefly of minute acicular crystals. It contains catechu-tannic acid (22–50 %) and catechin (7–33 %). There are also present varying amounts of water, vegetable acids and their salts, sugar, starch, cellulose, wax, oil, vegetable debris and mineral matter. Different commercial samples exhibit a wide range of variation, especially as adulteration is frequently practised. The catechin is not identical with that of cutch (Acacia catechu) and occurs in white, silky needles. It is sparingly soluble in cold water, but freely soluble in boiling water and alcohol. With ferric salts it produces a deep green colour. As a tanning material it is of the catechol class with a fairly high pH value and total salts content.

Used alone as a tanning material gambier gives a rather spongy leather, but when used with other tans, such as wattle extract or myrabolans, it is well suited for both light and heavy leather. Among tanners in Great Britain it has been used mainly for calf skins and kips. Gambier has also found favour for the dressing of fur rugs, used in conjunction with alum and salt. It may also be used in tanning or dressing fishing nets.

Most of the world's production of gambier finds use as a masticatory in the East as a constituent of the betel quid so familiar in many Asiatic countries. The delicacy or alleged delicacy of
flavour of gambier when used in this way is said to be due to the catechin present. It is believed that in some parts of the East betel chewing is practised less by the younger generation than it is by their elders. This may have a bearing on future gambier production.

Small quantities of gambier or catechu are employed for medicinal purposes, the action being that of a powerful astringent. It is naturally incompatible with gelatin, iron salts and alkalis.

Introduction to Other Countries
The gambier plant has been introduced to other countries, such as Ceylon, the Seychelles, British Guiana and various West Indian islands, but nowhere has its cultivation on a field scale been taken up outside the Malayan region. In 1890, stimulated by the high prices and short supplies of gambier extract in commerce, a large consignment of seedling plants and cuttings were despatched from Kew to the West Indies (Trinidad, St. Vincent, St. Lucia, Dominica) and to British Guiana (Kew Bull. 1890, pp. 109—111). In some instances plants survived for a few years and flowered, but for the most part the plants did not thrive and soon succumbed (W. Ind. Bull. 1 (1904), pp. 80—85). This may have been due partly to a lack of understanding of the rather special climatic requirements of the gambier plant.
DHAWA OR COUNTRY SUMAC

Indian Sumac, Country Sumac or 'Dhawa', as it has been called in India, consists of the dried leaves and twigs of *Anogeissus latifolia*, a medium-sized to large deciduous tree common in many parts of India. It is a well-known tanning material in India and has long been employed by Indian tanners.

The tree occurs throughout the sub-Himalayan tract from Ravi to Nepal (ascending to 4,000 ft.) and southwards throughout the greater part of the Indian Peninsula. It also occurs in the drier parts of Ceylon but is absent from eastern Bengal, Assam and Burma. The tree is characteristic of the drier type of deciduous forest. It usually occurs intermixed with other trees. In some regions it is present in nearly pure stands. The tree is particularly abundant in the south east of Madras State where it may constitute 50% of the tree vegetation on the upper dry slopes.

The tree seldom attains very large dimensions or a girth of more than 6 ft. The wood is very strong and tough and is much used for cart axles and other purposes requiring great strength. The tree is also of interest in that it is the source of 'ghatti gum', a well-known Indian gum with similar uses to gum arabic. It is known by various native names such as 'dhawa', 'bakli' (Hind.), 'Dindal' (Kan.) and 'vellay naga' (Tamil). The thin, smooth bark of the tree is also fairly rich in tannin (about 13%).

The other less well-known species of *Anogeissus* that occur in the Indian Sub-continent possess leaves rich in tannin that might be regarded as sumac substitutes. They are *A. acuminata* (which occurs in Burma also) and *A. pendula* a small tree; the former with 9—32% tannin in the leaves and the latter with 23% (old leaves).

*Tannin Content of Leaves*

The leaves of 'dhawa' vary from 1½ to 3½ in. or more in length and are broad in proportion to their length. They are pubescent or downy when young, but smooth when full grown. With the approach of the dry or the cold season the leaves turn a coppery red to reddish brown colour making the tree very conspicuous. The tree is bare of leaves during the greater part of the dry season. In most parts of northern India and Pakistan the young leaves
come out in about May. The small heads of greenish yellow flowers appear from June to September according to locality.

As the young leaves and shoots appear, they are reddish in colour and at this stage are very rich in tannin. The term 'Dhawa sumac' has been applied to the material collected in this immature stage, to distinguish it from the mature green leaves. This Dhawa sumac (dried) has been found to contain as much as 38.5% tannin which is 10% more than the usual commercial grades of Sicilian sumac (Rhus coriaria). Mature leaves collected at the same time have been found to contain up to 32% tannin, although the average tannin content would appear to be appreciably lower. A mixture of the dry green leaves and the immature young leaves and shoots is said to have a tannin content of about 30%. The proportion of soluble non-tannins is not high for leaf material (10–13%) and may be regarded as advantageously low.

In Dhawa sumac prepared entirely from the young red leaves Fraymouth and Pilgrim found 49% tannin and as much as 55% in prepared and sieved Dhawa sumac. This is an exceptionally high tannin content for any class of leaf material and in fact compares with pathological plant tissue such as plant galls.

**Tanning Properties**

The tanning properties of both the mature and the immature leaf of *Anogeissus latifolia* are regarded as very satisfactory and well suited for the light leather industry, yielding soft leathers of light colour and firm texture. It has been pointed out, however, that it would be unwise to consider the material as a rival to true sumac. One observer has indicated that the length of time required for tanning raw pelt with this material is about double the time required with ordinary or Sicilian sumac, although this fault might be remedied. Another criticism was that leather tanned with the material was found to be somewhat more sensitive to light (change of colour on exposure) than leather tanned with ordinary sumac. In general, however, the leaves of *Anogeissus latifolia* are regarded as a satisfactory tanning material for light leather.

**Drying the Leaf**

It would seem that difficulty has been experienced in India with the customary shade-drying of the leaves when collected in bulk for commercial purposes. When placed in heaps the leaves soon ferment and this is accompanied by darkening and a loss in tannin.
SILVICULTURE

content. Drying the leaves in the sun results in much quicker
drying and retention of good colour but it unfortunately causes a
loss of tannin content. From experiments carried out at the
Imperial Institute it would appear that the loss in tannin may range
from 5 to 13 units per cent\(^1\), and that this loss is accompanied by
an appreciable increase in the percentage of soluble non-tannins
present (from about 11\% to 15\%). In spite of the loss in tannin
caused by sun drying, it would seem that the sun-dried leaves still
contain a percentage of tannin that compares favourably with that
of Sicilian sumac.

Silviculture

Difficulty has been experienced in India in germinating the seeds
of \textit{Anogeissus latifolia} and the belief is held\(^2\) that it is only in certain
years that seed of good fertility is produced and that such years
may be those following very dry years. The seeds are small and
weigh 3,000—3,500 to the ounce. Young seedlings grow 4—8 in.
in their first year during which time they develop a taproot about
18 in. long. They are liable to injury by frost but not by browsing
animals. Root suckers are produced. Two year old trees may be
4\frac{1}{2} ft. high and ten year old trees 15 ft., with a girth of 5\frac{1}{2} in.
Thirty year old trees may be expected to have a girth of 12—18 in.\(^3\).
Growth is therefore rather slow.

In most parts of India, the tree has been found to coppice and to
pollard well, provided it is cut at the right time of the year (May).
This may be an important point should the possibility of cultivating
the tree for tannin with mechanical harvesting be considered at
any time. It has been found in some areas that, within two
months of coppicing, strong shoots of bushy growth have appeared,
these being covered with new young leaves rich in tannin. After
stripping such coppice shoots of leaves, fresh new leaves have been
produced soon afterwards. It would seem, therefore, that the
tree may be responsive to good silvicultural treatment for the
production of leafage in bulk for tannin, and that it may in time
attract attention in countries outside the Indian Sub-continent.
ROOTS
CANAIGRE is the name used for the dahlia-like tubers of *Rumex hymenosepalus*, a dock that occurs wild in parts of the south-western United States of America and in northern Mexico. These tubers are rich in tannin, and have been used in the past in domestic tanning where the plant occurs, and in commercial tanning, but only in the latter part of last century and in the early part of the present century. Other names recorded for the plant are 'tanners' dock', 'wild rhubarb' or 'wild pie plant', the plant being somewhat sour to the taste and alleged to have been sometimes cooked and eaten by early settlers. The name canaigre is considered to be a French rendering or corruption (canne—cane: aigre—sour) of the Spanish name caña agrio. It is thought that missionaries sent the plant to France at an early date.

Early History
An account of the early history of canaigre as a tanning material has been given in some detail by Collingwood, Toumey and Gulley and by Trimble, from whose accounts much of the following information has been obtained. Although long known to the Mexicans as a tanning agent and used by them for skins, it was not until the latter part of the last century that canaigre attracted the attention of Europeans and the high tannin content of the dry root became established. In 1868 a Mr. John James of San Antonio, Texas, sent a letter and specimens of dried tubers to the Chemical Division of the United States Department of Agriculture at Washington. The parcel and letter apparently became mislaid, but in cleaning out some ten years later they were found by the chemist of that time who made an analysis of the roots, and published a report (*Rep. U.S. Dep. Agric.* 1878—9). The report concluded with the following remarks: 'Whether this root is valuable either for tanning purposes or for medicinal use must be determined by actual experimentation. The result of the analysis fails to show the presence of any substance that would prove injurious to leather, and the large proportion of tannic acid is certainly a favourable indication. In many particulars this root resembles rhubarb, and it seems probable that it may be used to advantage in place of rhubarb, where a more astringent medicine is indicated.'
The first attempt to establish the commercial value of canaigre as a tanning material is reputed to have been in 1882, when a Colonel J. C. Tiffany, then Government agent for the Apache Indians at San Carlos, Arizona, dispatched considerable quantities of the root from Deming, New Mexico, and El Paso, Texas, to New York and to Great Britain, Germany and Austria. Through being dispatched whole (instead of sliced) and improperly dried and arriving in poor condition, the roots were not well received in the first instance. However, two years later (1884), one of Col. Tiffany's sons sent consignments of properly dried sliced root which arrived in good condition and made a more favourable impression for tanning. Inadequate supplies of roots from wild plants appear to have restricted further efforts at large-scale exploitation for a time. In those days transportation was not as it is now. The Canaigre Supply Coy. of Tucson, Arizona, then exploited the product for a time and prepared an extract from the roots. Later, an extract factory was established at Deming. In 1885—6 canaigre was displayed as 'a new tanning material' at the New Orleans Exhibition among products from New Mexico. In 1886 a tannery was erected at Tucson for tanning hides with canaigre but 'owing to lack of proper management and disagreement among the stockholders the business did not thrive'. During 1891 and 1892, the export of dried tubers from Arizona, New Mexico and south-western Texas assumed greater importance and the Southern Pacific Coy. 'handled 370 carloads of sliced and dried roots consigned to Europe'. More may have been sent by other channels.

The usual method of working the roots in those early days has been described as follows: 'The ordinary method of preparing canaigre for shipment is for someone to locate a good patch, then with a force of men make a camp at this place. The men dig the roots by contract, a certain price being paid for the roots delivered at the cutting machine. The machine slices the roots into pieces one-twentieth to one-fourth of an inch thick. These pieces are then exposed to the sun and air until air-dried. In this state they contain about 8% moisture and from 20 to 35% tannic acid, and can be safely shipped if they are kept dry. This is a cheap and efficient method, requiring little capital or machinery and being especially adapted to handle canaigre growing in a wild state'.
during World War II, attention was again paid to canaigre, stimulated by the disruption of outside supplies of tanning materials to the United States and also probably by the steadily diminishing home supplies of tans such as chestnut, oak and hemlock.182

Figure 9. Canaigre (Rumex hymenosepalus): the dahlia-like tubers of this dock, from the southern United States of America, are rich in tannin, but their high starch and sugar content is a drawback.

The Plant and its Occurrence

The canaigre plant is a perennial with stout erect stems 1—3 ft. high and rather large succulent leaves. The stems and leaves die off in the summer, but the tuberous root remains alive. The leaves are 6—30 cm. long, often with an undulate or wavy margin, acute at the apex and narrowed at the base to a short thick petiole. Upper and lower surfaces of the leaves are very similar. Some plants have relatively wide leaves while in others the leaves are narrow. The large compound inflorescences, 10—30 cm. long, develop conspicuous, usually rose coloured fruits with broad valves (8—12 mm.) reticulately veined. The seed itself (4 mm. long) is smooth, shining, and sharply four-angled. Although the plant flowers freely, only a small percentage of the flowers normally yield fertile seeds.

The cluster of large dahlia-like tubers at the base of the stem or stems in this species is characteristic and, in general appearance, not unlike the cluster of roots in some varieties of sweet potato. The size of the tubers naturally depends a good deal on the vigour
of the plants and the nature of the soil. In weight they vary from a few ounces to over a pound. Some are long and slender while others are short and thick. They may be in clusters of three to a dozen and occur at soil level down to a depth of a foot. The colour varies from reddish brown to black depending on age and probably on the amount of iron in the soil. Patches of corky or lenticellular tissue occur on the tubers below which small roots develop, but these disappear on maturity of the tubers.

Buds form on the crown of the tuber from which new stems arise. Although the tubers may reach their maximum size after the first season’s growth, they live for several years continuing to send up shoots each spring. In this respect the plants differ from other well-known tuberous-rooted plants, such as the potato and the dahlia, where the mother tuber dies after the first season. Young tubers are nearly white internally but become yellowish red as they age. On being cut and exposed to the air the tissue darkens. The texture of the fresh tuber is similar to, but denser than that of a potato. When dry the tubers become nearly black and very hard—to too hard to be cut with a knife. The fresh tubers present no difficulty in being sliced and dried.

The canaigre plant has a fairly wide distribution in the southwestern United States being found from California and Lower California to New Mexico and Western Texas, and in Mexico. It occurs in dry areas on the plains and low mountains, also in river bottoms and along washes where it exhibits the most luxuriant growth and the best tuber development. The plant appears to prefer sandy soils subject to flooding. In such places it may form dense growth, 2—3 ft. in height, which resembles a cultivated crop at a distance. In Arizona the plant is reputed to grow in nearly all the lower plains and river valleys of the southern part of the State and to be abundant in many parts of the Salt and Gila River valleys. In this region the plant normally appears above ground shortly after the winter rains (January—February) and grows rapidly. By the end of April it is commonly in full bloom and by the end of May has matured its seeds, and the aerial parts wither and die down. Thus in the wild state the period of growth of the aerial parts only extends over a few months. With early winter or fall rains, the plant may commence growth in November or December, the winter not being sufficiently severe to destroy the foliage. This leads to thriftier growth.

The nature of the plant and its habit of growth renders it well suited for hot and arid regions with a short, rainy season, for it
CULTIVATION

completes its growth in a few months and then dies away, the fleshy tubers being well able to withstand a long dry season and to resume growth as soon as the rains return.

Cultivation

It was early realized that if the canaigre industry was to develop, the plant would have to be cultivated, and wild stands would not prove satisfactory or adequate. The earliest experimental cultivation of canaigre on a field scale was doubtless that carried out by Collingwood, Touney and Gulley in Arizona. More extensive field trials were commenced in the southern United States during World War II. The early trials of last century yielded interesting results. The best and most convenient method of propagation was found to be by tubers rather than seed. In any case viable seed is not produced at all freely. A suitable spacing distance was found to be 2 ft. 6 in. between the rows and 9 in. between the plants in the rows. Plants were found to grow quite well on heavy soils and to give a good yield of roots provided the ground was well prepared and the roots not planted deeply. Neglect of these precautions in heavy soils led to poor tuber yields or even to failure of the tubers to develop.

One of the most interesting results of these early experiments was found to be the beneficial results in root yield from early planting accompanied by irrigation (during the dry months). With stands raised from tubers planted in July and employing irrigation, growth had commenced by October, although the plants did not flower and die down until the following May. At this time the average size of the new tubers was three times that of the tubers used for planting. These had been taken at random from wild plants and were not selected. The average yield of fresh tubers from these irrigated plants was 8—10 tons per acre. There was a wide variation in the quantity of tubers per hill indicating that a larger yield may have been obtained by selection of seed tubers and rejection of the older tubers. Tubers planted after January yielded a light crop of new tubers. Those planted in March made hardly any tuber increase but produced leaves and a stunted seed stalk. However, after being dormant, such plants made normal tuber growth the following season. The opinion is now held that for the successful commercial production of canaigre in the relatively dry south-western United States, irrigation will be essential, such is the increase in yield resulting from irrigation.
From the early experiments it was apparent, under the prevailing conditions, that the plant had a fairly regular time for flowering, dying down, and passing into the dormant condition, whatever the time of planting, but that tuber development was influenced very considerably by the time of planting. The number of tubers formed and their size is influenced largely by the time they have for development after the ground is wet in the autumn, the continued moisture of autumn and winter ensuring steady growth.

Although the plant occurs in the wild state mainly on loose sandy soils it was found that in cultivated plots better yields were obtained from moderately heavy or even quite heavy soils that had been well cultivated and where shallow planting was practised than was the case on very light land. Furthermore, cultivation on the heavier land did not appear in any way to reduce the tannin content of the tubers.

Using average-sized seed tubers, about a ton are required to plant an acre where a spacing of 2 ft. 6 in. by 9 in. is employed. The cultivation of canaigre on a field scale has been compared with the cultivation of Irish potatoes or of sugar beet. Although the latter may offer the closer analogy, the cultivation of canaigre is much easier. The young plants, which arise from tubers not seeds as in sugar beet, grow rapidly and are not easily choked by weeds. A yield of 20 tons of fresh tubers per acre is considered within the bounds of possibility with the crop planted on good land and well cared for. High yields of 6 lb. of tubers, i.e. 6 lb. of tubers per plant, have been recorded. The probable costs of cultivation of canaigre have been likened to those for potatoes. A potato planter, with a little adjustment, has been found suitable for planting the tubers and a potato harvesting machine with suitable modifications for harvesting the crop.

Six tons of fresh tubers yield two tons of sliced dried tubers and this in turn would yield about one ton of extract. For extract, the conversion of the fresh tuber, without the labour of slicing and drying, has obvious advantages, one being the eventual return of the extracted tuber or ‘bagasse’ to the land.

Tubers may be kept or stored some time if simple precautions are taken, as the following remarks show. ‘After removal from the ground, canaigre roots, if piled in large heaps four or five feet deep, will heat and ferment; if in thin layers covered with dry earth, they may keep indefinitely two or three years, but when moistened, they will sprout and grow. Roots taken from a sack in the loft of our barn where they had remained a year, when
TANNIN AND TANNIN CONTENT

taken out, were dry and corky, shrivelled up and apparently dead, but when planted and moistened grew as readily as fresh gathered roots.

Drying

The drying of sliced or shredded canaigre tubers does not present difficulties, nor are the tubers difficult to slice or to shred. In the regions where the plant occurs, drying conditions are usually ideal during May and June for rain seldom occurs, humidity is low and there is abundant sun, heat and wind.

In drying trials carried out at Sacaton, Arizona, it was found that the tubers from the sandy soils of that area were very easy to wash and a potato washing machine was quite suitable. For shredding the tubers, a sweet potato shredder with slight adjustment, did the work very well. The shredded tubers were immediately spread in the hot sun, on concrete or asphalt. When thinly spread, at the rate of a pound per square foot, and turned twice during the day with a broom, drying was complete in 24 hours. A thicker layer naturally requires longer to dry. Fairly rapid drying is desirable to avoid any possibility of fermentation which reduces the tannin content and the tanning value.

Cultivation in Other Countries

The canaigre plant has been introduced to and cultivated in various other countries, but nowhere does this appear to have resulted in more than the growing of a few specimen plants for observation or the establishment of small trial plots eventually to be abandoned. Such countries include India, Queensland, New South Wales, South Australia, Southern Rhodesia and South Africa. The plant was found to grow well in various parts of Australia in light soils where the winters are short and not too severe.

Tannin and Tannin Content

In canaigre it has been shown that the tannin content of the fresh tuber is dependent to a large measure upon its age and the time of harvesting. Roots of similar age from different plants or different districts also show variation as would be expected. The tannin content of tubers that have been formed and have remained in the ground for a year or more is usually between 30% and 35% (dry weight). With tubers under a year old the tannin percentage is generally less than 30% and considerably less for very young
CANAIGRE

tubers. Average moisture content is 65—75 %. During the first season after the formation of the tubers, the tannin content rapidly increases as the season advances. This is clearly illustrated by figures obtained by Collingwood, Toumey and Gulley. They are as follows, and are for the newly formed tubers from plants established the previous autumn from seed tubers.

<table>
<thead>
<tr>
<th>Tubers dug</th>
<th>Tannin content</th>
<th>Tubers dug</th>
<th>Tannin content</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 17th</td>
<td>3-9%</td>
<td>October 15th</td>
<td>23%</td>
</tr>
<tr>
<td>June 14th</td>
<td>16-7%</td>
<td>November 16th</td>
<td>24-4%</td>
</tr>
<tr>
<td>August 2nd</td>
<td>18-2%</td>
<td>January 10th</td>
<td>25%</td>
</tr>
<tr>
<td>September 13th</td>
<td>23-1%</td>
<td>January 17th</td>
<td>28-9%</td>
</tr>
</tbody>
</table>

The tubers dug in January with only 3-9 % tannin were very immature and were only 3 in. long and ½ in. in diameter. The rise in tannin content as the season advances is very obvious. Tubers that have commenced to sprout or to show buds at the crown usually have a higher tannin content than those of similar age but unsprouted. This probably accounts for the higher tannin content figures after September. The amount of colouring matter also increases with the age of the root and it may therefore not be desirable to defer harvesting beyond the latter part of the summer. Furthermore, as autumn approaches, drying conditions are not so good. Damaged tubers are liable to be quickly attacked by mould. Tannin occurs in the stem and leaves of the plant but only in small amounts.

At least two distinct strains of canaigre are now known to exist. These differ in colour and in tannin, also in their behaviour in leaching experiments.

Difficulties in Tannin Extraction

The large amounts of sugar and starch present in canaigre (8—20 % sugar and 25—40 % starch) are the cause of grave difficulties in attempts to extract the tannin or manufacture tannin extracts from it. Canaigre differs from other tanning materials in the presence of these large amounts of sugar and starch. The usual commercial method of extraction of tannin employing the counter-current principle with hot water is impracticable or inefficient because the swelling and gelatinization of the starch by the hot water prevents proper extraction of the tannin from the shredded material. The high percentage of sugars results in an
DIFFICULTIES IN TANNIN EXTRACTION

extract that is unduly high in soluble non-tans and with a correspondingly low percentage of tannin. Energetic steps have been and are being taken in the United States to overcome these difficulties. Whilst a measure of success has been obtained under experimental or laboratory conditions it has not been found feasible or economic, as yet, to apply them to commercial or largescale conditions.

With regard to the starch problem it was found that with the counter-current method the vigorous mixing of the liquor and spent material between each leach (at 104—113° F), followed by mechanical separation of liquids and solids, gave greatly improved tannin extraction, e.g. 29.4% tannin was recovered from roots containing 35.5%. The addition of an organic solvent to the leaching water has also been found to increase tannin yield but its economic desirability has not been fully evaluated. It has been shown experimentally that the sugars present in the extract may be removed by fermentation by using specially isolated bacteria obtained from canaigre tubers or the soil in which they grow, and that this may be effected without material loss of tannin. In extracts prepared from the fermentation procedure the tannin content was raised from 49.7% to 62.1% and the extracts were found to compare favourably with commercial extracts such as powdered chestnut and solid quebracho.
DOCKS

Besides canaigre, known also as red dock and tanner's dock, there are many other docks or species of *Rumex* known to possess roots rich in tannin. Several of these have been considered as sources of tannin, especially in war-time, but they have never become permanently established as commercial sources of tannin. Dock roots have long been used medicinally in many countries on account of their astringency or tannin content. The genus *Rumex* is a large one with over a hundred species distributed throughout all temperate climates. They are perennial (rarely annual) plants with a strong, well-developed root system and are frequently troublesome as weeds.

Investigations on the tannin content of the roots of common docks in European countries have shown that the tannin content of several species is liable to vary a great deal with the season or time of year when the roots are harvested. Roots of *Rumex hydrolapathum* contained 21.3% tannin in June and 11.5% in September; those of *R. patientia* 21.4% in April and 16.5% in June; and those of *R. acetosa* (a very common species) 22.6% in January, 20.8% in April, 15.2% in July and 17.6% in September.

It would also appear that soil or environmental conditions may have a considerable affect upon the tannin content of docks. The giant or great water dock (*R. hydrolapathum*), which may reach 6 ft. in height and is often common by streams and in ditches, was found when cultivated (in Germany) to have a root tannin content of 12—21% under wet conditions and only 6—8% under dry conditions.

The tannin content of some other docks has been recorded as follows: *Rumex abyssinicus*, 15%83; *R. conglomeratus*, Europe, 9—10%83; *R. cordatus*, S. Africa, 10%188; *R. crispus*, Europe, 3—6%83; *R. ecklonianus*, S. Africa, 6%188; *R. hastatus*, Himalayas, root-bark 21—23%29; *R. nepalensis*, India, 5—6%20; *R. palusier*, Europe, 6%83; *R. sanguineus*, Europe, 12%.

The soluble non-tan content of dock roots is usually, but not always, higher than the tannin content. The nature of the tannin and the tanning properties of the common European docks are said to be rather similar to those of canaigre (*R. hymenosepalus*).
DOCKS

The collection of dock roots on a large scale is accompanied by many difficulties and considered opinion seems to be that under ordinary conditions the utilization of dock roots for tanning, whether from wild or cultivated plants, is unlikely to prove profitable. Quite high yields of dock roots have been obtained in experimental cultivation, e.g. 9,000 kg. of dried root per hectare.
SIBERIAN SAXIFRAGE

A root tanning material that has attracted attention in Russia and certain other countries is that known as 'badan', a collective term for various species of *Bergenia*, particularly *Bergenia crassifolia* (syn. *Saxifraga crassifolia*) the 'Siberian' or 'Russian Saxifrage', the first of the plants of this class to attract attention as a possible source of tannin.

The genus *Bergenia* consists of about eight species, some with several varietal forms, that were formerly included in the genus *Saxifraga*. Several of the species, including *B. crassifolia* are grown for ornament in gardens. Horticulturally they are distinct from the Saxifrages and usually possess large, somewhat fleshy leaves with stout sheathing petioles. The massive inflorescence bears large colourful flowers (mainly pink) that appear in spring. They are sometimes called megaseas by English gardeners and are favoured for flower borders and large rock gardens.

*Bergenia crassifolia* is one of the best known of the cultivated species. As the name implies it is a native of Siberia, having been introduced to cultivation as a garden plant as long ago as 1765. There are several cultivated or garden varieties with red or pink flowers and one with variegated leaves. The flowering shoots may reach 2—3 ft. The plant is a perennial and possesses a massive, somewhat woody, root which may attain considerable length (up to 6 ft.) under favourable soil conditions. Both the root and the leaves, which are produced near the ground more or less in a rosette, are relatively rich in tannin. New shoots and rosettes are produced freely and the plant is easily propagated by division of the crown or rootstock. It may also be grown from seed which usually ripens in July.

In the wild state in Siberia, the plant is said to occur in abundance at times. It is found mainly in the region of the Altai Mountains and extends to Mongolia although its precise distribution in Russia does not appear to be well defined. It may grow up to altitudes of 7,000—8,000 ft. or where tree vegetation ceases, and is capable of withstanding extreme cold. It often occurs in remote areas where transport difficulties render any form of exploitation difficult or uneconomic. The roots of wild plants are frequently very difficult to dig up. It is these considerations that have led to
SIBERIAN SAXIFRAGE

experimented cultivation with a view to tannin production in various parts of Russia. The plant has also been grown experimentally in Czechoslovakia, Poland, Germany and the United States of America.

Originally attention was centred mainly on the root as a source of tannin but later the leaf attracted most attention, doubtless largely on account of the greater ease in harvesting. The roots of mature plants commonly contain about 20—21% tannin and the leaves 16—17%, while the percentage of soluble non-tans is high (roots 21% according to SAGOSCHEN). There appears to be some evidence that altitude may affect tannin content and that plants grown at high altitudes possess more, sometimes considerably more, tannin (up to 50%) than similar plants grown at low altitudes. Immature plants yield less tannin than mature plants as might well be expected.

With regard to the yield from experimental cultivation it was found in Poland that 20,000 kg. of fresh roots and 15,000 kg. of fresh leaves (or 5,000—6,000 kg. dried leaves) were obtained per hectare, the tannin content of the roots being 15.8% and the leaves 18.7%. In Czechoslovakia a yield of 6,000 kg. of leaf per hectare was obtained.

If the roots are dried before tannin extraction there is a noticeable darkening in the colour of the tannin, i.e. an increase of the red colouring matter. They may, however, be kept for some time if suitably stored or clamped like potatoes.

The leaves are difficult to dry but it is said they may be preserved fresh in silos, like ensilage, without deterioration of the tannin, for a considerable time. Each season’s harvest might presumably be dealt with in this way, until processed for tannin, thus obviating the troublesome procedure of drying the leaves which in itself causes deterioration in tanning value. Two crops of leaves are possible in a season and these are easily harvested by machinery.

The tanning present in badan is of a mixed nature but is mainly of the pyrogallol class and has given satisfactory results in tanning. To what extent badan, i.e. Bergenia crassifolia and allied species such as Bergenia cordifolia, may be cultivated and developed for tannin in the future will doubtless depend largely upon the availability of supplies and the prices of the more conventional tanning materials to the country concerned.

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SEA LAVENDER

Certain species of Limonium (Statice) have attracted attention as tanning materials. Since many species have blue or bluish flowers and occur in brackish situations or near the sea they are commonly called 'sea lavender'. The name Limonium is derived from the Greek 'lemon', a meadow, as the plants commonly occur in salt meadows. The genus Limonium contains some 200 species widely distributed throughout the world. The genus Statice, as originally defined by Linnaeus, included both the 'sea pinks' and the 'sea lavenders', but it is now customary to regard the 'sea pinks' as a separate genus (Armeria) and the sea lavenders as Limonium. Several species of Limonium are cultivated as garden plants, in the flower border or rock garden, and are hardy in temperate climates except those species from the Canaries. A light or sandy soil is best suited to them.

Some seven or eight species of Limonium have claimed attention as sources of tannin or possible sources of tannin, the tannin being located mainly in the roots which are frequently very large or extensively developed in proportion to the rest of the plant. It is mainly in eastern Europe and southern Russia (Crimea and Caucasus regions) that the plants have been considered as sources of tannin.

The root of a common sea lavender of the coasts of Britain and western Europe (Limonium vulgare or Statice limonium) has been used in the tanning of leather from early times in some countries, e.g. in France, Spain and Portugal, the root being said to possess about 17\% tannin. In southern Russia also, the roots of Limonium latifolia, which may reach a considerable length have long been used in the tanning of sheepskins for use as clothing by the local inhabitants. The roots of Limonium gmelini have been similarly used in southern Russia, and have probably attracted more attention as a commercial tanning material than any other species.

The name 'kermek' has been applied in southern Russia to Limonium gmelini and L. latifolia as tanning materials. Both these species are well known as garden plants, having been introduced to cultivation in 1791. The two species are similar in many respects, being low-growing plants with the leaves mainly in rosettes, and with flowering stalks 1—2 ft. high. Both are wild in eastern Europe
SEA LAVENDER

and southern Russia—notably in the Crimea and Caucasus regions. As the roots may be 3—5 ft. in length, harvesting, with wild plants, may be a difficult matter. Unlike 'badan' (Bergenia crassifolia) the leaves contain only very little tannin—about 2·5%. Matured roots are said to have an average tannin content of 17% with 14% soluble non-tans and 2% sugars. Middle age roots are richer in tannin than very young or very old roots.

In some areas very large quantities of roots are said to be available, some of the best quality being in the Terek region north of the Caucasus. Leather tanned with 'kermek' is stated to be greenish in colour and not very satisfactory according to some standards.

When grown experimentally, the yield of roots or the yield of tannin with 'kermek' has not always been promising. However, the plants have the ability to grow under salty soil conditions unsuited for most other plants. In the Crimea they have been considered promising for the utilization of what would otherwise be waste land. Possibly the plants may have similar uses in other countries.
PLANT GALLS
Plate XVI

Plant Galls used in Tanning

1. Oak Galls from Quercus infectoria, E. Europe. 2. 'Mecca' Galls from Q. infectoria, Asia Minor. 3. Acorn Galls, or 'Knoppen' from Q. robur, E. Europe. 4. Pistacia Galls from Pistacia khirjuk, India. 5. Pistacia Galls, from P. terebinthus, E. Europe. 6. 'Chinese' Galls from Rhus semialata, China. 7. Tamarisk Galls, or 'Tukut', from Tamarix aphylla, Morocco. 8. Tamarisk Galls from T. gallica, India
INTRODUCTION

Plant or vegetable galls are often rich in tannin and several of those kinds that occur in abundance in different parts of the world and which are easy to collect have been used in local tanning (Plate XVI). Some have also entered world commerce as tanning materials in the past. However, the tendency for many years has been for galls to be used less and less in commercial or large-scale tanning.

Plant galls are abnormal accumulations of plant tissue caused through external parasitic influence. They are found on a large number of different plants and may be caused by an equally large number of different insects or other organisms (bacteria, eelworms). Nor are plant galls confined to the higher plants, for they have also been recorded on various fungi, mosses and even seaweeds. There is a wide range in size, shape, colour and texture among the galls that occur on the higher plants. The texture varies from soft to extremely hard and woody, such as many of the oak galls which may only be cut with a saw.

Most galls form as a result of insect puncture and the depositing of an egg. Generally it is not the initial puncture that excites the host plant to form the abnormal tissue which later constitutes the gall, but rather the stimulus or irritation caused by the movement of the larva after it has hatched out. Another necessary condition is that the egg should be laid in or in close proximity to the cambium, for it is only this tissue which is capable of giving rise to new tissue. All insect galls contain a cavity in which the insect develops or multiplies. Old galls generally have holes made by the imprisoned insect at the time of departure. Sometimes other insects become predatory on those that originally inhabited the gall and were the cause of its formation.

The use of plant galls by man goes back to early times. They were used by the Ancient Egyptians for dyeing, along with iron salts. As early as the fourth and fifth century B.C. the use of oak galls in Greece and Asia Minor was well established and they were a common article of trade. They are referred to by Hippocrates, Theophrastus, Dioscorides, Pliny and other writers. At that time they were also used medicinally. At the time of the Crusades, oak galls were regularly exported from Asia Minor. Japanese and Chinese galls (on Rhus semialata) are reputed to have been known in Europe in the fifteenth century.
OAK GALLS

Oak galls are the best known of the vegetable galls used for tanning, especially those which have been known in the trade as Mecca, Aleppo, or Turkish galls (Plate XVI, p. 256). These are considered to be derived mainly from Quercus infectoria which occurs in Asia Minor and eastern Mediterranean countries. Galls of many different kinds are very prevalent on oaks. Several species of Quercus, in Europe and North America especially, are known to yield galls of a good size that are rich in tannin. Some of these have entered commerce in the past, but in general they have fallen into disuse in tanning, probably largely on account of the labour involved in collection.

The use of Mecca or Aleppo galls (also called Turkish or Levant galls, nut-galls or gall-nuts) in Europe for dyeing and tanning goes back to early times. One of their early applications was for staining the hair black. Apart from their employment in tanning they have been used as a mordant in the textile trade and in the manufacture of inks.

Quercus infectoria occurs usually as a rather gnarled small tree or shrub not exceeding 6—10 ft. in height, which retains its leaves throughout the year. It occurs in the eastern Mediterranean region, in Asia Minor, Mesopotamia, Syria and Persia. The galls, which are formed on the young twigs, are caused by the Cnipid fly, Andricus gallae-tinctariae or Cynips tinctoria. The female fly lays an egg in or on the cambium of a young shoot. The larva soon hatches out, and, except for a central cavity in which it lives, becomes surrounded by the tissue of a developing gall. At first, the galls are green, due to the presence of chlorophyll, and quite soft. Later they become darker in colour and very hard. When the insect emerges from the gall, it does so by boring a hole about half way between the base and the apex. If the galls remain on the trees during the winter or for several seasons they may become bleached or whitish in colour, and are then of little use for tanning as they have a low tannin content.

When required for tanning, the galls are usually collected in August or September and have to be well dried. They are generally spherical in shape, though sometimes pear-shaped, and vary in diameter from about \( \frac{1}{4} \) inch to as much as 2 inches.
OAK GALLS

The surface of the mature dry gall may be smooth and shining, as though varnished, and chestnut brown, but more usually the surface is rough and of a greyish brown colour. The upper part (nearest the apex) may bear unevenly distributed, circular, light coloured, patches with radial markings, or alternatively small conical protuberances. Frequently the inner part of the mature gall is of a harder, more woody tissue than the outer gall and has been termed the 'inner gall'. When the galls are gathered at the correct stage, i.e. in the immature state before the insect emerges, the inner tissue is soft, of a deep greenish yellow colour, with a very astringent taste and slightly sweet after-taste.

Many different grades or kinds of oak gall have entered commerce in the past. These have generally been distinguished by the place of origin and by the size, colour and general appearance of the gall. The following are examples: Mecca, Aleppo (Haleb), Smyrna, Mosul, Bassorah (Basra). The last mentioned are galls collected in the upper reaches of the Tigris or Euphrates and shipped from Basra, frequently to Bombay. They may be exported from Bombay as Indian or Bombay galls, and in the past have found their way largely to China. Galls from Asia Minor, particularly Aleppo (Haleb), have generally proved to be of the highest quality and to have the highest tannin content. Aleppo galls are stated to be collected largely in the neighbourhood of Killis, Aintab and Marash. Galls may also reach Aleppo (Haleb) from Mosul and other parts of Kurdistan, e.g. Zakho, Mardin and Diarbekr. Aleppo or Haleb has been the most important centre for the gall-nut trade. Smyrna gall-nuts are reputed to be collected largely in the neighbourhood of Afium-Kara-Hissar, some 200 miles east of the town of Smyrna. At one time the export of gall-nuts from Smyrna was mainly to Germany, the best kind (a relatively small unpunctured gall) being known by the name of 'jerli'.

The tannin content of Turkish or Aleppo galls may vary between 36% and 58%. The aqueous extract is said to contain free gallic acid in addition to the tannin and an easily soluble form of ellagic acid. The tannin is not homogeneous and is stated to be built up as a polygalloyl-ellagic acid.

Galls from other European species of Quercus, apart from Quercus infectoria, have appeared in trade as tanning materials in the past. A small type of gall, known as 'Morea', 'Greek' or 'Marmora' galls and averaging only about $\frac{1}{3}$ in. in diameter, with a large exit hole, has been imported from the Grecian Archipelago. They are believed to be derived from Quercus cerris. Their tannin content

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OAK GALLS

has been given as only 29—30%\(^\text{183}\). ‘Abruzzo’ or ‘Italian’ galls are believed to be largely derived from Quercus ilex and possibly other species of Quercus.

The best known European galls are those obtained from eastern Europe (the Balkans and adjoining regions), which are commonly known as ‘knoppers’ or ‘knoppen’ or ‘acorn galls’ (Plate XVI, p. 256). With these galls the insect responsible (a gall wasp Cynips calicis) deposits its egg between the cup and the acorn in the young fruit, the gall developing where the acorn would normally be. The galls are usually \(\frac{1}{3}-1\frac{1}{2}\) in. in diameter and quite different in appearance from the Turkish or Aleppo galls already described (see Plate XVI). They may form on the two common oaks, Quercus robur and Q. petraea\(^\text{183}\) and on Q. cerris\(^\text{129}\). There are various kinds of knoppen recognized, such as those formerly obtained from Hungary, Bohemia, Dalmatia and Serbia. The tannin present in these galls (about 45\%) is considered to be similar to that in Aleppo galls\(^\text{129}\). Extracts have been made from knoppen\(^\text{159}\) and the material much used by tanners in Czechoslovakia. Other galls on Q. robur and Q. petraea have also been collected from parts of Germany and other central European countries for tanning\(^\text{183}\), but they do not appear to have a high tannin content (about 30\%).

Galls frequently occur on the many species of oak to be found on the North American continent, and sometimes attain a very large size. Some American oak galls in the Kew Museum supplied by Sir Joseph Hooker from the Sacramento Valley, California, in 1877 are very large, 3 in. in diameter, soft, spongy and astringent. Unfortunately, the species of oak concerned is not indicated. The common white oak (Quercus alba) in the young state frequently bears leaf galls (due to Acraspis erinacei) covered with purple spines, as well as galls on the twigs, some of which have yielded a tannin content of 31\%. Quercus palustris also yields leaf galls. In Texas, galls on the live oak, Quercus virginiana (Q. virgins) are said to resemble Aleppo galls closely and to have a tannic acid content of 40\%\(^\text{178}\).
Chinese or Japanese galls derived from *Rhus semialata* (Plate XVI, p. 256), are a well-known commodity in the Orient, being used for medicinal purposes, tanning, dyeing, and in some areas, where the custom is practised, for blackening the teeth. In addition to their use in China and Japan they were exported to other parts of the East where there is a resident Chinese community (as in Malaya) and are commonly to be seen in Chinese pharmacies, being used mainly as an expectorant and astringent and applied topically to swellings and wounds.

Chinese galls have long been known in Europe and were first imported as curiosities and for use by early druggists. It was about the middle of last century that their use in tanning became general and they were later imported in quantity, mainly to Britain, for use in tanneries. Hankow and Hong Kong have been the main exporting centres in the past. At one time the demand for the galls for tanning far exceeded available supplies, being esteemed for high quality tannin, extracts, and gallic acid.

The galls are due to the puncture and deposited ova of an aphis (*Melaphis chinensis* or *Schlechtendalia chinensis*) on the leaves and petioles of *Rhus semialata* (syn. *Rhus chinensis*). This moderate-sized deciduous tree has a wide distribution. In addition to China and Japan it occurs in Formosa, Indo-China, Upper Burma and India (outer Himalaya from the Indus to Assam). The tree has a thick, rough, deeply-furrowed bark, pinnate leaves with a winged petiole and panicles of yellow-green flowers. The galls, when first formed on the leaf or leaf petiole, are globular or cone-shaped. As they grow they become branched or bear horn-like protuberances in each of which there is a cavity occupied by the gall insects. The galls are at first greenish yellow in colour, but later turn to a darker green with patches of red or maroon. When quite mature the gall splits open or ruptures allowing the insects to escape. Galls entering commerce do not usually show any signs of fissure as they are generally collected before they reach this stage. Harvesting may be carried out from July to September. When gathered, the galls may be placed in boiling water to kill the insects and then thoroughly dried in the sun.

A notable and characteristic feature of this gall is the dense
velvet-like indumentum or furry layer over the whole gall. This is chestnut or yellowish brown in the dry gall. The dried or commercial galls are hard, oblong, hollow, contorted bodies irregularly shaped and tubercled. The usual size is 5—9 cm. long and 2½—4 cm. broad, and the weight 3—12 gm. The Japanese galls are usually rather smaller than the Chinese. The wall is very thin, often less than 1 mm. thick, but thickening towards the base. It is extremely brittle and of a resin-like consistency and a whitish inner surface. The galls have an exceptionally high tannin content, figures given by different authors ranging from 50% to 80%. A summary of what is known of the chemistry of the tannin from these galls (known as 'tannic acid' or 'Chinese tannin') has been given by Rotlispeper. In tanning, the galls have a somewhat similar action to oak galls (Aleppo galls).

Whether Rhus semialata is the sole source of the Chinese galls that enter commerce is not definitely known, for somewhat similar galls are known to be produced on other species of Rhus. However, it is believed that at least the bulk of the galls that have entered commerce have been from Rhus semialata.
TAMARISK GALLS

The galls found on several species of Tamarix (Tamarisk) are rich in tannin and are used locally in tanning or may enter commerce as a tanning material. The best known are those of Tamarix aphylla (syn. T. articulata) and T. gallica (Plate XVI, p. 256).

Tamarix aphylla generally occurs as a shrub or small tree, but may attain large dimensions. It has a wide distribution—from Morocco to India. Its resistance to drought, heat and cold, its ability to withstand desert or semi-desert conditions and its value as a sand­-binder, wind-break and source of fuel have been the cause of its being cultivated in many parts of the world, including the U.S.A.—California and Arizona—where dry conditions prevail. In parts of north west India (Peshawar) it is the most important tree and of very great value to the local inhabitants159. Other virtues are its rapid rate of growth, the ease with which it may be propagated from cuttings or truncheons and its ability to withstand salty soil conditions. The galls are commonly collected in N.W. India by women and children in March and April, and find their way to the bazaars. They have been exported from Bombay as a tanning material in the past.

It is in Morocco, especially southern Morocco, that the galls are of special significance in tanning. They are relatively small in size, but are much used in the tanning of the finer qualities of sheep and goat skins in the production of 'Morocco leather'. They are known by the name of 'tak-out' or 'teggout' and the tree or shrub itself as 'thaia'. In tanning, the galls are ground and placed in boiling water and the dehaired skins immersed in the liquor for about 10 days. They may subsequently be dyed, madder and alum being commonly used for red shades and pomegranate rind for yellow. The galls are used in the Sahara and other parts of North Africa in tanning. They have been known in Europe as a tanning material from early times, and were probably used in the sixteenth century177. They are a rich source of tannin, the average tannin content being 40—45%. In general tanning properties they are regarded as similar to oak galls and sumac. The fresh galls produce a very light coloured, almost white, leather with a slightly rose coloured or violet tint183. On aging, the skin becomes
TAMARISK GALLS

darker and of a brownish tint. Sometimes they are utilized locally for dyeing and for medicinal purposes as an astringent.

In Morocco *Tamarix aphylla* grows best in the coastal districts but also grows satisfactorily inland. The galls are a common article of commerce with the natives, the trade being centred mainly at Marrakesh. There, three qualities are recognized—‘takaout draouia’ (the best quality and used mainly for goat skins), ‘takaout skoura’ (used mainly for sheep skins) and ‘takaout ghrisia’ a poorer quality. There is also that from Tafilalet—less common and less appreciated.

A good account of the formation of the galls and the insect responsible (an acarid—*Eriophyes tiliae*) has been given by Trabut. The galls form mainly on the flowers or flower buds but sometimes on the young branches. As young trees require several years before they commence to flower, galls may not be produced freely until the free-flowering stage has been reached. The flower or bud is attacked at the base of the calyx. As the gall forms, the parts of the flower become indistinguishable. The calyx and corolla may sometimes be recognized. The ends of the petals may show through and remain white. In the fresh state a certain amount of chlorophyll is present in the gall. The moisture content of the fresh green gall is high, 100 gm. of fresh galls becoming 45 gm. when dry. The galleries present are occupied by the acarid which multiplies freely. Other organisms predatory on the acarid or on one another may also be present. The galls develop during the summer and are collected in the autumn, usually in October or November. Careful drying to avoid fermentation and consequent deterioration is necessary. A well-developed tree of *Tamarix aphylla* is said to be capable of yielding about 25 kg. of galls in a year in Morocco.

The galls of *Tamarix gallica* are generally considerably larger (two or three times) than those of *T. aphylla*, but have similar properties and uses. This species also has a wide range of distribution and occurs from China and Japan to southern Europe and many parts of Africa. In India where it favours sandy or gravelly soils or maritime situations, not being affected by salty conditions, it may attain the dimensions of a large tree.
PISTACIA GALLS

Tannin-rich galls are formed on several species of *Pistacia* and owe their origin to the activity of aphides (species of *Pemphigus* and *Aploneura*). Those species of *Pistacia* known to produce galls capable of use for tanning purposes include *Pistacia terebinthus*, *P. vera* and *P. atlantica*, which occur in Europe, and *P. khyinjuk*, *P. mutica* and *P. integerrima*, which are mainly Indian (Plate XVI, p. 256). Galls are not always prevalent or common on these trees, and it is thought that activity on the part of the gall-forming aphides may be dependent upon a number of factors varying from one season to another. The three aphides *Pemphigus cornicularius*, *P. utricularius* and *P. semilunarius*, may be responsible for galls on *Pistacia terebinthus*, *P. vera* and *P. atlantica*. *Pemphigus semilunarius* may be responsible for galls on *Pistacia mutica*, and *Aploneura lentisci* for those on *Pistacia lentiscus*.

The best known of the *Pistacia* galls are probably those of *P. terebinthus*, a small tree or shrub of the Mediterranean region, and the source of Chiang turpentine, a greenish yellow oleo-resin with medicinal uses. The galls form on the leaves or leaf petioles and are generally pear-shaped at first, green in colour with reddish marks, rather sticky, and of a balsamic odour. They may lengthen considerably and become pod-like reaching a length of 6-8 in, finally rupturing at the end or splitting. In the dry state they are usually dark brown, hard and quite hollow. The wall is only 1-2 mm thick, very brittle, and may bear small globules or incrustations of resin. The galls are a rich source of tannin (50-60 % or more), but do not appear to have ever been extensively used in tanning, probably owing to the uncertainty of supplies. Names used for these galls include ‘*Pistacia*’, ‘turpentine galls’, and ‘Carob galls’ (owing to the resemblance to the Carob pod).

Very similar galls to the above are produced on *Pistacia atlantica* according to specimens in the Kew museum. In North Africa (Algeria) this deciduous tree may reach a height of 40 ft. or more and a bole circumference of 12-15 ft.

In Tripoli the tree grows in rocky districts of the northern slopes of Gehel and is also said to be cultivated to a small extent near oases. Near streams, isolated old specimens occur. Three different types of galls may be found on the tree. One (due to
PISTACIA GALLS

*Pemphigus cornicularius* transforms the whole leaf into a horny growth of varying shape reaching a length of 6—8 in. and breadth of $\frac{1}{4}$—1½ in. They are brownish purple with a resinous odour. The tannin content has been estimated at 24 % and soluble non-tans at 20 %. Rounded galls attached to the veins of the leaves, chiefly on the lower surface, are formed by *Pemphigus utricularius*. They are usually small, about $\frac{1}{4}$ in. in diameter, but reach $\frac{3}{4}$ in. and are yellow, yellowish brown or reddish in colour. The tannin content has been estimated at 37—40 %, soluble non-tans at 12—15 %. The galls are reputed to be the ones most frequently seen in Tripoli and are an article of commerce, being sold by druggists and herbalists under the names of ‘afs’ and ‘afs-el-batum’. They are also used by natives for dyeing light skins. Laboratory tanning tests have shown that they produce very good light leather and could be employed as a substitute for other tans used for light skins, also for inks. The leaves of the tree have been found to contain 19 % and 21 % soluble non-tans and have been recommended as a substitute for sumac.

The galls produced on *P. vera*, the tree yielding the pistachio nut, may be very much smaller. Samples seen by the author, probably picked in the immature state, were light brown in colour, pear-shaped, about an inch long and half an inch in diameter. Galls on *P. vera* which have reached the mature stage may, however, be much larger and resemble those already described for *P. terebinthus*. In the past, galls believed to be derived from the pistachio tree have been shipped from Persia to Bombay and been sold under the name of ‘Bokhara’ galls, ‘gul-i-pista’, or ‘Bosganj’ galls.

In the Bombay bazaars and elsewhere in India, galls known as ‘kakrasinghee’ or ‘karkalasingi’ are common. These are considered to be derived from *P. integerrima*, a medium-sized tree of north west India. The galls are rich in tannin, probably comparable with other *Pistacia* galls in this respect, but appear to be used in India mainly for medicinal purposes. They are considered tonic, expectorant and useful in cough, asthma, fever, want of appetite and irritability of the stomach. *P. khinjuk*, a shrub or small tree of north west India, may also yield large, horn-like galls very like those of *P. terebinthus*. 

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MISCELLANEOUS
MISCELLANEOUS TANNING MATERIALS

The plants that have been included here consist of (a) those species known to have been used in the tanning of leather by man somewhere in the world and (b) those species for which a tannin content of 10% or more (dry weight) has been recorded for some part of the plant. It is felt that those plants with more than 10% of tannin may sometimes be regarded as potential tanning materials in their countries of origin, even though they may not have been used hitherto in tanning. A few species that are of general interest for other reasons have also been included.

Owing to considerations of space it has not been possible to give common or colloquial names for all the species dealt with. They have, however, been given for the more important species and for those that are known to be of some importance in local tanning. The figures given represent the approximate percentage of tannin, on a dry basis, unless otherwise indicated. Reference numbers are also given.

The following abbreviations have been used:

- b., bark
- f., fruit
- l., leaves
- r., root
- w., wood
- Af., Africa
- Am., America
- Arg., Argentina
- Aus., Australia
- Braz., Brazil
- Eur., Europe
- Ind., Indian Sub-continent
- Indon., Indonesia
- Madag., Madagascar
- Mal., Malaya
- N.S.W., New South Wales
- N.Z., New Zealand
- Phil., Philippines
- Trop. Af., Tropical Africa
- Trop. Am., Tropical America
- W.I., West Indies

Abies  The bark of European firs has been used to adulterate spruce bark (Picea abies) but has a lower tannin content. A. balsamea b. 12.5% N. Am.; A. fraseri b. 11% N. Am.; A. nordmanniana b. 10.5% E. Eur.67.

Acacia  Many species have bark or pods rich in tannin (for Australian species see p. 52): A. albida b. 28% Trop. Af.67; A. arabica (see Chapters 9 and 28); A. auricularis b. 9-9% N. Am.137; A. baileyana b. 14—17% Ind. cultivated20; A. benthamii b. 15.5%, pods 19—21% S. Af.188; A. bussei b.
MISCELLANEOUS TANNING MATERIALS

Acacia (contd.)
17—21% E. Af.87; A. confusa b. 12—14% Formosa, Phil.83; A. cyanophylla b. 16—19% cultivated in E. Af.87; A. cyclops b. 7—12% S. Af.188; A. farnesiana pods without seeds 23% used in tanning, Tropics38, 58; A. karroo b. 13—19% S. Af. used in tanning188; A. leucophloea b. 15% 'pilang' Indon. bark much used in tanning164; A. pennata b. 9% Ind. used for tanning fishing nets in Bombay20; A. seyal b. 18—20% Trop. Af.58; A. sieberiana pods used in tanning, W. Af.; A. subalata pods up to 25% E. Af.87; A. suma heartwood 11% Ind.87.

Acer The bark of A. campbellii, Himalayas, and A. spicatum, N. Am., are known to contain tannin. The red autumn leaves of A. gymnala contain a crystalline tannin used in China and Japan to dye silk and cotton83.

Achras A. zapota ('sapodilla' or 'chickle') b. 21% Trop. Am. cultivated; bark used for tanning fishing tackle in the Philippines38, 83.

Acidocarpus A. excelsus b. 15-7% Madag.83.

Acrostichum A. aureum, all parts of the fern contain tannin, Ind.20.

Adansonia A. digitata ('baobab') Trop. Af. bark contains tannin.

Adenanthera A. microserma ('segawe') b. 25—30% Indon. bark much used in local tanning154.

Adina A. cordifolia b. 7—10% Ind.20.

Aegialitis A. rotundifolia twig bark 11% Ind.20.

Aegle A. marmelos f. 7—9%, rind 18—22% Ind.20.

Aerva A. lanata, all parts of this common tropical weed contain tannin20.

Aesculus A. hippocastanum (horse chestnut) Eur. bark contains tannin in small amount183.

Agrimonia A. eupatorium herb 5% Ind.20.

Ailanthus A. altissima (syn. A. glandulosa, tree of heaven) b. 11% Orient20.

Albizia The bark of some species is fairly rich in tannin: generally reddish in colour, used as a fish-net tan or for dyeing cloth, e.g. A. lebbek b. 5—15% tropics20; A. lebbekioides Malaysia b. 12.5—17%38; A. procera b. 12—17% tropics. Other species are A. basaltica b. 14% Queensland51; A. chinensis b. 22% Ind.20; A. granulosa bark used in New Caledonia57.
MISCELLANEOUS TANNING MATERIALS

Alchornea A. cordifolia (‘epa’) b. 11%, l. 10%, leaves and twigs used as fish-net tan in Nigeria; A. triplinervia b. 11—12% S. Am. (syn. A. nemoralis?)

Aleurites A. fordii (‘tung nut’) b. 12%, fruit husks 4—5% China. Bark of A. moluccana (‘candle nut’) 5—22%. Has been used in local tanning and dyeing, Ind. 

Allophylus A. edulis b. 10% Braz.

Alphitonia A. excelsa b. 11% Queensland.

Amyris A. elemifera b. 12% N. Am.

Anacardium A. occidentale (cashew nut) b. 9—21%, l. 23% tropics

Anaphrenium A. argentum (syn. Heeria argentea) b. 33%, leaves and twigs 4.8% S. Af. has been used in tanning at the Cape (with wattle)

Andromeda The leaves of the Arctic shrub A. polifolia are said to have been used in Russia for tanning.

Angophora A. lanceolata b. 6—11% E. Aus. The kino of this and other species (e.g. A. intermedia, 47%) is rich in tannin

Annona Bark of A. muricata (soursop) and A. squamosa (custard apple) have been used in local tanning in the W. Indies

Anogeissus A. latifolia (‘dhawa’) b. 10—15%, Ind. (l. 30%, see ‘country sumac’, Chapter 32); A. acuminata b. 9—32% Ind.; A. pendula b. 12% Ind.; A. schimperi b. 17% W. Af., used in native tanning

Aphloia A. theaeformis l. 9—10% Mauritius

Apocynum A. venetum bark and rootstock said to be used in tanning in India.

Apuleia A. praecox b. 34% Braz., b. 10.7% Paraguay

Arachis A. hypogaea (peanut or groundnut) testa or skin surrounding kernel 7%, tropics.

Arbutus A. unedo (strawberry tree) b. 45% (according to Mafat) S. Eur. Leaves, fruit and bark have been used in Mediterranean countries in tanning

Arctostaphylos A. uva-ursi (bearberry) 10—14% N. Eur. Leaves and twigs used in Russia and Sweden in tanning leather. A. glauca (California) has similar properties.
MISCELLANEOUS TANNING MATERIALS

Ardisia A. polycephala b. 10·5% N. Am.187. A. serrata furnishes a good tan bark in the Phil.88.

Areca A. catechu (betel nut) unripe kernels 13--27%88, Eastern tropics, good tanning properties yielding a pale cream coloured leather; has been used in Java; the solid extract or 'kossa', with 65--67% tannin, may also be used. Normally the betel nut is too expensive or too much in demand for other purposes to be used in tanning.

Artocarpus The bark of several species is known to contain tannin but less than 10%, that of the jak, A. heterophyllus (syn. A. integrifolius) is said to be used in India in dyeing and tanning183, 153.

Aspidosperma Aspidosperma sp. ('peroba') b. 31% Braz.83.

Avicennia A. nitida (white mangrove) b. 12% W. Af.; A. marina (syn. A. officinalis, white mangrove) b. 6% E. Af.87 (see Mangrove Bark, Chapter 3).

Baikiaea B. plurijuga (Rhodesian teak) b. 20--26%, w. 10--11%18, 153 an important Rhodesian timber tree; bark tannin very strongly coloured.

Banksia B. integrifolia b. 5--11% Queensland; B. serrata b. 11--13% N.S.W.51; other species with lower tannin contents.

Barringtonia B. acutangula b. 16% Ind. Burma20; used in tanning in Burma. B. racemosa (mangrove) b. 18% Ind. E. Af.28 yields reddish leather38.

Bauhinia B. malabarica b. 9--12% Ind. B. vahlii (a gigantic climber) b. 19% Ind. yields light coloured leather38. B. rufescens and B. thomningii b. 18--20% used in local tanning in West Africa56. Other species contain tannin20.

Bischofia B. javanica twig bark 16% Ind.20.

Boswellia B. serrata b. 13--15% Ind.20.

Brabeium B. stellatifolium (wild almond) b. 13% S. Af.188.

Brachystegia Many species are common or dominant trees in tropical Africa, especially in Rhodesia. In general the bark is fairly rich in tannin but the colour is dark and the tan/non-tan ratio is low; individual trees of the same species vary much in tannin content. B. floribunda b. 7--16%; B. globulifera b. 6--16%; B. itolienlis b. 9--19%; B. microphylla b. 8--25%; B. mopanea b. 15%; B. randii b. 10%; B. spicaeforisis b. 11--15%; B. tamarinoides b. 12--17%; B. utilis b. 9--16% (Mon. Dig. Brit. Leath. Mfirs' Res. Ass., July 1952, 55--56).
MISCELLANEOUS TANNING MATERIALS

**Bridelia** Several species are known to contain tannin. *B. retusa* b. 16—40% Ind.\(^{20}\).

**Brosimum** *B. speciosum* b. 12% Venezuela\(^{82}\).

**Bruguiera** Several species are important mangroves in the Old World tropics and the tannin content is variable (see Mangrove Bark, Chapter 3): *B. conjugata* b. 12—32% Phil.; *B. cylindrica* (‘madama’) b. 15% Ind.\(^{20}\); *B. eriopetala* Java\(^{91}\); *B. gymnorrhiza* b. 19—36% Aus.\(^{51}\); *B. parviflora* b. 9—20% Ind. Phil.\(^{20}\); *B. rheedii* b. 10—22% Aus.\(^{51}\).

**Buchanania** *B. arborescens* b. 11% a fishing-net tan, Ind. Phil.\(^{20, 38}\); *B. lanzan* bark used in tanning in Travancore\(^{57}\).

**Bucklandia** *B. populnea* b. 11% Ind.\(^{20}\).

**Burkea** *B. africana* bark used in tanning in N. Nigeria, fruit husks also contain tannin\(^{56}\).

**Byssonima** The bark of some species is used in tanning notably *B. spicata* (‘tam’) b. 43% Antilles, W.I.\(^{83}\); *B. crassifolia* b. 25% Braz.; *B. verbascifolia* (‘murici’) b. 20% Braz.\(^{29}\).

**Caesalpinia** See Chapters 24—27.

**Caffea** Coffee beans or the seeds of several species of *Caffea* are known to contain tannin in varying amounts\(^{129}\).

**Callitris** Several species, collectively known as ‘cypress pines’ in Australia, have bark rich in tannin. The bark, notably that of the black cypress pine (*C. calcarata*), has been successfully used in tanning (sole leather tannage), in spite of high colour, being usually mixed with wattle. The bark has a low soluble non-tan content and is considered suitable for extract manufacture if available in quantity. *C. arenosa* b. 10—32%; *C. calcarata* b. 10—32% (black cypress pine), leaves and twigs 6—7%, w. 2%, bark excellent for belting leather, too dark for sole leather; *C. glauca* b. 11—23% (white cypress pine); *C. gracilis* b. 12%; *C. intertropica* b. 11%; *C. propinqua* b. 13%\(^{51}\); *C. rhomboidea* b. 11—19%\(^{188}\); *C. robusta* b. 11—19%\(^{51}\), 22% cultivated in S. Af.\(^{188}\); *C. tasmanica* b. 17%\(^{91}\).

**Calluna** *C. vulgaris* (common ling) Europe, said to have been used in tanning in the 18th century\(^{183}\).

**Calophyllum** *C. inophyllum* b. 12—19% Ind. Mal. Phil.\(^{38}\).

**Calotropis** *C. gigantea*, gall nuts said to be used in tanning in India\(^{57}\).
Camellia The tannin in tea (C. sinensis or Thea sinensis) is important in connection with quality and flavour. Tea (dry leaf) usually contains from 5—10 % tannin; never used in tanning.83, 89, 153.

Campomanesia C. guaviroba b. 11 % S. Am.69.

Cantula C. exusa bark used in native tanning in E. Af.183.

Carapa C. moluccensis b. 23—34 % Aus.81; C. guianensis, used in tanning in Guiana.38.

Careya C. arborea l. 19 %, bark used in tanning in India and Burma57.

Carissa C. opaca ('karunda') b. 5—15 %, l. 11 % tans very slowly, Ind.13, 83.

Carpinus C. betulus (hornbeam) Eur. leaves contain ellagitannin163; C. orientalis b. 9 % Eur.83.

Carya C. illinoensis (syn. C. pecan) (pecan nut) N. Am. The shells of pecan nuts have been used in Texas as a commercial source of tannin and the extracted shell for charcoal.

Casearia C. tomentosa b. 11 %, dark colour, Ind.20.

Cassia C. auriculata ('turvar', 'avaram') see Avaram bark, Chapter 8. Many other species are rich in tannin: C. artemisioides leaves and twigs 14 % W. Aus.51; C. didymobotrya bark used in native tanning, E. Af.87; C. fistula ('sonari' or Indian laburnum) b. 12—18 %, bark used like 'avaram' gives a pale leather, Ind. also Indon., cultivated ornamental; C. javanica bark used in native tanning, Indon.91; C.marginata twig bark 14 %, Ind. used like avaram bark20; C. siamea b. 4—9 %, l. 7 %, pods 6 % Ind.20; C. singueana bark used in native tanning, E. Af. 87; C. surattensis shrub, b. 13 % Ind.20.

Castanea Chestnut, see Chapter 17: C. ashei b. 12 %, w. 12·3 % N. Am.157; C. argentea w. 27 % Indon.111.

Castanopsis C. chrysophylla b. 19 % N. Am.183; C. hystrix b. 11·5 % Ind.; C. indica b. 6—12 %, l. 10 %20 (see Chapter 17).

Casuarina Several species have bark rich in tannin57 or are used in local tanning. C. equisitifolia (she oak) b. 6—18 % tropics and sub-tropics, bark a fish-net tan in Ind. and Java20; C. cunninghamiana b. 7—11 % Aus.188; C. decussata b. 12 % W. Aus.61; C. glauca b. 10—19 % Aus.51.

Catalpa C. longissima bark used in tanning in W.I.57.

Ceanothus C. velutinus l. 17 % N. Am.83, 89.

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MISCELLANEOUS TANNING MATERIALS

Cecropia Some species used in local tanning, e.g. C. peltata W.I. and Brazilian species. The bark of C. toona has been used in tanning in India; gives purplish colour to leather; C. tubiflora b. 12.6% S. Am.

Cedrela The bark of C. toona has been used in tanning in India; gives purplish colour to leather; C. tubiflora b. 12.6% S. Am.

Centrolobium C. sp. (' arariha ') b. 33% Braz.

Ceratophyllum C. apetalum b. 16—19% Aus.

Ceriops See Mangrove Bark, Chapter 3.

Chamaebatia C. foliolosa (bear clover) dried shoots 13% N. Am.

Chickrassia C. tabularis b. 22% Ind.

Chloroxylon C. swietenia (satinwood) b. 17% Ind.

Chrysobalanus C. icaco (coco-plum) Trop. Am., pulp of fruit rich in tannin, yields soft porous leather.

Chrysophyllum C. glycyphloeaum b. 32% Braz. used in tanning, yields light coloured leather.

Cistus C. salviifolius; in Mediterranean countries this shrub is used with pomegranate rinds in tanning.

Cleistanthus C. collinus b. 33%, l. 19%, green fruit 14% Ind.

Coccoloba C. laurifolia (pigeon plum) b. 24% N. Am.

Cocos C. nucifera (coconut palm) powdery portion of fibre of fruit 8% Ind.

Cola C. nitida (cola nut), kernel contains tannin, about 1.6% W. Af.

Colpoon C. compressum (syn. Oxyris compressa Cape sumac), l. 15—24%; used locally in tanning, a catechol tan, S. Af.

Combretum C. album b. 16% Congo; C. hartmannianum b. 12% E. Af.

Conocarpus C. erectus (buttonwood, ' mangue ') b. 15—22%, w. 8%, a mangrove in Trop. Am.

Copaifera C. langsdorffi b. 14% used in tanning, Braz.

Coriaria C. myrtifolia (French sumac), see Sumac, Chapter 29; C. nepalensis l. 20% Ind.; C. ruscifolia l. 16% N.Z.

Cornus C. amomum (swamp dogwood) b. 13% yields firm leather N. Am.

Corylus C. avellana (hazel) Eur., bark contains a yellow dye and 3% tannin.
MISCELLANEOUS TANNING MATERIALS

Cotylelobium C. sp. ('resak tembaga') w. 34% Indon. 171.

Coulteria C. tinctoria said to be used in Morocco in tanning.

Crossostylis C. multiflora w. 21%, a mangrove in New Caledonia 51.

Croton C. succiruber b. 11% Paraguay 89.

Cupania C. uraguensis b. 17% Paraguay; C. vernalis b. 15% Paraguay 89.

Curtisia C. faginea b. 21-27% S. Af. used locally in tanning but colour very dark 188.

Cylista C. scariosa r. 10% climbing shrub, Ind. 20.

Dalbergia D. lanceolaria b. 14% Ind. 20.

Daphne D. guidium ('garoe') bark used in Algiers for tanning and dyeing 57.

Dillenia D. indica b. 10%, l. 9% Ind. 20; other species said to be used in Indon. and Ind. in local tanning 157.

Dimorphandra D. mora, bark has been used in tanning, Guiana, St. Domingo.

Dioscorea D. rhizophonoides ('somemoniimo') tuber 13%, cultivated in Formosa, gives dark red-brown leather 83; D. atropurpurea (false gambier, 'cu-nao') dried tubers 38% used in Indo-China for dyeing silk and cotton and as a sail and fish-net tan 153.

Diospyros Bark and green fruits, e.g. D. kaki (persimmon), often rich in tannin. D. burmanica dry extract 40%, used in Burma in tanning 57; D. ebenum, bark said to have been used in Reunion for tanning 57; D. embryopteris b. 12%, fruit 15%, bark and fruit used, Ind. Siam, fruits much used as a fish-net tan; D. melanoxylon b. 19%, fruit 15%, half-ripe fruit 23-27% used in native tanning Ind. 20.

Dipterocarpus D. tuberculatus b. 24%, young leaves also contain tannin 20.

Dryobalanops D. oblongifolia b. 27% Indon. 171.

Dryopteris D. felix-mas (male fern) rhizome 10% Eur. 153.

Dryoxylum D. binectariferum b. 10-15% Ind. 20.

Elaeocarpus Many species with tannin in bark, mainly less than 10%; E. dentatus b. 20-22% N.Z. 183; E. grandis b. 6-10% Aus. 31, 89; E. hookerianus b. 9-10% N.Z. 57.
MISCELLANEOUS TANNING MATERIALS

Elaeodendron. *E. croceum* (saffron wood) b. 16% S. Af. inner bark yellow and in demand locally for tanning^{188}; *E. glaucum* b. 8—13%, l. 8—15% yields yellow or buff leather, Ind.{^20, ^38}.

Elephantorrhiza. *E. burchelli* (' eland's boonjes ') roots 15—17%, stems and leaves 13%, pods 5%, S. Af., the long tuberous roots of this small shrub were favoured in local tanning, producing a soft, tough leather; percentage soluble non-tans high^{13, ^188}.

Engelhardtia. *E. spicata* b. 13—16% Ind. reputed to be a good tanning material^{20}.

Entada. *E. scandens* or *E. gigas* (sea bean) tropics: the bark of this giant climber has been used in tanning^{20}: pods also rich in tannin^{83}.

Enterolobium. *E. contortisiliquum* (syn. *E. timbouwa*) used in native tanning b. 14—22% S. Am.{^83, ^89}.

Eperua. *E. falcata* b. 25% Guiana^{171}.

Erica. Tannin is present in many species. 'Briar root' (*E. arborea ?*) or ' heather root ' (possibly *Calluna vulgaris*) is said to have been used in the Landes, France, for tanning during World War II, producing a very firm leather of a pleasing light colour with low water permeability. Both pyrogallol and catechol tannins are present, the latter predominating.

Erythrophleum. *E. fordiit wood* tans like chestnut, Indo-China^{38}; *E. guineense* bark used in tanning in W. Af.^{56}.

Erythroxylum. Several species with tannin: *E. squamatum* leaves and bark as tan material in Guadeloupe^{57}.

Eucalyptus. (See Chapter 7 and Chapter 20.)

Eucryphia. *E. cordifolia* bark used extensively for tanning in Chile: an extract has been made and exported^{49}.

Eugenia. The bark of several species of this large genus is rich enough in tannin to be used for local tanning, especially in South America. *E. arnottiana* b. 16% Ind.^{20}; *E. aromatica* (coves) flower buds 10—13% tannin resembles gall tannin^{20, ^155}; *E. brasiliensis* b. 35%, l. 12%, w. 7%^{83}; *E. confusa* (snakewood) b. 19% Am.^{157}; *E. cumini* (syn. *E. jambolana*) b. 13—19%, l. 13%^{20}; *E. francisci* b. 10% Aus.^{51}; *E. gerrardii* b. 16% S. Af.^{188}; *E. jambos* b. 7—12% Ind.^{20}; *E. lucida* b. 16% Braz. gives a light brown leather^{83}; *E. michelii* (syn. *E. uniflora*) b. 20—28% Paraguay^{83}; *E. pungens* b. 10% Paraguay^{83}; *E. rhomeiba* b. 10% Am.^{157}; *E. smithii* b. 16—28% Aus.^{51}.
MISCELLANEOUS TANNING MATERIALS

Excoecaria  *E. agallocha* ('gecon') b. 10—13 % Ind. Aus. 20, 51.

Exocarpus  *E. cupressiformis* b. 15—23 % Aus. 51, 86.

Exothea  *E. paniculata* b. 13 %, w. 8 %, N. Am. 157.

Fagus  The common European beech (*Fagus sylvatica*) contains only 2—3 % tannin in the bark. The waste sulphite liquor from the pulping of beech wood may be used in tanning blends.

Ficus  Some wild figs are used in native tanning in tropical Africa, e.g. *F. platyphylla*, *F. capensis*, *F. glomosa* 56, 87; *F. asperrima* b. 14 % Ind. 57; *F. benghalensis* b. 11 %; *F. glomerata* b. 14 % Ind. 20.

Flacourtia  *F. ramontchi* bark said to have been used in tanning in Reunion 57.

Fluggea  *F. leucopyrus* b. 10 % Ind. 20.

Fraxinus  The European ash (*F. excelsior*) has less than 4 % tannin in the bark: tannin also present in the leaves.

Fuchsia  *F. macrostemma* (‘churko’) b. 20—26 % Chile, the bark has appeared in commerce as a tanning material 83.

Fusanus  *F. spicatus* (Aus. sandalwood) b. 20—22 % Aus. 51.

Garcinia  *G. mangostana* (mangosteen) fruit rinds 7—14 % tannin, sometimes collected and used in tanning, e.g. in Chinese tanneries in Malaya 88: tannin of the catechol type 89.

Geranium  The roots of several species are known to be rich in tannin. *G. maculatum* r. 27 % N. Am. 183; *G. sanguineum* r. 13 % Eur. 88; *G. wallichianum* r. 25—32 % 20.

Gewenia  *G. urbanum* r. 30—40 % Eur. 83, 183.

Gordonia  The bark of some species may be used for tanning at times in Malaya 88. *G. lasianthus* b. 15 % N. Am. 157.

Grevillea  *G. chrysodendron* b. 11 % Aus.; *G. heliosperma* b. 12 % Aus.; *G. siraita* b. 18 % Aus. 51.

Grewia  *G. tiliaefolia* l. 11 % Ind. 20.


Gunnera  *G. chilensis* r. 9 % used for tanning goat skins in Chile 57.

Hakea  *H. glabella* b. 18—20 % Aus.; *H. leucoptera* b. 11 % Aus.; *H. saligna* b. 20 % Aus. 51.

Halesia  *H. carolina* b. 11 % N. Am. 157.

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MISCELLANEOUS TANNING MATERIALS

**Halgania** *H. lavandulacea* l. 4—9% have been used in local tanning in W. Aus.51.

**Hamamelis** *H. virginiana* (witch hazel) one of the few crystallizable tannins present in the bark\(^{153}\): tannin also present in leaves 8% N. Am.\(^{183}\). *H. vernalis* l. 2—13% N. Am.

**Haronga** *H. madagascariensis* b. 11% Madag.\(^{83}\).

**Harpephyllum** *H. caffrum* (kafir plum) b. 18%, twigs and leaves 11% S. Af. bark yields soft pinkish red leather of good texture\(^{188}\).

**Heeria** *H. argentea* b. 33—3' % S. Af.\(^{57}\).

**Heritiera** *H. fomes* ('sundri') b. 8—9%, twig bark 12%, l. 11% Ind.\(^{20}\); *H. littoralis* b. 14%, w. 13%, f. 12% Old World tropics\(^{83}, 183\); *H. minor* b. 12%, l. 9% Ind. important tan in Gangetic delta\(^{38}, 83\).

**Heuchera** *H. americana* root contains tannin, N. Am.\(^{57}\).

**Hopea** *H. odorata* b. 15%, l. 11%, w. 10%, bark yields supple pale leather, Ind.\(^{38}, 83\); *H. parviflora* b. 14—28% low non-tan content, Ind.\(^{20}\).

**Horsfieldia** Bark of *H. sucosa* used in native tanning in Malaya\(^{38}\).

**Hydnora** The rhizomes of some species (parasitic herbs) contain much tannin and are used by natives in the Sudan and S. Af. for tanning skins\(^{87}\). *H. longicollis*, rhizomes 32% S.W. Af.\(^{83}\).

**Hymenaea** *H. coubaril* b. 17—20% S. Am.\(^{83}\); *H. stilbocarpa* ('jatoba') b. 19% Braz.\(^{20}\).

**Hymenocardia** *H. acida* b. 8% sometimes used in Central Africa as a tan.

**Hyphaene** *H. shatan* l. 12% Madag.\(^{83}\).

**Hyronyma** *H. alchorrioides* b. 35% Braz.\(^{83}\).

**Ilex** Bark and leaves of several species known to contain tannin. *I. paraguariensis* (Paraguay tea) l. 5—20% S. Am. useless for tanning leather\(^{87}, 83\).

**Imbricaria** *I. maxima* bark used as a tanning material in Reunion\(^{57}\).

**Inga** *I. affinis* b. 17—25% Paraguay\(^{83}\).

**Intsia** *I. amboinensis* b. 27—32% Indon.\(^{171}\); *I. palembanica* b. 28% Indon.\(^{171}\).

**Isoberlinia** *I. paniculata* b. 14—22% and *I. tomentosa* b. 9—15% from N. Rhodesia, not promising as tanning materials.

**Ixonanthes** *I. icosandra* bark used as a fish-net tan in Malaya\(^{38}\).
MISCELLANEOUS TANNING MATERIALS

_Jatropha _J. curcas_ b. 37%3, sap 10%38 tropics; _J. zeyheri_ dry tuber 20% S. Af. The tubers of this herbaceous plant are favoured for tanning in parts of the Transvaal188.

_Juglans _J. regia_ (walnut) b. 5%, dried fruit husks 20%83 has been used for tanning in Lombardy183.

_Juniperus _J. communis_ (juniper) bark said to be used in Russia in tanning57, 83.

_Kandelia _K. rheedi_ (‘ gorgia ’) b. 17—20% Ind.20, 83.

_Khaya _K. senegalensis_ (African mahogany) b. 10% sometimes used in W. Af. in native tanning56, 87.

_Krameria _K. triandra_ (rhatany root) r. 40% Peru153.

_Lagerstroemia _L. parviflora_ b. 7—10%, l. 16% Ind. ‘ tans a light-weighting leather with a good light fawn colour’. _L. spectosa_ (syn. _L. flos-reginae_) f. 14—17%20.

_Laguncularia _L. racemosa_ (white mangrove, ‘ mangue ’) b. 15—18%, l. 20%, w. 5%; leaves used in S. Am. and Jamaica57 in tanning; pyrogallol tan yielding light coloured leather; see Chapter 383, 157.

_Lamica _L. grandi_ (syn. _Odina wodier_) b. 10% Ind.20.

_Larix_ See Larch, Chapter 13.

_Laurus _L. peumo_ (syn. _Cryptocarya peumis_) said to be used in Chile in tanning183.

_Lawsonia _L. alba_ (henna), Levant, leaves used for tanning as well as dyeing57.

_Leudem _L. palustre_ shrub at one time used in tanning in N. Eur.57.

_Leela _L. manillensis_ b. 11% Phil.21.

_Leucadendron _L. argenteum_ (silver tree) b. 9—16% S. Af.83, 188.

_Leucosperrnum _L. conocarpum_ b. 12% S. Af.188.

_Lithraea _L. gilliesii_ b. 16% Argentina53.

_Louchoacarpus _L. mossambicensis_ b. 21% E. Af.; _L. neuroscapha_ b. 34% Braz.83.

_Loranthus_ Many of these parasitic plants are rich in tannin. _L. longifolius_ young shoots 10% Ind.20.

_Lucuma _L. glycyphloea_ b. 32% Braz. yields a good light-coloured leather57.

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Luehea *L. speciosa* bark used in tanning skins of small animals in Brazil.57

Lumnitzera *L. racemosa* b. 15—19% bark may be used in tanning Ind.20, 38.

Lysiloma *L. bahamensis* b. 12% W.I.157.

Macaranga *M. pellata* b. 18%, l. 9% Ind.20; *M. tanaria* a fish-net tan in Phil.38; *M. gigantea* and *M. mappa* used for tanning in Indon.91.

Maclura *M. aurantiaca* (syn. *M. pomifera*) w. 9—10% N. Am.157; has been used in tanning and dyeing83.

Madhuca *M. latifolia* (syn. *Bassia latifolia*) b. and l. sometimes used, Ind.57; *M. longifolia* (syn. *Bassia longifolia*) b. 17—27% Ind.20.

Mallotus *M. philippinensis* b. 6—10% a dark reddish tan but sometimes used in India20, 57.

Malpighia Several central and south American species rich in tannin. *M. punicea* b. 21% Nicaragua83; *M. spicata* b. 43% Guianas183.

Mangifera *M. indica* (mango) b. 16—20%, seeds 8—9%, dried flowers 15% bark used in India but resinous20, 153.

Manilkara *M. hexandra* (syn. *Minusops hexandra*) b. 10%20; 40%183 Ind., bark sometimes used.

Melanoxyylon *M. brauna* b. 34% Braz.83.

Mesembryanthemum *M. edule*, a succulent plant from S. Af., much cultivated, dry leaves 19%, dry stems 14%; tannin of catechol class suitable for tanning183.

Mimosa *M. pudica* r. 10% tropics87.

Minusops *M. elengi* b. 3—7% sometimes used in India57.

Musa *M. sapientum* (banana) flesh of unripe f. 8%, ripe f. 2%, skin of unripe f. 30—40%, of ripe f. 4—5%24.

Myrica The barks of several species are rich in tannin *M. cerasifera* b. 16% N. Am.157; *M. nagi* b. 20% kino 60—80% Ind. China20; *M. nagi* and *M. gale*, Eur. have been used in tanning183.

Myrsine *M. melanophleos* b. 11% S. Af.188.

Myrtus *M. edulis?* b. 21% S. Am.89; *M. silvestris* b. 32% Braz.83.

Niplo *N. peregrina* b. 16% used in tanneries in parts of Brazil where richer tan-barks are not available88.
MISCELLANEOUS TANNING MATERIALS

Nyctanthes *N. arbor-tristis* bark said to have been used in India.

*Nymphaea* Rhizomes of several species contain tannin; those of *N. alba* said to have been used in tanning, Eur.

Oldenlandia *O. umbellata* bark used in tanning in India.

Olinia *O. radiata* b. 17% S. Af.

Oroxylon *O. indicum* bark and fruit used in tanning in India.

Osyris *O. arborea* l. 20% Ind. Leaves of *O. lanceolata* (' marghatah ') used for tanning in Morocco.

Oxalis *O. gigantea* (' churko ') b. 20—26% much used for tanning in Chile.

Oxydendrum *O. arboreum* (sorrel tree) N. Am., has been used in tanning.

Oxycoccus *O. callistachyus* b. 11—16% W. Aus.

Pachystemon *P. trilobus* l. 14% Ind.

Parkia *P. filicoidea* b. 12—14% used in Sudan, gives a harsh dark coloured leather. *P. javanica* b. 6—21% Ind. Phil.

Paulinia *P. cupana* (' guarana ') pods 48% seeds 8%, guarana paste 6%, pods give a soft leather, like pod tans, tannin of pyrogallol class.

Peltophorum *P. dubium* b. 24—31% Paraguay; *P. inerme* b. 11% Phil.

Pemphis *P. acidula* b. 19—43% E. Af. sea coast: used in native tanning.

Pentace *P. burmannica* and *P. tonkinensis* have attracted attention as tan-barks.

Persea Several species with tanniferous barks. The bark of *P. lingue* and *P. meyeniana* (Persea or Valdivia bark) which is aromatic and contains 17—24% tannin was once extensively used for tanning in Chile, yielding the characteristic Valdivia leather. *P. americana* (avocado) the fruit shells contain tannin.

Persoonia *P. longijolia* b. 11—14% W. Aus.

Peumus The bark of certain Chilean species is rich in tannin and used locally in tanning.

Phoenix Several species contain tannin. The date palm (*P. dactylifera*) may be used in Morocco for tanning.
**MISCELLANEOUS TANNING MATERIALS**

*Phyllanthus* Several species are rich in tannin. Bark, leaves and fruit of *P. emblica* (syn. *Emblica officinalis*) (’aonla’ or ‘emblic myrabolan’) much used in India and other parts of the East in tanning and much esteemed: twig b. 24%, bole 8–9%, l. 23–28%, unripe f. 30–35%; *P. polyphyllus* b. 11–16%, Ind.20; *P. discoides* b. 9–10% S. Af.188; *P. distichus* b. 18% Ind.20.

*Phyllocladus* *P. trichomanoides* b. 28–30% has been used in tanning in N.Z.; *P. asplenifolia* b. 23% N.Z.; *P. glauca* b. 7–12% N.Z.; *P. rhomboidalis* b. 15–20% Aus.51.

*Picea* See Spruce, Chapter 5.

*Pimenta* The leaves of allspice or pimento (*P. officinalis*) used for oil distillation in the West Indies, contain tannin and might be used in local tanning88.

*Pinus* See Pine, Chapter 12.

*Piper* *P. aduncum* (‘apertaruao’) l. 9–10% Braz.29.

*Piptadenia* The bark of some species is used in tanning in Brazil, e.g. *P. macrocarpa* b. 34%, catechol tan98 and *P. rigida* (‘angico’) b. 20%29. Other noteworthy species are *P. cebil* b. 15% S. Am.; *P. chrysostachys* b. 15% Madag.83.

*Pistacia* Leaves, galls and berries of several different species may be used in local tanning. *P. atlantica*, galls 24–40%, used in tanning in Morocco, leaves 19%, recommended as a sumac substitute; *P. chinensis* l. 10% China88; *P. integerrima* b. 8%, l. 16%, galls 20–75%, Ind.20; *P. lentiscus* (Cyprus sumac, ‘lentisco’) l. 9–19%, used for tanning in Morocco and Mediterranean countries and a common adulterant of sumac188; *P. mutica* galls 15%, l. 12% Ind.20; *P. terebinthus* (Chian turpentine tree) fruits used for tanning in Morocco, b. 14%, l. 9–19% used in Macedonia87; *P. vera* (pistachio nut tree) galls 50%20 (see Galls, Chapter 40).

*Pithecolobium* *P. dulce* b. 12–37% much used in Philippine tanneries averaging about 30%31; grown throughout tropics. *P. subacutum* b. 5–23% Phil.21.

*Platycarya* *P. strobilacea* f. 25%; pyrogallol tan, China, used locally in tanning.

*Plumbago* *P. europaea* the whole plant, especially the roots, rich in tannin; used in France57.

*Podocarpus* Several species with tannin in bark, usually below 10%61, 188. 283
MISCELLANEOUS TANNING MATERIALS

Polygonum Numerous species are known to contain tannin especially in the roots or rhizomes. *P. alpinum* (‘taran’) has been considered as a commercial source of tannin, mainly in Russia. The plant occurs in the mountains of southern and central Europe and in Siberia and Asia. It is sometimes grown as a garden plant (white flowers for cutting). The root-stock has been employed in local tanning and contains 16—22% tannin, 14—18% soluble non-tans and 5% sugars; *P. amphibium* l. 18% rhizome 18—22% N. Am.; *P. bistorta* r. 21% Ind.; *P. cuspidatum* l. 17% (cultivated); *P. plebeium* whole plant 11% Aus.; *P. sacchalinense* l. 24% (cultivated) gave satisfactory (reddish) sole leather in tests.

Populus Bark of several species known to contain tannin, usually well below 10%; *P. tremula* and *P. pyramidalis* have been used in Europe in tanning.

Potentilla *P. erecta* 29%; *P. tormentilla* ( tormentil) r. 17% Eur. roots used in tanning in Britain in 18th century, also those of cinquefoil. Other species have lesser amounts of tannin.

Prosopis *P. africana* b. 14—16% used in W. Af. gives reddish brown leather; *P. juliflora* (mesquite) b. 6—7% N. Am. has been used in local tanning; *P. nigra* solid wood extract 45% used in S. Am.; *P. oblonga* b. 14% a native tan in Sudan gives a firm brown leather.

Protea Bark used at the Cape for tanning in early days. *P. caffra* b. 12%; *P. grandiflora* b. 13%; *P. mellifera* b. 16%.

Prunus *P. amygdalus* (almond) shells 4-5% have tanned leather successfully experimentally. *P. avium* b. up to 16%.

Pseudotsuga *P. taxifolia* (syn. *P. douglasii*) (Douglas fir) b. 7—18% bark of young trees richest; yields light, even coloured well plumped leather; wax also present in bark.

Psidium *P. guajava* (guava) b. 11—30%, l. 8%, bark and leaves have been used locally in India for tanning; *P. pomiferum* b. 12%.

Pterocarpus *P. delevoyi* b. 13—27%, l. 4% Congo; *P. draco* (dragon’s blood) kino 34% Central Am.; *P. marsupium* (Indian kino) kino 50—80%, b. 4%.

Pterocelastrus *P. variabilis* b. 13% used in local tanning S. Af.
MISCELLANEOUS TANNING MATERIALS

Pteracymbium P. tinctorium b. 10\% Phil.\textsuperscript{21}.

Pteroleobium P. exosum bark used in native tanning E. Af.\textsuperscript{87}.

Pteraspermum P. niveum b. 10\% Phil.\textsuperscript{21}; P. obliquum b. 7—28\% Phil.\textsuperscript{21}.

![Figure 10. Pomegranate (Punica granatum): the bark and the rind of the fruit are well-known tanning and dyeing materials in Mediterranean countries and have been used by tanners from the earliest times](image)

\(Punica\) P. granatum (pomegranate) b. 10—25\%, root b. 28\%; dry fruit shells 26\%\textsuperscript{87}; the bark and fruit shells have from early times been well known and much used tanning materials in Mediterranean countries and the East. The Romans and Phoenicians used them. The bark was once much used for 'Morocco leather'.

\(Purshia\) P. tridentata f. and seeds 12\%, N. Am.\textsuperscript{183}.

\(Pyrus\) Bark of several species contains small amounts of tannin.

Quercus Oak Bark, see Chapter 4; Oak Wood, see Chapter 18.

Quillaja \(Q.\) saponaria (soap bark tree) b. 15\% Chile\textsuperscript{83}.

Ratanea R. ferruginea ('capororoca') b. 10\% Braz.\textsuperscript{29}.

Rheedia R. brasiliensis b. 18—21\% Paraguay\textsuperscript{83}.

Rheum Rheum sp. (Turkmen-Rhubarb) r. 11\%, l. 4—5\% extract from roots found suitable for tanning Russian leather and pigskin yielding a durable elastic leather\textsuperscript{188}.

Rhizophora See Mangrove Bark, Chapter 3, p. 60.
Rhodamnia  *R. cinerea* bark used in tanning and dyeing, Indon.°

Rhododendron  *R. ferrugineum* leaves have been used for tanning in Piedmont.°

Rhodomyrtus  *R. tomentosa* b. 19% large shrub, S. India.°

*Rhus* Several species in this large genus are known to possess bark or leaves of high tannin content and some are used in local tanning (see also Sumac, Chapter 29; Tizra, Chapter 21; Galls, Chapter 38).  *R. incana* var. *coriaria* b. 19% S. Af.; *R. laevigata* b. 18% S. Af.; *R. mysurensis* twig bark 18%, gives excellent cream coloured leather, Ind.°; *R. natalensis* b. 15% S. Af.; *R. oxyacantha* b. 17%, w. 12% Ind. tans similarly to quebracho, also used in Libya; *R. punjabensis* l. 13% Ind.; *R. rhodanthema* b. 23% l. 16% Aus.; *R. succedanea* b. 10% Ind.; North American species include *R. aromatica* l. 21%; *R. copallina* l. 27—36%; *R. glabra* l. 27%; *R. lanceolata* l. 22%; *R. microphylla* l. 19%; *R. trilobata* l. 39%; *R. typhina* l. 25%; *R. virens* l. 20%°

Robinia  *R. pseudoacacia* (false Acacia) b. 7%, w. 3%; has been considered as a source of tannin in war-time.

*Rumex* See Docks, Chapter 34.

*Sabal*  *S. palmetto* (sabal) r. 10%, roots have long been used in S. United States in local tanning and extracts prepared°

*Salix* See Willow Bark, Chapter 11.

Salodoricum  *S. koetjape* b. 11% Phil.

*Saxifraga* See Badan, Chapter 35.

Schinus  *S. aroeiro* b. 23—35%, gives reddish brown leather, Braz.°; *S. molle* (pepper tree) b. 23% used in S. Am. in tanning.

Schleichera  *S. oleosa* b. 7% Ind. bark has been used in tanning in Java.

Schotia  *S. speciosa* b. 16% infusion very dark. S. Af.

*Scilla*  *S. maritima* bulbs 24% Morocco.

Sclerocarya  *S. caffra* b. 10%, gum also contains tannin. S. Af.

Semecarpus  *S. anacardium* (marking nut) bark and fruits contain tannin; latter sometimes used by tanners. Eastern tropics.

Sequoia  *S. sempervirens* b. 2—8%, w. 12% infusions very dark. N. Am.
MISCELLANEOUS TANNING MATERIALS

Serenoa  *S. serrulata* (palmetto) stem 5%, root 7-6% leaves also contain tannin; has been used in tanning in Florida.7, 83.

Shorea  *S. robusta* (‘sal’) b. 9—10% l. 8—23% used locally in tanning. Ind.20; *S. siamensis* b. 13%, l. 12—23% Ind.89, 13.

Simaruba  *S. amara* bark used in local tanning, British Guiana.188.

Sloanea  *S. australis* b. 10% Aus.51.

Soaresia  *S. nitida* (‘oiticica’) b. 35%, Braz.83.

Solanum  Several species are known to contain tannin; *S. sodomum* used for tanning in Morocco.

Sonneratia  Several species (mangroves in the Pacific and Indian Ocean regions) contain tannin. Bark may be used locally but the quantity is insufficient for commercial usage. *S. alba* b. 8% Aus.51; *S. apetala* b. 11%, twig b. 14%, f. 10%, l. 8% Ind.20; *S. caseolaris* (syn. *S. acida* (‘ora’) b. 9—15%, twig b. 11% Ind.20, 38.

Sorbus  The bark of *S. aucuparia* and *S. domestica* is said to tan leather a good brown colour.

Soymida  *S. febrifuga* b. 13—14% Ind. Yields light coloured leather.

Spiraea  *S. ulmaria* (syn. *Filipendula ulmaria*) leaves said to have been used in Iceland for tanning and dyeing.183.

Spondias  The bark of *S. mangifera* (syn. *S. pinnata*) has been used in local tanning in India and that of *S. mombin* (syn. *S. lutea*) in W.I. and Guiana.57.

Statice  See Sea Lavender (‘Kermek’), Chapter 36.

Stryphnodendron  *S. barbatinana* (‘barbatinana’; ‘barba de Timon’) b. 22—35%, w. 14%, f. shells 27%. Bark now much used for tanning (and extract) in central and southern Brazil; trees barked after felling. Bark tans quickly giving reddish or dark leather if untreated; wood not generally used.

Swietenia  *S. mahogani* (syn. *S. macrophylla*) (mahogany) b. 15%, w. 6%, bark has been used (mixed) in Jamaican tanneries.

Syncarpia  *S. leptopetala* b. 18—20% Aus.51.

Syzygium  *S. jambolana* (syn. *Eugenia jambolana*) (jambolan) b. 18—19%, l. 12—13% bark may be used in dyeing and tanning in eastern tropics. *S. guineense*, bark sometimes used in W. Af.59.
MISCELLANEOUS TANNING MATERIALS

Tamarindus T. indica (tamarind) b. 7%20 bark and leaves have been used for tanning in India57.

Tamarix (see Tamarisk Galls, Chapter 39). T. articulata b. 14%,
galls 50% N. Af.; T. dioica twig b. 10%, l. 8%, galls 50%;
T. gallica galls 50%20, 63.

Taxus T. baccata (yew) b. 9%, leaves also contain tannin, Eur.
Ind.20, 83, 89. T. cuspidata b. 10% Japan83.

Tecoma T. leucocylon bark has been used for tanning in Guiana,
T. pentaphylla b. 27% Venezuela89.

Tectona T. grandis (teak) b. 1%, l. 6% Ind.20.

Terminalia Many species possess bark or young fruits rich in
tannin (see Myrabolans, Chapter 22); T. arboea bark used in
tanning, Indon91; T. arjuna ('kahua') b. 20—24%,
l. 11—12%, f. 7—20% bark has been used in Cawnpore tanneries—gives a superior light brown leather20; T. bellirica
(see Myrabolans) b. 4%, f. without seed 25%, seed or stone 14%,
Ind.20; T. catappa b. 9—13% used in Andamans20, 83; T. chebula (see Myrabolans) f. 30—50% Ind.20; T. citrina
b. 26% Ind.20; T. edulis b. 11—42% Phil.21; T. latifolia,
bark has been used in Jamaican tanneries. T. mauritiana
b. 30% C. Am.83; T. myricarpa b. 18—24% seed 6%20;
T. nitens b. 9—33%, unripe fruits 29% Phil.21; T. pallida
(see Myrabolans, Chapter 22) f. 41% Ind.20; T. paniculata
b. 26% Ind.20; T. peltucida b. 17% Phil.21; T. platypylla
b. 10% Aus.61; T. sericea galls 10% S. Af.188; T. tomentosa
b. 5—13% often used in India in tanning, fruit also used88;
T. travancorensis source of myrabolans in India; T. velutina
b. 12—13% E. Af.83, 87.

Theobroma T. cacao (cocoa) the fermented bean contains tannin139.

Trapa T. natans (water chestnut) fruit shells 10% China83.

Trema T. lamarkiana b. 11—16% N. Am.83, 157; T. orientalis
b. 6—31% Ind. Phil.20, 21.

Trichelia T. categua b. 20% and T. hieronymi b. 15—23% are
used in native tanning in Paraguay83, 89, T. emetica b. 11—27%
S. Af.188.

Tristania T. laurina b. 20% Aus.51. Bark of T. conferta has been
used in tanning, Aus.57.

Tsuga See Hemlock, Chapter 6.
MISCELLANEOUS TANNING MATERIALS

**Ulmus** The bark of the common European elm (U. campestris) contains only about 3% tannin and tans a bad colour.

**Vaccinium** Both V. myrtillus (bilberry, 'myrtle' of old writers) and V. vitis-idaea (cowberry) were formerly used in small-scale tanning in Europe.

**Vateria** V. indica fruit shell 25% gives extract with little colour, Ind.

**Vatica** V. leucocarpa heartwood 33% Indon.

**Vitex** V. diversicata 1.14% leaves used in tanning, Indo-China.

**Vitis** The seeds of the grape (Vitis vinifera) contain tannin and are said to have been used in tanning.

**Wagatera** W. spicata pods 19% climbing shrub, Ind.

**Weinmannia** Several species with bark rich in tannin are used in local tanning, especially in S. Am. 'Encino' or 'encinillo' bark (Weinmannia spp.) is the important tanning material of the higher parts of Colombia. W. bojeriana b. 13% Madag.; W. racemosa ('kamaki') b. 14—30% bark used in tanning in N.Z. at one time; W. silvicola ('tanhero') b. 10—13% has also been used in tanning in N.Z.

**Woodfordia** W. fruticosa (syn. W. floribunda) b. 20—27%, l. 12—20%, flowers 20%, shrub, Ind.

**Ximenia** X. americana b. 17%, Trop. Af. used in tanning in Sudan, yields soft reddish tinged leather.

**Xylica** X. xylocarpa (syn. X. dolabriformis) ('pyinkado') b. 7—18% used as a fish-net tan; wood also contains tannin, Ind.

**Xylocarpus** X. gangeticus ('pussur') b. 24%, Ind.; X. granatum (syn. Carapa obovata) ('dhundal') b. 28%, Ind.

**Zizyphus** Z. jujube ('ber') b. 4—9%, sometimes used in India; Z. mucronata b. 12—15% S. Af.; Z. nummularia twig b. 12%, l. 9%, Ind.; Z. oenoplia b. 12% Ind.; Z. sativa b. 7%, f. 10%, Ind. (Ind. Surv.); Z. xylopus ('gothar') b. 7%, f. 23%, fruits used in tanning in some parts of India, yield a good leather but produce much mucilage.
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