STUDIES ON POST HARVEST TECHNOLOGY INCLUDING PROCESSING OF ORANGES (*Citrus reticulata Blanco.*) AND MANGO (*Mangifera Indica* Linn.) FRUITS

THESIS

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DECLARATION OF THE STUDENT

I hereby declare that, the experimental work and its interpretation of the thesis entitled "**Studies on Post Harvest Technology Including Processing of Oranges** (*Citrus Reticulata Blanco*) **and Mango** (*Mangifera Indica* Linn) **Fruits**" or part there of has not been submitted for any other degree or diploma of any University nor the data have been derived from any thesis Publication of any university or scientific organisation. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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This is to certify that the thesis entitled "Studies on Post Harvest Technology including processing of Oranges (Citrus reticulata Blanco) and Mango (Mangifera indica Linn.) fruits, submitted to Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) for the award of the degree of Doctor of Philosophy in Agriculture (Horticulture), is a record of bonafide research carried out by Shri. A.G.Huddar under my guidance and supervision and is of sufficiently high standard to warrant its submission to the Vidyapeeth (University) for the award of the said degree.

No part of the thesis has been submitted for any degree or diploma or published in any other form.

The assistance and help received during the course of this investigation and source of literature have been duly acknowledged.

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I. INTRODUCTION

Mandarin oranges (*Citrus reticulata* Blanco)

The group citrus fruit represent the loose and tight skinned oranges, lemons, limes, grape fruits etc. Among the citrus fruits, loose skinned oranges or the mandarins are very popular and kinnow oranges have become extremely popular due to juicy rich content and colour. The other oranges namely the tight skinned oranges which are popularly known as Mosambi, Sathgudi, Malta, Valenica, Washington navels, Jaffa etc. have also good market.

All the citrus fruits are a rich source of Vitamin C/Ascorbic acid which helps in the collagen formation in the human tissue mechanism. Limes and lemons are rich in vitamins, minerals, alkaline salts, but not so in fruit sugars. Unlike oranges, limes and lemons are sour in taste and highly acidic. Because of their high acidity and sourness, they are used in the preparation of pickles.

The inner white peel of citrus fruits contain pectin. The latter is used in jam/jelly preparations. Orange oil from the peel is a good source of flavouring ingredient for a variety of beverages.

India stands fifth in the world with nearly 29.80 lakh tonnes citrus fruit production in 19096-97. Collectively, citrus fruits rank third in area (3.7 lakh ha.) and production (after mango and banana) in the production of fruits in India.*

*(Source - A Decade of N.R.C.C., Nagpur, 1997).

Table showing production of citrus fruits in major citrus growing countries in the world (1994-95)

Country	Production ('000 Tonnes)
Brazil	14812.0
U.S.A	13567.0
Spain	5137.7
Mexico	4458.0
India	2979.0
Italy	2748.0
Egypt	2472.1

(Source N.R.C.C. Prospective Plan 1996-97)

Among all the citrus fruits grown in the country, Nagpur Mandarin orange, commonly referred to as 'Santra' occupies an unique place in citrus cultivation and marketing in India. Commercially known as Nagpur oranges and also labelled as king of oranges are technically mandarins, botanically identified as Citrus reticulata, Blanco. Because of the attractive colour, pleasant flavour and taste, it has ready acceptance with the consumer. Vidarbha region of Maharashtra is the major Nagpur mandarin producing belt in India. It is mainly concentrated in Nagpur, Amaravati, Wardha and Chanda districts of Vidarbha Region of Maharashtra.

Mandarins constitute maximum (around 45%) "in" area and production among all citrus fruits grown in different regions (apart from Vidarbha region of Maharashtra and central India) are Coorg Mandarin in Karnataka, Madhya Pradesh, Haryana, Rajasthan, western U.P and Darjeeling, Mandarin in Sikkim and west Bengal.

Among mandarins, kinnow cultivation registered a phenomenal growth after introduction in Punjab in 1956. Area under kinnow leaped from 500 ha. in 1970 to 18,292 ha. in 1990.

In north western parts of the country, cultivation of local mandarin and traditional citrus fruits like Malta orange have been partly replaced by kinnow mainly because of its response to inputs and consequent higher returns. During the last 25 to 30 years, the area under Nagpur mandarin has increased from nearly 17,800 ha to about 60,000 ha. The kinnow cultivation has been tried and found successful in this region too. Kinnow is, however, not successful in tropical parts of south India. The mandarin industry is likely to register considerable growth in future as the fruitss can be eaten out of hand and are in great demand, particularly the seedless ones in European market.

Kinnow oranges have a great export potentuial as compared to the traditional varieties of mandarin oranges of India due to the fact that they have most deep red orange colour, more juice content, highly colourful juice and very attractive for the purpose of marketing. The kinnow variety has very high yield potential, but lesser adoptability to varying agro-climatic conditions.

Since the area and production of mandarin oranges is increasing, it has become increasingly important to reduce the post harvest losses by developing suitable technology protocol to handle the fruits right from harvesting stage to the final stage of consumption so that they reach the consumer in a good condition at reasonable price. Traditioanl methods of packing, trasportation, storage and marketing are causing heavy losses by the time, the oranges reach the consumer, which is reported to be about 25 to 30%, because the fruit is highly perishable at ambient temperature and need trasportation and distribution period over 10 days to reach the consumer. The transpiration loss of moisture from the fruits affects the texture of the fruit and results in losses in weight directly affecting the grower. Hence packaging, trasportation and storage at right temperatures are the vital factors in post harvest handling of these fruits.

Taking into consideration all the above aspects of orange industry in India, the present investigation was undertaken with the following objectives: -

1. To standardise the post harvest treatments for the transportation and storage of fruits with least extent of losses.
2. To study the changes in the fruit during storage.
3. To control the spoilage by various means.

Mango (*Mangifera indica* L.) is the choicest of all fruits, because it posseses attractive colour, highly acceptable taste and excellent flavour. It occupies the same position in Tropics as is enjoyed by apples in Temperate America and Europe. In India it is also referred to as King of fruits. The Asian countries practically control the mango export trade in South East and Far East Asian countries. Fresh mangoes and their products are also exported from India to more than 25 countries, but the quantities of individual items are too small to attract any attention. Mango is beign grown in more than 87 countries of the world, but India ranks first in the world with respect to both area (1.1 million hectares) and production (9.4 million tonnes) (Chadha, 1990). India contributes to more than 70 percent of the total world mango production and the crop is largely grown in Uttar Pradesh (34%), Bihar (13.2%) and Andra Pradesh (12.8%). The export of fresh mangoes from India during 1987-88 accounted to 14,900 metric tonnes valued at 170.3 million rupees. The export of mango pulp accounted for 62 per cent of the total exports of processed fruit and vegetable and was valued at 220 million rupees (Chadha, 1989).

One of the finest of Indian mangoes rated as the best by many at home and abroad which is grown to some extent in the South is Alphonso. It is specifically preferred for export because of atractive fruits and optimum size and shape. The fruits have pleasing pinkish blush towards the basal end, the taste is superb with an excellent sugar/acid blend, captivating flavour and good keeping quality (Cheema and Dani, 1934). Besides being a table variety much in demand, it is also a favoured fruit of the processing industry because it retains the characteristic flavour even during processing (Majumdar and Sharma, 1986). In spite of these merits and demands both in the internal and international markets, the variety suffers from serious problems, mainly development of spongy tissue in ripe fruits. To overcome the problem of alternate bearing, Indian Agricultural Research Institute, New Delhi, released an outstanding hybrid called Mallika (Neelum x Dashehari) which has a strong tendency to bear every year, beside having fruits of larger size and superb fruit quality (Singh *et al.*, 1977). Bomboy Green the most popular commercial variety of Northen and Eastern regions is also gaining importance for processing in Southern region. It has an excellent sugar/acid blend and characteristic pleasant flavour.

Out of more than 500 varieties of mangoes known in India, only 20 to 30, which include regional specialities like Alphonso, Dashehari, Banganpalli and Bangalora are commercially very popular. They are suitable for canning. There are numerous juicy varieties that are used for pulp, puree, juice squash and other products.

Most of the varieties evaluated for processing by various researchers though have given satisfactory canned or bottled products, yet the chewing properties of the canned mango slices do get deteriorated due to the loss of texture during processing and storage. In most cases, the slices become very tender or pulpy and loose their shape and size. The pulp gets disintegrated into the syrup used for filling.

There is little information available on the processing qualities of many mango varieties and hybrids which are very high yielding and have very good taste, colour and flavour too.

It was therefore felt necessary to evaluate the processing qualities of a few selected mango varieties/hybrids grown in this region and have been found promising. ALPHONSO is by far the best variety for processing but the non-availability of large quantities of this variety for processing and the high cost of fresh fruits (because fresh fruits are in great demand in domestic as well as in export market), it is very important that we find an alternative variety which is equally good for processing to replace Alphonso. Therefore the mango varieties that have shown promise in this area vis-a-vis cultivation and yield viz., Ratna, Mallika and Bombay Green were choosen for these studies.

A systematic investigation was carried out keeping in view the points mentioned above with the following objectives :

1. To evaluate the suitability of two hybrids, Mallika and Ratna and the variety Bombay Green for processing into canned mango slices.

2. To study the changes in quality attributes during storage of the canned mango slices at room temperature.

3. To study the varietal response for processing canned mango slices.

II. REVIEW OF LITERATURE

Review of Literature has been done on the following aspects of Oranges and mangoes

2.1 ORANGE

2.1.1 Harvesting

2.1.1.1 Abcission

2.1.2 Pre-packing treatment

2.1.2.1 Colouring

2.1.2.2 Waxing

2.1.3 Package design and fruit transportation

2.1.3.1 Transport

2.1.3.2 Storage

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2.1.4 Evaluation of fruit injuries

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2.1.5.1 Physiological loss of weight

2.1.5.2 Titrable acidity

2.2 MANGO

2.2.1 Morphological and physico-chemical characteristics of Mango cultivar

2.2.1.1 Weight of fruit

2.2.1.2 Volume of fruit

2.2.1.3 Specfic gravity

2.2.1.4 Size of the fruit (Length and Breadth)

2.2.1.5 Colour of the peel and pulp

2.2.1.6 Firmness of fruit

2.2.1.7 Weight of pulp, stone and peel

2.2.1.8 Pulp to stone ratio

2.2.1.9 Size of stone (Length and Breadth)

2.2.2 Chemical composition of mango fruits

2.2.2.1 Moisture

2.2.2.2 Total soluble solids

2.2.2.3 Titrable acidity

2.2.2.4 Sugars

2.2.2.5 pH

2.2.2.6 Ascorbic acid

2.2.2.7 Carotenoid pigments

2.2.3 Preparation, processing and Evaluation of mango products

2.2.3.1 Mango squash

2.2.3.2 Canned mango slices

2.4 Changes in chemical composition of Mango products during storage

2.2.4.1 Canned mango slices

2.2.4.2 Treatment of fruits with chemicals to improve procesing qualities

2.1 ORANGE

Citrus fruits are exposed to a variety of combination of climatic factors and also to soil and cultural conditions. The number of cultivars, rootstocks and their combinations will reveal the wide variation in the genetic constitution. Fruits are harvested more than once in a year during different seasons. Fruit composition which in turn decides the post harvest behaviour of the fruit is influenced by the climate and other environmental factors, soil and cultural conditions and rootstocks and varieties (Pantastico, 1975). So the physiological changes associated with harvesting, packing, transport and storage of citrus fruits cannot be simple and be generalized. The work done on different varieties under different situation is reviewed here.

Kawashima, 1971). Temperature does not affect the synthesis of carotene, but synthesis and breakdown of Lycopene are affected by temperature. 60 to 70^0F is optimum for lycopene synthesis, while more than 85^0F inhibit its synthesis.

2.1.1.1 Abcission

High endogenous abscissic acid contents increase the ease of manual harvest and favour the mechanical harvest. Some chemicals like Ascorbic acid, citric acid, bromoacetic acid, Ferric ammonium citrate, 2, 4-D, NAA, methyl ester, Ethrel and cyclohexamide were found to increase abscission of citrus fruits (Thompson *et al.*, 1975).

The care excercised during the harvest until the storage has a role in the storage life of citrus fruits. Injury to the fruits during harvest, packing or durng the transit. Depending upon the variety and the severity of bruising, injury can stimulate respiration. Even a slight dropping or streaking on the surface of the fruit causes an upsurge in respiration. Vines (1965) clearly illustrated this in valencia oranges. Injury to the fruit aggrevate the storage disorders.

Grading to cull out young, small and unripe fruit is important, particularly in mechanically harvested fruit in view of the reports of Ahroni (1968) and Murata and Miyashita (1971) who observed that young and small citrus fruits have increased respiration and ethylene production after harvest. This was not observed in mature citrus fruits. In a mixture of lot containing immature and mature fruits, the storage life of mature fruit will be reduced. The injured fruit also releases more ethylene and reduce the storage life of healthy fruit. So grading is important.

2.1.2 Pre-packing treatments

It is a common practice in the arid sub-tropics to hold citrus fruits in the shade at ambient temperature for one or more days before washing and packing. The fruit becomes less turgid and therefore more resistant to mechanical injury. Injuries created during harvest may become more resistant to infections also. Injuries on the surface of oranges held under ambient conditions offer resistance to infection by fungi within 24 hours, presumbly because of mild desication (Eckert and Kolbezen, 1963).

Hot water treatment of oranges and lemons was found to eradicate the incipient infections of *Phytophthora citrophthora*. Fawcett (1922) developed a hot water treatment of incubating the fruit for 30 hours and then submerging it in water at 120^0F for 2 minutes.

Degreening of citrus fruits is done prior to packing or wax coating. Degreening with ethephon 1000 ppm for 3 to 600 seconds depending upon the variety was comparable to that obtained in commercial type degreening rooms (Young *et al.*, 1970). Degreening of valencia oranges treated with Ethephon was somewhat slower in the light than in the dark (Oberbacherk, 1968). Treated Mosambi oranges stored in the dark were brighter yellow and glossier than those kept in open (Chauhan and Parmer, 1972). Efficiency of ethephon in degreening was higher at 77^0F as compared to 63^0F, and it was nil at 43^0F. Ethephon was found to induce carotenoid synthesis in addition to degreening (Daito and Hirose, 1970).

Ethylene accelerates the decomposition of chlorophyll without significantly affecting the synthesis of carotenoid pigments (Kitagawa and Tarutani, 1972). Roper and Miller (1951) proposed a hypothesis to explain the effects of ethylene on the physiology of plant cell – especially the chloroplasts. Ethylene serves to hydrolyse the plastid stroma and produces materials that can be used in respiration, as a result the chlorophyll is left unprotected, is acted upon the chlorophyllase and subsequently oxidised by H_2O_2 in the presence of a Fe $(OH)_2$ catalyst. In these reactions, the internal quality of the fruit is left unaltered because the activities are centred on the flavedo of the rind.

2.1.2.1 Colouring

After degreening fruits may still be pale in colour. Dyeing intensifies this colour for greater consumer appeal. In citrus fruits, only dye which has been approved for general use-Citrus Red No. 2 is 1 – (2, 5 dimethoxyphenylazo) –2 naphthal with an established tollerance of 2 ppm. Residues are determined by washing the dye from the fruit with chloroform and calculating the concentration by comparing light absorption at 520 nm with that of a standard dye solution. The oil soluble dye is dissolved in an organic solvent and emulsified in water. The stability of the emulsion is critical in the process. Too much emulsifier results in pale colouring, since the dye remains in the emulsion. Too little emulsifier leads to uneven colouring and peel injury. Dyes are some times added to waxes, requiring only one application. Minimum legal limits for treatments are 4 min at 120^0F for oranges and 2 ½ min at 115^0F for temple orange and tangelos. The fruits are rinsed with a water spray to remove excess emulsion.

2.1.2.2 Waxing

A discontinuous layer of wax applied artificially with sufficient thickness and consistency to reduce an aerobic conditions within the fruit provides the necessary protection against decay organisms. Waxing is especially important if tiny injuries and scartches on the surface of the fruit are present. These can be sealed by wax. Another obvious advantage of waxing is the enhancement of the shining and retention of the freshness in the fruit.

Waxing retards the transpiration and thus retains the freshness of the fruit. It reduces the CO_2-O_2 tension inside the fruit which is responsible for the extra storage life of the fruit. Several high shine wax coatings contain (1) high melting resin (2) a plasticizer and (3) highly volatle solvent. In India a mixture of sessal wax or carnuba wax, sugarcane wax and bleached wax has been found suitable for citrus fruits. While the fruits are still on the tree, the hard wax fraction increases in amount more rapidly than oil. During storage, the oil increases while the hard fraction remains constant. The maximum oil to hard wax ratio occurs at the peak of the respiration rate. The later stages of storage are marked by degradation of the wax and especially by reduction in the amount of oil. In immature citrus fruits, the soft wax forms a continuous film with little surface structure. Upon maturation the progressive formation of more and harder epicuticular wax resulted in more visible structure. The eventual cracking and lifting of the wax film indicated loss of its ability to expand with the slow developing cuticle – cell wall complex. Artificial waxing to mature fruit will supplement the natural wax lost this way (Albrigo, 1972).

2.1.3 Package design and fruit transportation

Packing is done for the ease of handling and loading in transport. It prevents damage to the fruit and moisture loss. Moisture loss is prevented when packed in moisture vapour barrier materials are used (Hardenburg, 1971). Plastic film is most effective in minimising the moisture loss. Waxed fibreboard cartons, parchment wraps and other specially treated packing materials can also retard moisture loss. With citrus in film bags, decay is much greater hazard than desiccation. More ventilation is required to prevent high humidity. Mesh bags provide a better environment and less decay, but film bags are less expensive. Numerous perforations are needed in polyethylene bags containing citrus to lower the humidity and minimise decay. Only polythene bags are good to have a higher number of holes needed for packing citrus (Grierson, 1968). Oranges packed in mesh bag lost 51 percent weight when stored at 70^{0}F for 7 days. On the other hand the loss in weight was 2.8 percent only when packed in perforated polythene bag under similar storage conditions.

Packing in corrugated fibre board cartons usually results on delayed cooling in refrigerated storage. Making ventilation holes in the container will help in quick loss of heat by the packed produce (Sommer and Luvisi, 1960). Raju and Iyanger (1962) have defined the basic requirements of a package. They emphasized that the package must be functional and should be designed to meet the rigid requirements of handling, transport and storage and climatic conditions. They reported that the drop heights that packages would sustain in relation to the weight are the most important factors in determining losses.

They observed that in practice packages weighing 80 lb and below would experience a drop of nearly 6 ft. under conditions prevailing in India. Their findings showed that the intensity of shocks during shunting goes up to 30 g. It was also observed that in transport packages are subjected to sustained vibrations which might generate stresses high enough to cause disintegration of food product like fruits and vegetables. In case of wooden containers, vibrational effects may lead to loosening of the nails and thereby weakening of packaging case. Raju *et al* (1962) studied some aspects of package design and some factors affecting it like packaging characteristics of the products, material used for packaging and cushioning, size and shape of package and orientation of the contents. He reported that the bamboo baskets used for perishables like fruits, vegetables, eggs, poultry, fish etc. do not give adequate protection to the contents on account of poor compression strength. Studies carried out at C.F.T.T.I., Mysore have shown that by reinforcing the basket with 1/8 – 1 /4 inch thick strips on all four corners, and around the bottom and top perimeter and along the diagonals of the lid, the baskets could be made sufficiently strong.

In packaging of fruits and vegetables, the most common cushioning material used in paddy straw or green leaves. Their experiments have shown that although paddy straw is ideally suited for this purpose, it should be free from sharp edges and infection. Since fruits and vegetables respire and transpire, the heat, carbon-dioxide, ethylene and water vapour produced should be dissipated quickly by the cushioning material.

Raju and Iyanger (1962) observed that India produces variety of tropical and sub-tropical fruits and due to rapid ubranisation, these have to travel from the growing area to the distant consuming centers. Even the properly harvested, stored and graded fruits require adequate packaging to withstand the harzard during transportation and marketing. If the produce is packaged in lots which are too large it suffer bruising and crushing during transport while too small package may be uneconomical. In India, smaller lots of vegetables and fruits are carried in head loads, by pack animal on in bullock cart, while large consignments are carried out by trucks, railways and steamers.

They suggest that improvements in the transportation system, coupled with pre-treatment will go a long way towards successful transportation and storage and thus better marketing of produce.

Mekee *et al* (1963) reported a formula for the compression strength of corrugated boxes. The equation is $S = 5.874 * Eh^{0.508} Z^{0.492}$

Where,

E = the edgewise compression strength.

h = the board caliper (board properties)

Z = perimeter (dimension property)

S = constant, which came from considering all types of single wall container

Anandswamy *et al.* (1964) have reported that mild treatment with chlorine or SO_2 has resulted in reduced spoilage in package commodities where spoilage has been due to infection from the cushioning material. They recommended that painting the outside of the wagon with aluminium paint, use of exhaust fan inside the wagon and a partial insulation with wooden rafters would be beneficial.

Bhagwan (1968) studied various aspects of standardization in the field of food packaging. He stated that effective standardization can be achieved by using good quality ISI standards of packaging materials, by taking into account the net weights and their tolerances so as to eliminate consumer complaints and provide check on the automatic packaging machine and labelling the consignment to inform the purchaser about the nature and amount of food present in the container.

Srivastava (1970) studied recent developments in procurement, storage and transportation of fruits and vegetables. The procurement of raw material may reduce spoilage and increases the economy of factory. Procurement can be achieved by contract farming of production. Due to refrigerated storage the respiration rates are reduced thus the storage and shelf life can be increased. Waxing of fruits and vegetables can increase storage life and reduce spoilage. Preferably it has to be done at the time of harvesting. Short distance transport is mainly done by man. For long distance under ambient condition the carrier should not be overloaded. Proper ventilation etc. is necessary to get better results.

Hanlon (1971) while describing the design consideration of corrugated fibre board boxes, has suggested the most economical proportions that the length should be twice the width and height should be equal to the length, to accommodate the given amount of space using the least amount of board. This design has the further advantage of interlocking in a stack to form more stable pile by placing each box at right angles to the ones below it. A perfect cube is just about the poorest shape for warehousing because it can not be interlocked.

Anandswamy and Venkatsubbaiah (1976) studied the effects of wooden and corrugated shipping containers for export of coorg (Mandarin) oranges. A consignment of about 4 tonnes of coorg mandarin oranges, treated with fungicide wax was exported in the wooden boxes and another portion of 9 tonnes packed in corrugated boxes was exported from Chettalli (Coorg) to Singapore via Madras port. The entire consignment reached the destination in good condition thereby revealing the suitability of these containers developed by CFTRI for export of Coorg oranges.

Laul *et al*. (1976) had stated that in India, the spoilage in wooden cases in transport has been reported to be as high as 30 percent. The marketability of the fruits is also affected due to loss of moisture and texture resulting in overall financial losses to the grower.

The cushioning material used by them was news paper pads containing 50 g dry grass (tanas) to avoid fruit coming in direct contact with grass. News paper was also used as lining material for wooden case.

Fox (1978) established that the corrugated containers and the combined board from which it was constructed, are structures. They behave like any other structures. They obey the laws of mechanics. Their behaviour is predictable and they can be modeled mathematically. Another interesting result of their study was that the boxes when loaded internally fail in compression and not in tension. Bursting strength does not play an important role in evaluation of the ability of a container to withstand internal loading.

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Anonymous (1989) has conducted in transit trials during transportation of oranges packed in corrugated paper boxes and concluded that the corrugated paper boxes are an alternative to the traditional wooden boxes from both the cost and efficiency point of view. The box design selected in the trials was matching with the size of traditional wooden boxes. However, this size has to be modified. The size suggested is 480 x 350 x 350 mm. Boxes of this size will fit in the truck lengthwise and breadth wise, without leaving any room to cause shaking or vibrations inside. A size smaller than this is likely to escalate loading and unloading costs. The 5-ply (100 gsm and 120 gsm) and 7-ply (100 gsm) boards performed to satisfaction. However, further strength is to be imparted by using higher grade paper.

2.1.3.1 Transport

The physiological consideration in the aspect of transport is that how best the physiological processes of senescence, moisture loss are arrested in the fruits during transit. Sophestication of transport system comes when the fruit has to be transported over a long distance. In case of short distance transport, the means of transportation could be rail or road. To avoid injury to the fruits during road transport, padded trucks are better. If it is a long distance transport and the bulk is small, the cargo lifting is possible otherwise the refrigerated carriers, whether ship or wagon are preferred (Pantastico, 1975).

2.1.3.2 Storage

Citrus fruits can be stored for a longer period of time. They are sorted at the period of their peak harvest and released slowly in the market when the harvesting period finished. Storage operation attempts to provide all possible artificial storage conditions to prolong the usability of the product. The popular types of artificial storage for citrus are : (1) Cold storage (2) controlled atmosphere storage (Pantastico, 1975).

2.1.3.2.1 Cold Storage

In cold storage both the temperature and humidity are controlled. The temperature is reduced and the humidity is increased. Low temperatures will retard the rate of respiration while high humidity check the transpiration. Thus both these put together prolong the storage life of citrus fruits.

Table : Recommended cold storage conditions for different citrus fruits

Variety / type	Temp. ^{0}F	RH %	Storage life in weeks	Weight loss %
Calamondin	48-50	90	2	6.5
Coorg mandarin	42-45	85-90	8	13.0
Valencia orange	40-43	88-92	5-6	12.0
Sathgudi orange	42-45	85-90	16	15.0
Lime, yellow	52-55	85-90	8	15.0
Lime, green	52-55	85-90	7	18.0
Lemon	42-45	85-90	6	-
Grape fruit	42-45	85-90	8-12	--
Pomello	45-48	85-90	12	--

(Pantastico, 1975)

2.1.3.2.2 Controlled atmosphere (CA) storage

Technically, CA implies addition or removal of gases resulting in an atmospheric composition substantially different from that of normal air. However, in common usage CA is used to denote the increased CO_2, decreased O_2 and high N_2 levels as compared with normal atmosphere. The metabolic effects of CA are the retarded rate of respiration by which the storage life of fruit is increased.

Reports on CA storage of citrus fruits are conflicting. South African Naval oranges stored in the atmosphere containing 8 percent O_2 and 12 per cent CO_2 developed off flavours and the rind was damaged (Barker, 1928).

Similarly oranges is an atmosphere of 5 percent O_2 and 10 percent CO_2 developed off flavours and fruit injury (Huelin, 1942). Increasing concentrations of CO_2 were associated with increasing decay of citrus fruits (Salama *et al.*, 1965).

Rind injury to grape fruit was caused by long exposure to high concentrations of CO_2 (Hatton *et al.*, 1972). In severe cases the rind was water soaked, while in mild cases it turned brownish red in colour accompanied by prominent oil glands. The ethanol content of grape fruit was found to increase with concentration and duration of exposure to CO_2 (Davis, 1972).

CO_2 delayed degreening in lemons. Increased CO_2 and reduced O_2 concentrations retarded the rate of colour change from green to yellow (Grierson *et al.*, 1966). A combination of 5 percent O_2 and 7 percent CO_2 was found best in prolonging the storage life of Tahiti limes, but considering the increased decay, incidence of rind scale and reduced juice content the use of CA storage for limes was not favoured by Hatton and Reeder (1968).

Regardless of the reports concerning the adverse effects of CA storage on citrus, many accounts indicate beneficial results. Florida pineapple oranges have been reported to keep in a marketable condition for five months in an atmosphere of 14.2 percent O_2 and 7.3 percent CO_2 (Stahl and Cain, 1937). Valenica oranges held at 15 percent O_2 plus 0 percent CO_2 for 12 weeks at 34^0F plus one week at 70^0F had a higher flavour rating than similar fruit held in other CA or air (Chace, 1969). A concentration of 10 percent CO_2 was shown to reduce low temperature pitting of Marsh grape fruit (Vakis *et al.*, 1970).

In view of these conflicting reports it is concluded that CA requirements for different citrus types differ, and the citrus fruits in general are very sensitive to CA storage. Hence, CA conditions have to be standardized for different varieties grown under different agro-climatic conditions.

2.1.3.2.3 Ventilation

Lloyd *et al.* (1979) studied the fruit physiology and stated that the fruit after harvest continues to carry on the most of the life processes that were predominent just before harvest. They respire and in doing so use up oxygen, give off carbon dioxide and generate heat.

Table : Respiration rate of orange at different temperatures of storage

Temp. ^{0}C	Respiration rate mg CO_2/kg/hr	*Vital heat Kcal/ 1000 kg/24 hr
0	02-05	122.40 – 306.00
5	04-07	244.80 – 428.40
10	11	673.20
15	13-24	795.60-1468.80
20	23-34	1346.40-2080.80
25	25-40	1530.00-2448.00

* Vital heat ' 61.2 x Respiration rate

Pandeyet *al.* (1990) reported that three punches of 2.5 cm on all four sides are suggested for free circulation of air and moisture inside the corrugated orange packaging box. In traditional wooden boxes the battens on the side make about ½ cm to 1 cm channel in between two boxes, which help in air circulation. To match this, punches on four sides have been proposed as above.

2.1.4 Evaluation of fruit injuries

Roistacher *et al.* (1956) gave the method for detecting surface injuries to fruits occurring during harvesting, grading, packing and transport. They found that soaking fruits in a solution of 2, 3 , 5, triphenyl tetrazolium chloirde (TTC) aided in detection of surface lessions. The colourless TTC solution contacts living cells through the surface injuries and enzymatic reaction converts the TTC to an insoluble red formation. Thus a red halo appears around each injury making it easy to detect and count.

Grierson (1958) developed detector papers to locate areas of severe bruising occurring during loading and transportation. Release of peel oil alone or both peel oil and juice is detected by colour reactions of paper treated with phenolphthalein and oil soluble victoria blue. The reddish purple paper turns green when peel oil contacts it and blue when juice contacts it. Papers treated with alkaline, alcoholic, phenolphthalein were also discussed.

Eaks (1961) described simple methods to evaluate injury, from both newly developed and accepted handling practices, for citrus fruits. He found that the phenolphthalein reaction (2, 3, 5 triphenyl tertazolium chloride) is adequate i.e., the change from red to yellow with extruded peel oil from red to white with juice. Although the yellow spots from peel oil are not visible when juice is released the detection of extruded peel oil is of little consequence when the fruit is crushed enough to release the juice. Bruising damage was evaluated by determining the degree of stimulation in the respiratory rate of fruit.

Guillou and Richardson (1962) conducted laboratory tests with grape containers at Davis and emphasized the severe vibration injury possible to loose packed fruits.

O'Brien *et al.* (1973) observed that in bin depths of 24 inches or less, the percent of bruising is directly related to the percent of total amount of fruit that is in the top two layers. In bin over 24 inches deep additional factors yet unresolved are thought to be involved. Damage to fruit may be greater in lug boxes than in bins because of the greater proportions of fruits free to move.

They associated the damage with the acceleration levels experienced by the fruit. These accelerations generated at the road surface are transferred to the fruits through the truck chassis and suspension system.

Subramaniam (1965) analysed the transported fruits for reducing and non reducing sugar to know the damages during transport.

Fridley and Adrian (1966) found that the multiple impacts with less energy per impact caused the same injury as due to the fewer impacts with more energy per impact. Thus energy, at least when some minimum stress extended, is direct cause of injury.

Pictraw Chen and Squire (1971) reported that physical injuries to citrus fruits during harvesting and handling can generally be classified as internal injury or surface lesions. The major effect of these injuries are decrease in quality, impaired physical appearance and shorter storage life.

Schoort and Williams (1972) measured bruising in transport trials for apples and found that apples in tray packs suffered 10 % to 15 % bruising after a journey of 1600 km and six handling operations. Apples packed without cases received 15 % to 27 % for the same journey.

Chesson (1972) evaluated four infield handling and storge treatments for citrus. He had given the procedure for determining the rate of weight loss.

The determinations were made everyday for the first nine days after harvest and then every 2 – 3 days for the remainder of test. Explanatory test and results from Miller's work indicated that after the first nine days, the weight loss rate was quite constant. Each weighing interval was regarded as a drying period. The difference in weight loss (W_1-W_2) was calculated for each period.

To compare treatments where the fruit weights were different, the rate of weight loss becomes grams per 100 g – hr and is obtained by dividing the grams of weight loss per hour by the number of 100g units of fruits in the sample. For simplicity, the weight loss of sample at the end of drying period was used. The rate of weight loss (R) was determined by the following equation.

$$R = (W_1 - W_2) / T \times 1 / (W_2 / 100g) \times 100\ g$$

Where,

R = Rate of weight loss g per 100 g-hr.

T = length of period, hr

W_1 = Initial weight, g

W_2 = Final weight , g

The mean of the rate of the weight loss for replications was taken as the rate of weight loss for the treatment during that period and was assumed to be valid for the mid point the period only.

Laul *et al* (1976) studied the effect of treatments with fungicide and wax emulsion on storage behaviour of Nagpur Mandrin Oranges (Ambia) placed in ventilated wooden cases. He has also taken the weight loss as a criteria for accounting the spoilage.

Ghate and Harkare (1978) observed that percent weight loss was more in samples subjected to transportation test by bullock –cart than that for tractor trolley. It was found that the damages were observed at the bottom layer. Fruits subjected to transportation test by bullock cart showed comparatively more damages than tractor trolley. The oranges subjected to vibration test at 180 cycle / min for 1 hr. showed the maximum percent weight loss.

Holt *et al.* (1983) gave a plot of observations against time, showing how various management strategies could be assessed by comparing total deterioration against acceptable limits, thus forming a basis for management action either to sell or to introduce post harvest controls.

Malik *et al.* (1986) calculated the loss due to bruise and damages for all types of packages for all the consignments. He reported that the losses in wire bound wooden boxes were much less compared to the traditional wooden boxes. The loss in weight in transit was 10-35 % in wire bound wooden boxes, whereas it was 14 % in ordinary boxes. The loss due to damage was 8.16 % in wire bound wooden boxes. When the consignment reached Bangalore, the total loss worked out to be 18.15 % in wire bound wooden boxes and 30.71 % in ordinary boxes.

Pen *et al.* (1985) had given the classification analysis of good and bruised peeled apple tissue using optical reflectance. They stated that the browning which commenced within 5 min after bruising was 50 to 70 %, complete within 2 hours and progressed no further after 24 hours. The near infrared (2500 nm 700 nm) reflectance of bruise tissue (unpeled) was less than that for good tissue (unpeeled).

2.1.5 Post-harvest handling losses in citrus fruits

Rathnam and Nema (1967) estimated that losses in oranges under Jabalpur market conditions were to the tune of 14 to 23.2 percent. Biswas (1969) reported that post-harvest losses of oranges, ranged from 6-30.7 percent depending upon the mode of transport, transit time and season. The Directorate of Marketing and Inspection have put the transit losses of oranges at 8-28 percent depending upon mode of transport. Ramana *et al*. (1973) reported that there was a 30 percent overall loss in handling Coorg Mandarins. According to an estimate by US-AID project on post-harvest technology of Horticultural crops, nearly 8.5 percent of Coorg mandarins were sorted out during harvest, another 3.5 percent at wholesale level and further 3-5 percent at retail level. Post-harvest losses assessed in Nagpur mandarins transported to Delhi revealed that truck transport on average resulted in 20.9 percent loss of fruits, while rail transport resulted in 23.27 percent loss (Anon, 1990).

2.1.5.1 Physiological loss of weight

Awarh (1991) studied the effect of perforations of packing material on weight losses in orange fruit. Polyethylene packed fruits recorded lower losses in weight as compared to open mesh bags. Increasing perforations increased weight losses.

Ben Yehoshua *et al*. (1981) have stated that individual seal packaging of oranges can be a partial substitute for refrigeration as it inhibited weight loss more than cooling.

Passam and Blunden (1982) have reported that weight loss in West Indian limes was reduced by enclosure of fruits in polyethylene bags or by storage at high relative humidity.

Sadashivam *et al* (1972) have stated that sathgudi sweet orange fruits when packed with polyethylene films checked weight loss and extended shelf life by 21 days as compared with seven days for loose fruits.

Choudharia and Kumbhare (1979) reported that Sweet oranges (cv. unspecified) of uniform size, shape, colour and ripeness when packed in film packs (6 oranges / pack) using 100, 150, 200 or 300 gauge polyethylene with

0.2, 0.3 and 0.4 percent ventilation at 27^0C for five weeks recorded 50 percent loss in weight.

Pruthi *et al* (1984) analysed four commercial cultivars for physico-chemical composition. Recovery of juice, peel and pomace in malta oranges ranged from 50.8 to 55.4 percent, 23.2 to 30.9 percent and 13.6 to 22.1 percent, respectively.

Mollendorf *et al.* (1992) have stated that juice content tended to increase as the ripening increases. Similar trend was observed in Coorg mandarins by Angadi and Shantha Krishnamurthy (1992).

2.1.5.2 Titratable acidity

Bal and Chohan (1983) studied the quality of different sized kinnow mandarin oranges harvested at optimum maturity. Fruits harvested were graded according to size and quality. Titratable acidity decreased with increase in fruit size. Grade B fruits had higher juice content, TSS and ^{0}Brix / acidity.

2.2 MANGO

Mango is extensively used for processing into various products. The most important ripe mango products are mango squash, mango nectar, canned mango pulp and slices in syrup, mango cereal flakes and mango leather. Numerous varieties are available all over India, but only few varieties in each region are found to be most suitable for processing by various research workers. During the survey of literature large number of research papers, seminar proceedings and abstracts were scanned and only the relevant references are quoted under the following headings.

2.2.1 Morphological and Physico-chemical characteristics of Mango cultivars

Research studies done on some of these aspects are briefly reviewed here.

2.2.1.1 Weight of fruit

Nanjundaswamy *et al.* (1966a) while working on proximate composition and suitability for preservation of some important mango varieties grown in Salem, reported the average weight of fruit varied from 215 g (var. Varagambadi) to 380 g (var. Mulgoa).

Nanjundaswamy *et al.* (1966b) studied 13 important varieties of mango from Andhra Pradesh and recorded the average fruit weight 199 g (var. KO_{16}) to 525 g (var. Yerramulgoa).

Suryaprakash Rao *et al.* (1968) evaluated mango varieties of Andhra Pradesh for processing and reported the fruit weight 144 g to 450 g among 12 mango varieties.

While evaluating some mango varieties for processing into nectars, Roy *et al.* (1972) studied physico-chemical characters and stated that the average weight of Dashehari, Langra, Chausa and Bombay green varied from 150 g, 220 & 210 g and 150 g, respectively.

Satyavati *et al.* (1972) found the average weight of mango fruits ranging from 156 g to 301 g in seven different varieties from Kerala. According to Lodh *et al.* (1974) fruit weight varied from 209 g (Langra) to 622 g (Totapuri).

Singh and Tripathi (1974) worked on morphological and physico-chemical characteristics of mango cultivars and reported that average weight of fruit varied from 120 g (Rashu-E-Jahan) to 600 g (Langra Bengal).

Naik (1985) reported that the full grown Alphonso and Ratna Mango fruits had the average weight of 280 g and 403.8 g, respectively.

Bhuyan and Islam (1986) studied the physico-chemical characteristics of mango varieties at Nawabganj and reported that fruit weight varied from 202.8 g to 1014.4 g (Neelum) in different varieties of mango.

Khurdiya *et al.* (1988) recorded average fruit weight of 143.0 g (Amrapali), 155.0 g (Dasheri) and 120.0 g (Neelum) in different varieties of mango.

Prasad and Nalini (1988) investigated post harvest physiological changes and quality parameters in mango varieties and stated that cv. Bangalora had the highest fruit weight (315.0 g).

Reddy and Singh (1989) studied some polyembryonic varieties of mango for physico-chemical characteristics and reported that mean fruit weights varied from 113.0 g in Mylepelian to 411.30 in Kensington. Performance of some mango varieties produced in Chittagong was observed by Ahmed *et al.* (1989) and records show that the Cv. Kalia had highest fruit weight (214.8 g).

Badiyala and Awasthi (1990) evaluated twelve cultivars of mango and observed the fruit weight was significantly higher in Cv. Fazali.

2.2.1.2 Volume of Fruit

Palaniswamy *et al.* (1974b) studied the physico-chemical characteristics of 29 mango varieties grown in Tamil Nadu and reported that the volume of fruit varied from 88.7 ml to 650.4 ml.

The volume of Dashehari mango fruit changed from 133.8 ml to 195.5 ml at various stages of maturity (Garg *et al.*, 1975).

Yadav *et al.* (1984) recorded the average fruit weight of 185.50 g in variety Dashehari and 240.00 g in variety Langra.

Patil (1990) studied the physical characteristics of mango in cultivars Alphonso, Ratna, Pairi and Kesar and recorded the highest fruit volume in Ratna (357.60 ml) and lowest in Pairi (233.70 ml).

2.2.1.3 Specific Gravity

Harkness (1949) ; Harkness and Cobin (1950) reported that mango fruits of specific gravity less than 1.00 were definitely immature and failed to ripen after picking.

Specific gravity of the fruit can be considered a very good index for judging the maturity in mangoes (Popenoe, 1960 ; Teotia *et al.*, 1967, 1968).

Moti and Gangawar (1972) reported that the mature fruits of eleven promising sucking mango varieties exhibited specific gravity from 1.081 in Gilas to 1.019 in Kalapar.

Mann and Singh (1973) evaluated physical characters as measure of maturity for Dashehari and Langra cultivars of mango and reported a specific gravity of 1.008 or more for excellent palatability in Dashehari and 1.078 or more in Langra.

Prasad (1977) compared the bearing behaviour and fruit quality of South Indian and North Indian varieties and reported the specific gravity of 0.923 in Bangalora and 1.004 in Allampur Baneshan.

Physiological fruit maturity of Senstation and Zill varieties was attained when 15 per cent of the fruits sank in water (specific gravity 1.00) at 25^0C and that of cultivar Peach, when 53 per cent fruits sank in water (Anon, 1979).

Krishnamurthy (1980) studied the internal break down during ripening of Alphonso mango in relation to specific gravity of the fruit and concluded that the severity of damage was more in fruits of specific gravity 1.02 as compared to those of specific gravity 1.00 to 1.02.

Roy and Pandey (1983) while evaluating the existing method of harvesting of Dashehari mango, reported that the fruits with specific gravity more than 1.00 were physiologically mature.

Joshi and Roy (1985a) and Naik (1985) reported that nearly 80 per cent of the Alphonso mango fruits had attained specific gravity above 1.00 when the fruits from the tree were harvested after a few partially ripe fruits dropped naturally from the tree. The palatability of the fruits increased with increase in specific gravity, the fruits with specific gravity 1.02 to 1.04 were most palatable.

Tandon and Kalra (1986) conducted studies on developing of mango fruit to assess maturity and found that specific gravity changed from 0.968 (47 days after fruit set) to 1.015 (93 days after fruit set) in Cv. Langra while in

Mallika it ranged from 0.963 (47 days after fruit set) to 1.049 (119 days after fruit set).

Tandon and Kalra (1988) studied the ripening pattern of specific gravity graded Dashehari mangoes and concluded that Gr. I (Specific gravity < 1.0) fruits ripened with better quality and shelf life and retained freshness even after 11 days of storage.

Roy and Joshi (1988) categorised Alphonso mango fruits into 4 specific gravity groups namely specific gravity < 1, 1-1.0, 1.02-1.04 and > 1.04 and indicated that the fruits having specific gravity 1.02 to 1.04 could be considered the best for the subsequent marketing and storage.

2.2.1.4 Size of the fruit (Length and breadth)

Nanjundaswamy *et al.* (1966b) worked on 13 important mango varieties and reported that the average length of fruit varied from 7.6 cm to 11.0 cm while the diameter ranged from 5.9 to 10.0 cm.

Lodh *et al.* (1974) studied physico-chemical constituents of 8 important mango varieties and stated that average length of fruit ranged from 10.06 cm to 14.52 cm while the average fruit diameter varied from 5.96 cm to 9.31 cm.

Sadhu and Bose (1976) studied some promising mango varieties of West Bengal and reported that length of fruit varied from 7.3 cm to 12.6 cm while the major diameter and minor diameter ranged from 4.5 cm to 8.3 cm and 4.3 cm to 7.2 cm, respectively.

Awasthi and Pandey (1979) studied four cultivars of mango viz., Gilas, Lucknow Safeda, Sukul and Yakuti and recorded the length 5.80 cm, 7.54 cm, 10.44 cm, 6.03 cm with corresponding diameter 5.20 cm, 4.73 cm , 6.45 cm and 4.14 cm , respectively.

Limaye *et al.* (1984) reported that 'Ratna' mango fruit has average length of 10.69 cm and breadth of 8.36 cm. Ghosh *et al.* (1985) reported that among 10 mango varieties, the length of fruit ranged from 7.1 cm to 10.7 cm while diameter varied from 5.3 cm to 8.7 cm.

Fruit characteristics of different polyembryonic varieties were studied by Reddy and Singh (1989) and they reported average fruit length of 6.79 cm to 10.89 cm and diameter of 5.81 cm to 9.17 cm.

Badiyala and Awasthi (1990) recorded significantly higher length (14.56 cm) in Cv. Fazri, whereas diameter was higehst (8.06 cm) in Cv. Mallika.

2.2.1.5 Colour of the peel and pulp

Four different stages of maturity, termed as stage A, B, C and D have been worked out in relation to size, shape and colour of the fruit in Alphonso mango (Cheema and Dani, 1934 ; Joshi, 1975). The fruits of stage A have their shoulders in line with the stem end and skin is olive-green. It has been noticed that the fruits at this stage do not develop rich flavour. At stage B fruits have their shoulders out grown from the stem-end and are olive green. Fruits at this stage of maturity are best suited for export. At stage C, the shoulders outgrown the stemend and colour lightness towards yellow. The fruits at stage D are tree ripe with typical blush developed on the skin.

Cobin (1949) suggested that the Haden mango was ready for harvest after the ground colour changes from green to yellow.

Nanjundaswamy *et al.* (1966b) studied 13 mango varieties and observed that the fruits had yellow, yellow with slight green patches, yellow with cherry red patches and green colour varying from variety to variety.

Krishnamurthy and Subramanyam (1970) studied the parameters for optimum maturity of 'Pairi' mango and found olive green surface as an index for harvest of that variety.

Srinivasan and Shanmugavelu (1971) gave the Proximate composition of certain off season mango varieties of Tamil Nadu and revealed that Alphonso, Kalepad, Nadan, Rumani, Vasanjathi and Athimathuram exhibited cadmium orange colour. Saffron yellow in Neelum while the other varieties from lemon to Aureolin yellow colour at full ripening.

Jacob (1972) reported flesh colour as a good parameter for judging maturity of South African mangoes. Maturity was indicated by colour change of the flesh from white to yellow starting from the stem end point.

Awasthi and Pande (1979) screened four mango varieties for juice production and recorded the colour of juice as orange cadmium, apricot, lemon yellow and yellow in Gilas, Lucknow safeda, Sukul and Yakuti mango varieties, respectively.

Thomas and Oke (1983) studied on improvement in quality and storage of Alphonso mangoes by cold adaptation ripening and listed orange yellow with green spot and orange yellow colours of skin.

Patil (1990) observed light green colour of the Alphonso fruit at harvest while golden yellow at ripe stage.

2.2.1.6. Firmness of Fruit

Garg *et al.* (1975) recorded pressure of unripe fruits of Cv. Dashehari as 20.4 to 15.7 lbs/cm2 at various stages of maturity.

Chikkasubbanna and Huddar (1982) worked on ripening of Alphonso mangoes for processing and recorded the rupture force of 8.63, 5.62, 1.86 and 1.02 kg./cm^2 at 0, 4, 8 and 10 days of mango storage.

Kalra and Tandon (1983 a,b) reported the pulp pressure of 7.30 lbs /in^2 Mallika and > 4.4 KPa in Dashehari varieties of mango.

Verma *et al.* (1986) showed the pressure meter reading (PSI) of Dashehari mango varied form 22.00 to 5.00 pounds per square inch at different sampling dates.

Medlicott *et al.* (1988) studied pulp rupture force at three stages of maturity and reported 10.26, 10.30 and 10.81 kgf in Tommy Atkins mangoes at mature, half mature and immature stages.

Sahni and Khurdiya (1989a) noticed that the pressure of fruit decreased during ripening, initially maximum in 'Chausa' (27.5 PSI) followed by 'Neelum' (26 PSI) ' Dashehari' (20 PSI) and minimum in 'Amrapali' (14.2 PSI).

Medlicott *et al.* (1990) studied the ripeness characteristics of mature Tommy Atkins mangoes and recorded pulp rupture force of 8.28 kgf at harvest.

2.2.1.7 Weight of pulp, stone and peel

Nanjundaswamy *et al.* (1966 b), studied 13 mango varieties and reported that the percentage of pulp, stone and peel ranged from 59.4 per cent to 76.6 per cent, 9.3 per cent to 23.0 per cent and 10.7 per cent to 20.6 per cent, respectively.

According to Teotia and Awasthi (1966), the yield of slices varied form 43.5 per cent to 65.0 per cent, stone from 21.3 per cent to 32.5 per cent and peel from 13.3 per cent to 24.5 per cent among 13 mango varieties.

Suryaprakash Rao *et al.* (1968) showed that, among twelve mango varieties, the percentage of total edible portion, stone and peel varied from 57.6 per cent to 79.8 per cent, 10 per cent to 25.3 per cent and 9.7 to 20.0 per cent, respectively.

Roy *et al.* (1972) studied Dashehari, Langra, Chausa and Bombay green varieties of mango and reported that Chausa produced maximum edible part (67.6 per cent) followed by Langra and Dashehari, while Bombay green produced minimum (55.7 per cent). The less pulp yield of Bombay green could be attributed to its high stone (22.7 per cent) and peel (21.8 per cent) content.

Physico-chemical composition of different varieties of mango was observed by Satyavati *et al.* (1972) and recorded that the yield of slices varied from 52.6 to 66.7 percent. The percentage of slices was highest in Cripe. The percentage peel varied from 13.7 (Cripe) to 19.3 (Olour) and of stone from 19.6 (Cripe) to 32.1 (Sundri).

Palaniswamy *et al.* (1974b) reported that among 29 mango varieties, the weight of pulp, skin and stone ranged from 62.7 g to 429.5 g, 19.8 g to 111.6 g and 22.2 g to 153.3 g , respectively.

Shukla and Bajpai (1978) recorded variation in some quality parameter of Dashehari fruit and reported 9.60 to 10.05 per cent, 75.58 to 73.25 per cent and 16.70 to 18.06 in peel, pulp and stone percentage after 76 to 100 days after fruit set, respectively.

Kulkarni and Rameshwar (1981) recorded the maximum pulp content (81.0 per cent) in 'Vanaraj' and the minimum (62.5 per cent) in 'Chinnarasam' varieties of mango. The percentage of peel and stone ranged from 6.8 to 19.3 and 9.4 to 21.9, respectively.

Hernandez *et al.* (1982) reported that 65.03 to 73.23 per cent pulp recovery was obtained from fruits of mango cultivars, Irwin, Edwin, Palmer and Keitt.

Different polyembryonic varieties of mango at ripe stage were examined by Reddy and Singh (1989) and recorded that the weight of pulp, stone and peel varied from 49.10g to 276.34 g, 18.80g to 55.0 g and 36.04 g to 90.80 g, respectively.

Badiyala and Awasthi (1990) evaluated some mango cultviars of Kangra valley and stated the highest (20.90 g) stone weight in cultivar S.B. Rampur and the lowest (10.50 g) in S.B. Chausa.

2.2.1.8 Pulp to stone ratio

Garg *et al.* (1975) reported that the pulp : (peel + stone) ratio of unripe fresh Dashehari mango fruits varied from 1.15 : 1 to 2.18 : 1 at various stages of maturity.

Syamal and Mishra (1987) analysed some important mango varietis from physico-chemical parameters and recorded the highest pulp to stone ratio (7.15) in variety Langra.

Reddy and Singh (1989) studied some polyembryonic varieties of mango for physical characteristics and reported that the pulp ; stone ratio of the fruit at ripe stage varied from 1.68 (starch) to 6.34 (Kensignton).

Patil (1990) observed highest pulp to stone ratio (5.90 :) in variety Ratna and lowest (3.62 : 1) in Pairi mango fruits.

2.2.1.9 Size of stone (Length and Breadth)

Sadhu and Bose (1976) studied the morphological and physico-chemical characters of some mango varieties and reported that the length of stone ranged from 5.9 cm to 10.2 cm. However, the major and minor diameter of stone varied from 2.3 cm to 4.8 cm and from 1.6 cm to 3.0 cm, respectvely.

Ghosh *et al.* (1985) recorded the maximum stone length (8.0 cm) in Bombay green and minimum (5.2 cm) in Sardamani Bhog variety of mango. The variety Bombay yellow exhibited the highest stone diameter of 4.2 cm and it was least (3.0 cm) in Meghlantan and Piarafully varieties.

Naik (1985) recorded the length of stone of full grown Alphonso and Ratna fruits as 7.88 cm and 7.8 cm, respectively and the width as 3.80 cm and 4.15 cm, respectively

Physical characteristics of mango Cvs. Alphonso, Kesar, Pairi and Hyb. Ratna fruits at harvest and on ripening were studied by Patil (1990). The highest length of 11.40 cm and lowest length of 7.29 cm was observed in Kesar and Pairi varieties, respectively. Breadth of the stone between shoulders was found to be maximum in Pairi (4.12 cm) and minimum in Alphonso (3.92 cm) and between cheeks maximum in Pairi (2.07 cm) and minimum in Ratna (1.21 cm) fruits, respectively.

2.2.2 Chemical Composition of Mango fruits

2.2.2.1 Moisture

Laxminarayana *et al.* (1970) reported that mature green fruits of Alphonso were characterised by 80 per cent moisture at harvest.

Ripe fruits of Dashehari, Langra, Chausa and Bombay green varieties of mango exhibited 75.60, 76.20, 74.90 and 75.90 per cent moisture content, respectively (Roy *et al.*, 1972). According to Satyavati *et al.* (1972) moisture content of different mango varieties varied from 73.02 per cent to 85.90 per cent.

Kalra (1982) studied some physical-chemical parameters during storage of mango pulp and reported moisture per cent of 76.53, 78.86 and 78.19 in Dashehari, Langra and Chausa varieties, respectively.

Tandon and Kalra (1983) reported that there was a decrease in moisture content from 88.5 to 76.7 per cent in Dashehari variety except for a slight increase at initial stages of fruit growth.

Patil (1990) studied the composition of four mango varieties and reported that moisture content varied from 82.40 to 86.50 per cent at harvest and 79.40 to 83.24 per cent on ripening.

2.2.2.2 Total soluble solids

Soule and Hatton (1955) found that the total soluble solids content of mature fruits of Irwin, Haden, Sensation, Zill, Keitt and Kent mangoes ranged from 7.2 to 10.4 per cent.

In Egypt, El-Azzouni and Salama (1956) noted the mature fruits of mango cultivars Hindi Pairi and Mabrouka contained 9.8 and 8.5 per cent of total soluble solids, respectively.

Teotia and Awasthi (1966) analysed the ripe fruits of some varieties of mango and observed the variation in total soluble solids between 16.8^0 Brix and 23.45^0 Brix, the maximum being in Chausa and Minimum in Mithwa Malda.

Srinivasan and Shanmugavelu (1971) studied the quantitative variation in the proximate composition of different off season mango varieties and endorsed that total soluble solids content was maximum in Kalepad and Alphonso (23 to 24 per cent) and the minimum being with Athimathuram and Mudappa (11 to 12 per cent).

Awasthi and Pandey (1980) observed that the total soluble solids content of ripe mango fruits of different varieties ranged between 15.81 to 21.74^0 Brix.

Kalra *et al.* (1981) evaluated some mango cultivars on the basis of their biochemical composition and reported that total soluble solids content ranged from 12.0 to 25.5^0 Brix among 16 cultivars.

Roy and Biswas (1981) studied maturity standards of mango Cv. Bombay and inferred that the total soluble solids content varied from 8.00 to 17.00^0 Brix at 75 to 111 days after fruit set, respectively.

Prasad (1984) recorded maximum TSS of 20.55^0 Brix in Mulgao. Upadhyay and Tripathi (1984) studied the performance of some Baramasi mango varieties and stated the highest TSS (20.40^0 Brix) in Baramasi Mahso while the lowest (13.00^0 Brix) in Baramasi Bahua.

Godoy and Rodrignez (1989) analysed 5 cultivars from Brazil and reported that TSS from ranged 14.5 to 24.5^0 Brix.

Patil (1990) noticed that soluble solids ranged from 8.2 to 10.3^0 Brix at harvest and 18.0 to 22.5^0 Brix on ripening in four different varieties of mango.

2.2.2.3 Titratable acidity

Teotia *et al.* (1968) worked on maturity standard for Cv. Langra and opined that acidity per cent varied from 1.99 to 0.90 in unripe fruits and 0.24 to 0.41 per cent in ripe fruits at various stages of picking.

Kapur (1974) recorded 0.32, 0.46 and 0.15 per cent acidity in Dashehari, Safeda and Samar Bahisht varieties of mango at full ripe stage.

Pandey *et al.* (1974) reported that Dashehari fruits recorded 0.63 per cent titratable acidity (as malic acid) at the stage of maturity.

Rangwala (1975) stated that Alphonso fruits at 'A' and 'C' stages of maturity were characterised by 3.961 and 3.261 per cent acidity, respectively at harvest.

Patil (1990) observed 3.52, 1.33, 3.60 and 1.40 per cent titratable acidity in Alphonso, Ratna, Pairi and Kesar varieties of mango at harvest while 0.40, 0.17, 0.51 and 0.26 per cent in ripe fruits of these varieties, respectively.

2.2.2.4 Sugars

According to Krishnamurthy *et al.* (1960) the mature green fruits of Badami, Raspuri and Neelum exhibited 3.09, 2.33 and 5.90 per cent total sugars, respectively.

Teotia and Awasthi (1966) reported that the percentage of total sugar was quite high in all the mango varieties studied and ranged from 11.2 to 19.8 per cent. The reducing sugars ranged from 2.5 to 9.5 per cnet.

De and Debnath (1966) reported an increase from 0.48 to 2.60 per cent in sugars (all nearly reducing sugars) in Kachmitha variety of mango during maturation.

Krishnamurthy and Subramanyam (1970) reported that the Pairi fruits at optimum state of maturity exhibited 1.7, 0.2 and 1.9 per cent reducing sugars, sucrose and total sugar, respectively.

Pande *et al.* (1973) recorded 0.002 to 3.58 per cent reducing sugar and 0.005 to 22.82 per cent total sugar from pea stage to ripe stage, respectively of Dashehari mango.

Palaniswamy *et al.* (1974 b) observed the range of reducing the total sugars contents of different mango varieties between 2.25 to 6.40 per cent and 7.09 to 17.20 per cent, respectively.

Baldry *et al.* (1976) noticed 3.0 per cent reducing and 14.8 per cent total sugars in fresh fruit slices of mango.

Dabhade and Khedkar (1980 a,b) observed the higher percentage of reducing sugars in pairi followed by Totatpuri, Seedling I and Seedling II at harvest matuirty. Total sugar increased upto 4th, 5th, 7th and 8th week after fruit set in Pairi, Seedling I and Seedling II.

Kalra *et al.* (1982) reported per cent reducing sugars varied from 1.85 to 6.90 among 20 different mango varieties.

Prasad (1984) studied biochemical aspects of mango and found highest percentage of reducing sugars in varieties Alphonso (10.10 %) followed by Alampur (9.51 %) and least in Bhandauran (4.81 %).

Joshi and Roy (1985a) recorded 3.4 per cent and 14.5 per cent of reducing and total sugars, respectively in Alphonso mango fruits with 1.02 to 1.04 specific gravity group.

Syamal and Mishra (1987) analysed ten important mango varieties of Bihar and reported highest reducing sugars in variety Langra (5.82 %) and lowest in Sukul (3.26 %).

Ahmed *et al.* (1989) studied the performance of some mango varieties and reported highest percentage of total sugars in Cv. Kalia (20.30 %).

Changes in chemical composition of Alphonso, Ratna, Pairi and Kesar varieties of mango were studied by Patil (1990). He reported maximum reducing sugars (3.35 %) in Kesar and minimum in Pairi (1.34 %). While highest total sugars (4.98 %) in Ratna and lowest (3.95 %) in Pairi varieties at harvest were recorded.

2.2.2.5 pH

The green mature fruits of Badami, Raspuri and Neelum were characterised by pH value of 2.68, 2.64 and 3.06, respectively (Krishnamurthy *et al.*, 1960) while those of Dashehari by 4.0 pH (Agnihotri *et al.*,1963).

Krishnamurthy and Subrmanyam (1970) reported that Pairi fruits at optimum stage (II stage) of maturity recorded 1.9 pH.

Awasthi and Pande (1979) reported that fruits of Gillas, Luckow Safeda, Sukul and Yakuti mangoes, expressed the pH value 4.6, 4.4, 4.2 and 4.3, respectively.

Joshi (1983) observed that pH of mature Alphonso fruits was 2.85 while Gole (1986) reported that all full grown stage, seedling mango recorded maximum pH (2.6) followed by Alphonso (25) and Pairi (2.4).

Godoy and Rodrignez (1989) reported that pH values varied from 3.9 to 4.2 between extreme and Haden mango cultivars.

2.2.2.6 Ascorbic acid

Teotia *et al*. (1968) observed the highest ascorbic acid content (110.0 nmg/100g) in Langra Banaras and the lowest (8.9 mg/100 g) in Kaithki Bihar and Mahmudal Samar varieties of mango.

Roy *et al*. (1972) reported that Dashehari, Langra, Chausa and Bombay green mango varieties exhibited 15.0, 95.0, 8.0 and 2.0 mg/100g ascorbic acid, respectively at ripening.

Samad *et al*. (1975) compared data for biochemical analysis and reported range of 12.91 to 28.08 mg/100 g ascorbic acid in Dashehari and Koapahari cultivars of mango.

Thomas (1975) reported 88.0 mg/100 g vitamin C content in hard green, unripe Alphonso fruits.

Morga *et al.* (1979) worked on Physico-chemical characteristic of Carbao mangoes and reported 35.11 mg/100g ascorbic acid in ripe fruits.

Mukherjee and Tiwari (1979) studied ascorbic acid concentration in mango at marble, stone and post harvest stage in cultivar Langra. Ascorbic acid varied from 121 to 186 mg/100 g while in Dashehari 68 to 161 mg/100 g at stone stage.

Thomas and Oke (1980) reported that pulp of mature unripe fruits of Alphonso, Dashehari, Langra and Pairi cultivars exhibited Vit. C content as 89 to 103, 30.00 , 114 to 143 and 41.00 mg/100 g, respectively.

Patil (1990) reported highest ascorbic acid content of 81.50 mg/100g and 61.15 mg/100 g in Alphonso mango at harvest and on ripening.

2.2.2.7 Carotenoid pigments

Chaudhary (1950) studied on carotenoid pigments of different mango varieties during ripening and reported 13.00 μg/100 g carotenoids in variety Banarasi Langra.

Jacob *et al.* (1970) observed carotenoids at 3 stages of ripening of mango, phytofulence (39.25 %) constituted the majority in partially ripe mango, β-carotene constituted the majority in unripe (37.47 %) and fully ripe mango (50.64 %).

Roy (1973) showed a simple and rapid method for estimation of total carotenoid pigments in mango and recorded 6885, 4187, 3216, 8352 and 2439 μg/100g in Dashehari, Langra, Chausa, Bombay green and Safeda varieties of mango, respectively.

Mann *et al.* (1974) recorded a large and rapid increase in carotenoid content of Dashehari (to over 4000 μg/100g) and Langra (3000 μg/100g) in last week of picking and reported it as a good index of maturity.

Naik (1985) reported that the full grown mature Alphonso and Ratna mango fruits contined 280 and 460 μg/100g β-carotenoid, respectively.

Majumdar and Sharma (1986) expressed β-carotenoids in Mallika, Amrapali, Neelum and Dashehari as 10392, 16830, 5275 and 7452 μg/100g, respectively.

Verma *et al.* (1986) studied development of carotenoids during ripening of Dashehari mangoes and recorded 1.60 to 7.90 mg/ 100g pulp at different sampling dates.

Godoy and Rodrignez (1989) worked on carotenoid composition of commercial mangoes from Brazil and reported highest β-carotene and total carotene (2545 and 3043 μg/100g, respectively) in Extreme cultivar.

Patil (1990) expressed highest β-carotene in Alphonso (11222 μg/100g) and lowest in Ratna (10003 μg/100g) on ripening while highest β-carotene of 462 μg/100g and lowest 295 μg/100g in Pairi varieties was recorded at harvest.

2.2.3 Preparation, Processing and Evaluation of mango products

2.2.3.1 Mango squash

Satyavathi *et al.* (1972) examined the suitability of different varieties of mango of Kerala for processing squash prepared by the conventional method maintaining 25 per cent juice, 45^0 Brix, 0.8 per cent acidity and 350 ppm SO_2

Among different varieties, Olour ranked best followed by Neelum and Priyor for the preparation of squash.

Palaniswamy *et al.* (1974a) prepared the mango squash from different varieties as per the procedure recommended by Giridhari Lal *et al.* (1960) and reported maximum score in Alphonso (72.9) and Olour (72.8) and was classified as very good. The varieties K 0.8, Khudadad, Neelum, Peter, Rasam and Surangadi were classified as 'Good', Eruwadi, Rumani and Bangalora scored less than 60 and were found not suitable.

Kalra and Tandon (1986) opined that 25 per cent mango pulp would be insufficient for mango squash to provide good mango beverage with desired consistency, flavour and appearance.

2.2.3.2 Canned Mango Slices

Siddappa and Bhatia (1955) studied the effect of retention of peel on the quality of canned mango slices with 40^0 Brix syrup and concluded Badami, Neelum and Mulgoa are good varieties for canning.

Bose and Das (1958) studied the varietal suitability of fruits for preservation by canning and reported Himsagar as best variety. Langra was also found to be satisfactory but stored for only 5 months and Fazli was found to be unsatisfactory.

Teotia and Awasthi (1966) worked on varietal suitability of mango for canning with 40^0 Brix syrup strength and observed Dashehari to be the best among all the mango varieties tried for canning in respect of flavour, colour and texture.

Nanjundaswamy *et al.* (1966 a) canned 5 mango varieties with covering syrup of 40^0 Brix containing 0.25 per cent citric acid and found Badami the best followed by Varagambadi Gundu while Valaja was not suitable because of brownish discolouration of slices.

Suryaprakash Rao *et al.* (1968) evaluated mango varieties of Andhra Pradesh for processing as slices with 35^0 Brix syrup and 0.3 per cent citric acid and indicated that of the five commercial table varieties, Baneshan and Khader were satisfactory.

Satyavathi *et al.* (1972) studied the suitability of different varieties of mango with 40^0 Brix syrup and 0.25 per cent citric acid. They reported that Priyor and Neelum varieties were the best, followed by Sundri and Cripe. Muvandon and Olour varieties with high fibre content were found to be unfit for canning. Palaniwasy *et al.* (1973a) have also worked with similar covering syrup strength and acidity per cent for different varieties of Tamil Nadu for canning.

Adsule and Roy (1975) reported that the commercial Cv. Dashehari scored highest organoleptic score as a processing cultivar followed in order by the North Indian Cv. Langra.

Saha *et al.* (1976) processed Cv. Dashehari as canned slices in 35^0 Brix syrup and 0.25 per cent citric acid.

Awasthi and Pandey(1980) indicated variety Safeda Malihabad as the best variety for canning followed by Anopan. Krishnamurthy *et al.* (1984) suggested of 9 table, 4 juicy and 5 hybrid cultivars of mango, Baneshan, Survarnarekha and 5/5 Rajapur x Langra were the most suitable for canning as slices.

Khurdiya and Roy (1986) investigated on canning of mango slices in covering syrup containing mango pulp. It was observed that addition of 15 per cent pulp with 0.3 per cent citric acid scored the highest (6.5) and 40^0 Brix plain syrup with 0.3 per cent citric acid the lowest (5.0) score.

Dan *et al.* (1988) studied suitability of some mango hybrids for processing as canned slices and followed syrup strength of 40^0 Brix with 0.3 per cent citric acid and reported Banganapalli x Alphonso hybrid as promising.

Khurdiya and Roy (1988) observed the processing quality of mango hybrids developed at IARI and it was found that Mallika was the best followed by Amrapali and Dashehari for canning, based on colour, flavour and texture.

2.2.4 Changes in Chemical Composition of Mango product during storage

Patil (1990) recorded increased TSS content of 45.00 to 49.0^0 Brix, reducing sugars from 0.51 to 33.72 per cent ; total sugars 40.04 to 44.96 per cent ; titratable acidity 0.80 to 0.90 per cent ; pH 3.15 to 3.80 and decreased ascorbic acid content from 15.26 to 7.22 mg /100g pulp during 9 months of storage.

2.2.4.1 Canned Mango Slices

Teotia and Awasthi (1966) reported 16.80 to 23.48^0 Brix, 2.5 to 9.5 per cent reducing sugar, 11.2 to 19.3 per cent total sugars, 0.215 to 1.02 per cent acidity and 15.2 to 72.1 sugar acid ratio at initial stages of canning while at 6 months of storage it ranged from 20.52 to 28.52^0 Brix, 5.89 to 18.46 per cent reducing sugars, 17.61 to 25.10 per cent total sugars, 0.176 to 0.711 per cent acidity and 3.0 to 5.2 mg / 100g ascorbic acid. It was also reported that vacuum of the cans varied from 10.5 to 12.0 inches while per cent drained weight of slices ranged from 47.5 to 58.5 .

Suryaprakash Rao *et al.* (1968) evaluated mango varieties of Andhra Pradesh for processing as slices and found that TSS varied from 15 to 37.5^0 Brix, pH ranged from 2.95 to 3.6. Titratable acidity of slices was observed to be 0.32 to 0.81 per cent. Ascorbic acid in slices varied from 6.0 to 33.6 mg/100g and in syrup 3.1 to 29.8 mg/100g after nine months of storage. The vacuum and drained weight was observed to be 11 to 15 inches and 57.0 to 82.6 per cent, respectively.

Mehta *et al.* (1971) reported vacuum in Gaurjeet mangoes varied from 12 to 10 lb/sq inch, head space 0.8 to 0.9 cm, pH 3.8 to 3.7, TSS 16.0 to 17.0^0 Brix, acidity 0.2 to 0.3 per cent, reducing sugars 5.1 to 5.8 per cent ascorbic acid 12.5 to 10.0 mg/100g after 6 months of storage.

Satyavati *et al.* (1972) studied different varieties of mango for processing and observed that TSS varied from 17 to 27^0 Brix, acidity 0.26 to 0.64 per cent among different varieties when canned as slices. It was found that Priyor and Neelum varieties to be the best for canning followed by Sundri and Cripe. Priyor and Neelum varieties has a low fibre content (0.35 per cent and 0.48 per cent, respectively) and the canned slices were firm in texture. The Muvandaon, Sundri and Olour varieties with high fibre content (0.96 per cent, 0.56 per cent and 0.7 per cent, respectively) were found to be unfit for canning. Among different varieties vacuum varied from 11 to 12 inches, head space was observed to be 4/16 inches to 5/16 inches and drained weight 68.5 to 74.5 per cent.

Palaniswamy *et al* (1973a) recorded 9 to 20 lb/sq., 54.7 to 70.7 per cent vacuum and drained weight of slices, respectively. During storage TSS was maintained while acidity of the canned slices showed increase (0.32 to 0.512 per cent). Similarly, the reducing sugars content also showed increase and the maximum being with Kalepad (15.65 per cent). Total sugar content was noticed high in Neelum (25.0 per cent). Total sugar / acid ratio was found to be highest (52.6 : 1) in variety Rumani. In respect of ascorbic acid, maximum (6.96 mg/100g) was observed in Rasam followed by Khudaded, Mulgoa, Kalepad and Jehangir. But the ascorbic acid content was much reduced in all the varieties canned.

Cut-out data of canned mango varieties after six months of storage on vacuum, drained weight per cent, TSS, reducing and total sugars, acidity per cent and ascorbic acid and found to be 12 to 13 inches, 56.5 to 57.9 per cent, 25.8 to 27.3^0 Brix, 11.6 to 17.1 per cent, 19.8 to 23.5 per cent, 0.234 to 0.462 per cent and 4.0 to 42.4 mg/100 g, respectively (Awasthi and Pande, 1980).

Khurdiya and Roy (1986) analysed canned Dashehari mango at 9 months of storage and reported that the vacuum varied from 8 to 9 inches, head space 8 – 11 mm, drained weight 47.1 to 55.8 per cent, TSS (^{0}Brix) of slices 19.3 to 29.4 and syrup 19.3 to 33.4^0 Brix. Per cent acidity and pH of slices and syrup varied from 0.21, 3.95 and 0.20, 3.95, respectively.

AmbaDan *et al.* (1988) evaluated three mango varieties and reported highest drained weight (533 g) in Alphonso, acidity varied from 6.88 to 6.69 per cent. Lowest carotenoids (625 μg/ 100g) were recorded in Alphonso variety.

Khurdiya and Roy (1988) studied canning quality of Amrapali, Mallika and Dashehari, varieties of mango. It was observed that TSS, acidity and pH of slices varied from 30 to 35 per cent, 0.24 to 0.31 per cent and 3.4 to 3.5, respectively. While TSS, acidity and pH of syrup varied from 27 to 34 per cent, 0.21 to 0.29 per cent and 3.4 to 3.6, respectively. As regards to carotenoids of slices, maximum was recorded in Amrapali (4705 μg/ 100g) and minimum in Mallika varieties (2431 μg/ 100g).

2.2.4.2 Treatment of fruits with chemicals to improve processing qualities

Kariappa *et al.* (1966) noted that, in case of Coorg Santra cranges, turbidity of syrup and breakage of segments can be prevented by 60^0 B syrup containing 0.05 per cent calcium chloride. The segments were firm even after four months storage at room temperature.

Freeze dried firm, fully ripe, strawberries and saturated with a sugar solution containing 70-80 % by weight and then coated with a gel or arabic gum. The product had a good aroma and a natural colour and does not shrink during processing (Jung and Oswato, 1970).

Labelle (1971) reported that preheating of freshly pitted cherries at 140^0F for 5-20 min promoted firming, sufficiently to permit pasteurisation of fruit in bulk without excessive tearing. Addition of calcium up to 0.04 % of final product led to 50 per cent greater firmness.

A four per cent calciumchloride dip treatment reduced softening and development of senescent breakdown 'McIntoch' apple but did not significantly modify quality of 'Cortland' or 'Bald win' apples (Betts and Bramlage, 1977).

Souty *et al.* (1981) noted that canning apricot, Cv. Rcuge du Ronsillon, can lead to textural problems because of pectic degradation. Processing apricot halves with $CaCl_2$ improves canned product texture.

Tioga strawberries were canned in a heavy syrup and processed at 100^0C for 15 minutes. Effect of adding 0.25 % CMC and 0.1 % $CaCl_2$ to the syrup or coating fruit in 0.25 % CMC before syrup addition were studied. Sensory and physico-chemical results indicate that addition of CMC/$CaCl_2$ to the syrup gave the best quality fruit (Mohamed *et al*, 1988).

David *et al* (1989) reported that infiltration of apricot patterson cultivar fruits, which are susceptible to rapid softening, with calcium chloride before processing resulted in definite firming of the canned apricot.

Differential responses to $CaCl_2$ levels and storage duration by various textural measurements indicated that supplemental Ca not only increased firmness retention during storage, but also induced different patterns of textural change. Calcium chlride at 4 per cent has a greater firming effect, but caused severe surface damage (Abott *et al.*, 1989).

III. MATERIAL AND METHODS

3.1 ORANGE

The present investigations were undertaken in collaboration with the Regional Fruit Research Station, Katol, which is a premere research station for citrus fruits under Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, Maharashtra. Nagpur Mandarin oranges (*Citrus reticulata* Blanco) of optimum maturity were harvested from the citrus orchard of the R.F.R.S. Katol. The research covered three years data on oranges involving six crop seasons during the year 1994-95, 1995-96 and 1996-97.

3.1.1 Experimental materials

Freshly harvested oranges were packed in 2 types of improved corrugated Fibre Board boxes, traditional wooden boxes and packed loosely in mini lorry (only with paddy straw as cushining material) in order to assess the suitability of the corrugated paper boxes as compared to the traditional wooden boxes for long distance transport. Two mini truck loads were thus transported to Bangalore to a distance of 1055 kms. After arrival at Bangalore, the boxes as well as the loosely packed oranges were examined for their condition and keeping qualities in storage at room temperature over a period of 43 days. Various types of boxes (packages) used are described below :

3.1.1.1 Traditional wooden box (WB)

Traditional wooden boxes used in this studies were made of inferior timber like that of mango, deal wood etc. The size of the traditional wooden box was L18" x B13" x H13".

3.1.1.2 One piece corrugated fibre board cartons (CFB-1)

Design of the cartons used was as follows :

One piece corrugated (5 ply) fibre board cartons of the following dimensions.

External	Length	470 mm
	Width	280 mm
	Height	280 mm

A longitudinal groove on both broad sides for easy lifting of the carton of size, length 7.5 cm x width 1.25 cm, ventilation holes of 1.25 cms diameter on each side - lengthwise 4 in number. Holes are located equidistant from each other.

Grammage 5 ply 175 x 175 x 200 x 175 x 175.

Total layers of fruits in the carton	=	4
Number of fruits (Mandarin) per carton	=	80 to 120
Quantity net to be packed	=	14 ± 1 kgs/carton

3.1.1.3 Two piece telescopic corrugated fibre board carton (CFB-2)

Two piece telescopic corrugated fibre board carton with two trays each with the capacity to hold 30 fruits.

Quantity net to be packed 7 kgs

Dimensions

	Carton	
Internal	Top	Botton
Length	505 mm	495 mm
Width	310 mm	300 mm
Height	143 mm	140 mm

Flaps - Long sides :	Length	495 mm
	Width	149 mm
Broad sides :	Length	149 mm
	Width	300 mm

Fruit size used for packing 60-70 mm dia.

Total number of fruits per package = 60

In each layer tray 6 x 5 = 30

Hand holes on both sides 70 mm long x 20 mm wide

No. of oranges in a carton = 60

No. inserts used in the box

3.1.2 Experimental methods

3.1.2.1 Post harvest treatments (Common to all boxes)

After harvest, the fruit were collected on bamboo mats in layers. They were spread on levelled floor matted and cushioned with paddy straw to allow them to rest and cure for 24 hours to subside their metabolic activity. While packing the sound oranges were selected based on their uniformity in normal shape, size varying from 55 mm to 80 mm (equatorial diameter), smooth skinned and free from damage or bruises. Fruit selected were also free from blotchyness, white fly and insect attack. Selected fruits were having sugar acid ratio of not less than 1.9. Most of the fruits selected were having TSS not less than 8° Brix.

Depending upon the size of the orange, they were packed in quantities of 60, 80, 100 and 120 fruits in a carton/or box as the case may be.

Washing and drying : Prior to packing in the various boxes, the fruits were washed in chlorinated cold water, followed by rinsing in plain water. Drying was done with the help of a fan.

3.1.2.2 Chemical treatment (Common to all fruits which are packed in boxes)

1. After washing the fruits were dipped for 20 minutes in 0.1 per cent (1000 ppm) solution of Thiabendazole (TBZ) a fungicide. TBZ is formulated for agricultural use as a wettable powder containing 90 per cent active ingredient 'Tecto 90' [manufactured by Merck, Sharp and Dhome (Aust.) Pvt. Ltd.]. The concentration of TBZ for treating citrus fruit was 0.1 per

cent (1000 ppm). It was prepared by mixing the required quantity of TBZ powder (Tecto, 90 ®) with water while treating the fruits with the help of a bamboo basket dipping in the tank, it was ensured that the concentration of tecto was not allowed to fall below a minimum level of 0.08 per cent (800 ppm).

Preparation of the suspension : The correct procedure for mixing TBZ powder with water was followed to ensure thorough wetting and dispersion of the material. The powder was well stirred with a small quantity of water to form a smooth paste, before adding further water and transferring the mixture to a tank.

2. One lot each of oranges were waxed diping in 6 % HI-SHINE wax emulsion.

3.1.2.3 Sorting

Once again the oranges were sorted for discarding damaged and defective oranges. Bruised, sunburned, insect damaged, rotted and oranges having slightest indication of sooty mould and blotch etc. were discarded, thus ensuring that there is no initial presence of any pathogens. Sizing and grading was done as per the recommendations of the market planning and design centre of the Directorate of Marketing and Inspection, Ministry of Agriculture, Department of Rural Development, Government of India, Nagpur.

3.1.2.4 Packing

Paddy straw was used as a cushioning material inside all types of boxes used in this study. At the bottom of the box a layer of straw was laid as a bed to absorb the shock. Oranges were arranged over this in rows. A thin layer of straw was again laid over the oranges. Four to six layer of oranges were accommodated in this fashion. Before closing the box, adequate cushioning of straw was given. Wooden boxes were nailed, or closed with the help of adhensive tapes firmly to hold the box intact during handling and transportation.

Treatments

T_1 : Packing in traditional Wooden Box (WB) as described earlier

T_2 : Packing in one piece corrugated fibre board cartons (boxes) - (CFB-1) (No. of boxes used = 10)

T_3 : Packing in two piece telescopic corrugated fibre board cartons (boxes) - (CFB-2) (No. of boxes used = 10)

T_4 : Grading in three size

i) Large - diameter 70 mm to 80 mm = Grade I

ii) Medium - diameter 65 mm to 70 mm = Grade II

iii) Small - diameter 55 mm to 65 mm = Grade III

Control : Control consisted of freshly harvested fruits without any treatments but cured for 24 hours and packed loosely over a layer of paddy straw in a mini lorry and transported over a distance of 1055 kms. After arrival, they were transferred to crates for storage studies at room temperature (25°C to 30°C and R.H. 45-55%)

3.1.3 Observations

The following physical parameters and chemical constituents of oranges used for the transportation and storage studies were recorded.

3.1.3.1 Physical parameters

Ten fruits were selected randomly from each box of oranges and the observations were recorded on the following physical characteristics.

3.1.3.1.1 Weight of the fruit

Individual fruit was weighted on a sensitive electronic balance and the average weight of ten fruits were calculated and expressed in grams.

3.1.3.1.2 Size and shape of the fruit

The size was measured in centimeters across the diameter by two readings taken at right angles to each other and the height of the orange from base to apex recorded. The shape index was determined by dividing the polar diameter by the transverse diameter.

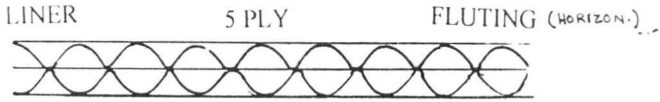
3.1.3.1.3 External colour

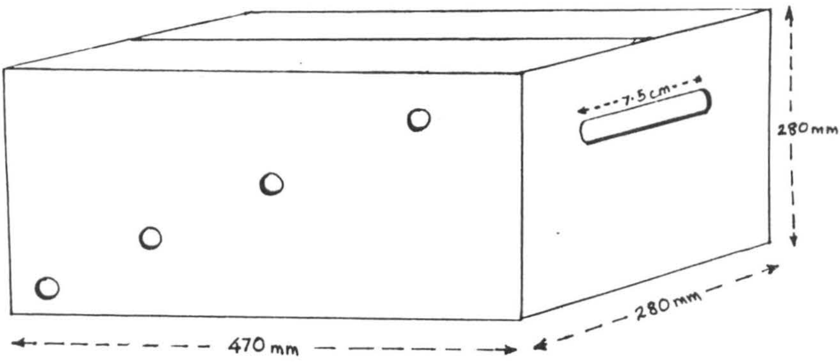
Royal Horticultural Society, London's Horticultural Colour chart was used to record the colour of the fruit as a standard reference for comparison (visual observation).

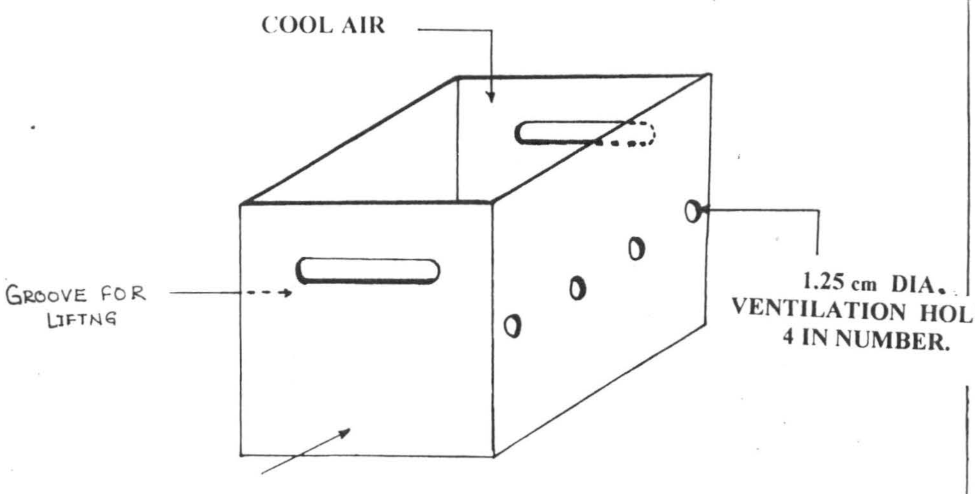
3.1.3.1.4 Firmness of fruit

The firmness of the fruit was measured in terms of pressure required to rupture the fruit and expressed in kg/cm^2 using a hand penetrometer (Ogawa-Seikai Co., Japan).

5 PLY CORRUGATED FIBRE BOARD PACKAGING OF MANDARINS

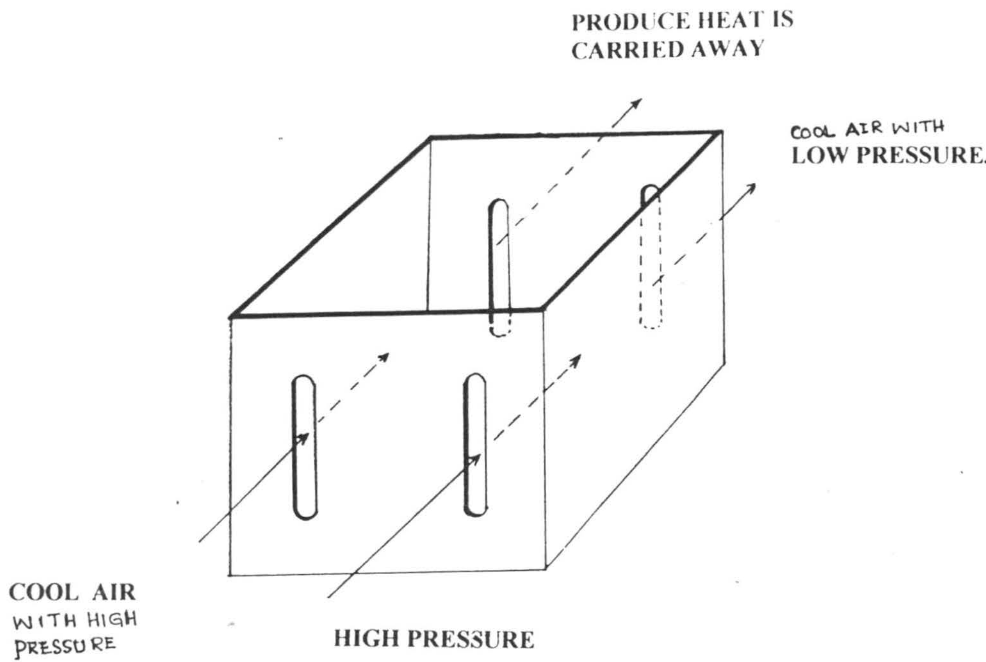






Dia-1 5 Ply corrugated fibre board box-1

5 PLY CORRUGATED FIBRE BOARD PACKAGING OF MANDARINS



Dia;-2 Corrugated fibre board box-2

3.1.3.1.5 Weight of peel and segments

Oranges were peeled and weight of peel and segments recorded separately after taking the weight using an electronic balance.

3.1.3.1.6 Pulp to peel ratio

The pulp to peel ratio was calculated by dividing the weight of segments by weight of peel.

3.1.3.2 Chemical composition of fruits

The chemical constituents were determined by blending the representative samples in a mixer grinder to get uniform juice, which was used for analysis.

3.1.3.2.1 Total soluble solids

Total soluble solids were recorded using a Erma hand refractometer (0-32^0 Brix) range. The T.S.S was expressed as ^{0}Brix after making necessary temperature corrections.

3.1.3.2.2 Acidity

Titrable acidity was analysed by titrating a known aliquot of sample against standard 0.1 N NaOH using phenolphthalein as indicator and was expressed as per cent citric acid (Ranganna, 1997).

3.1.3.2.3 Sugars

Reducing and total sugars were estimated by using Lane and Eynon (1923) method with modifications as suggested by Ranganna (1979).

Total sugar were estimated after acid hydrolysis of 50 ml aliquot of the deleaded sample with 5 ml of concentrated hydrochloric acid at room temperature for 24 hours.

Non reducing sugars were obtained by deducting the value for reducing sugar from total sugar. All types of sugars were expressed in per cent.

3.1.3.2.4 Sugar : Acid ratio

The values obtained for total sugars were divided by the corresponding values of acidity and expressed as sugar : acid ratio.

3.1.3.3 Observations during storage

3.1.3.3.1 Physiological loss in weight

Ten fruits were marked in each lot and their initial weights were recorded. Subsequently marked fruits were weighed on every 10 days and the loss in weight was noted from their initial weight and percent loss was computed and presented as cumulative physiological loss in weight.

3.1.3.3.2 Disease incidence and rotting

The stored fruits were examined everyday for incidence of disease and rotting of fruits whenever infected fruits were observed. They were counted and discarded. The rotting was expressed in per cent taking in to account, the number of fruits stored and number of fruits disposed off during storage.

3.1.3.3.3 Temperature of storage room

Maximum and minimum temperature of the room where the fruits were stored were recorded daily with a maximum / minimum thermometer during the study, and expressed in celsius and presented in Appendix I.

3.1.3.3.4 Relative humidity

Dry bulb and wet bulb temperatures of the storage room were recorded daily using dry and wet bulb thermometer and used for computation of relative humidity with the help of hygrometric tables and expressed in per cent.

3.1.3.4 Sensory Evaluation

The fruits were subjected to sensory evaluation by a panel of 10 judges The evaluation was carried out on a 100 point scale prepared on the basis of principles of sensory evaluation (Amerine *et al.*, 1965), which had marks for peel colour (15), pulp colour (15), texture of fruit / pulp (20), flavour (20) and taste (30). The score card used for sensory evaluation is furnished below.

Sensory evaluation score card

Name of the product : Orange

Date of judging : Time :

Sample code	Score					
	Peel colour (15)	Pulp colour (15)	Texture (20)`	Flavour (20)	Taste (30)	Total (100)
1						
2						
3						
4						
5						
6						
7						
8						

Note : Please give marks for samples as given below

If they are	Peel colour (15)	Pulp colour (15)	Texture (20)`	Flavour (20)	Taste (30)
Very good	13-15	13-15	16-20	16-20	25-30
Good	9-12	9-12	11-15	11-15	17-24
Average	5-8	5-8	7-10	7-10	9-196
Bad/poor	0-4	0-4	0-6	0-6	0-8

Name and Designation of the evaluation

Signature

Flow chart of post-harvest handling of oranges

Harvest optimum ripe fruits and collect in crates

↓

Empty the crates on levelled floor matted and cushioned with paddy straw

↓

Allow them to rest and cure for 24 hours to subside their metabolic activity

↓

Select for uniformity in colour and size, size varying from 55 mm to 80 mm (equatorial diameter), smooth skimmed and free from damage. Fruits selected should have TSS of $\nless$ 8° Brix

↓

Wash in chlorinated water followed by rinsing in cold water

↓

Dip for 2 minutes in 0.1 per cent TBZ solution and dry

↓

Wax by dipping in 6 per cent HI-SHINE wax emulsion

↓

Once again sort for unwanted fruits

↓

Size grade for packing (Large, Medium and Small)

↓

Pack in the boxes using paddy straw as a cushioning material. Arrange oranges in rows and again a layer of straw. Upto six layers of oranges could be accommodated depending upon size of the box

↓

Scure the box tightly/firmly for transport

↓

Storage at room temperature after transport

3.2 MANGO

The present investigation on varietal evaluation of mango (*Mangifera indica* L.) Cvs. Bombay Green and Hybrids Mallika and Ratna for canning the slices in sugar syrup were carried out at the Analytical and quality control laboratory, Centre for processed foods and the processing laboratory of the Division of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vignan Kendra, Bangalore, during the two consecutive years 1995-96 and 1996-97. The details of the experimental materials used and the methods adopted for the investigation are presented in this chapter.

3.2.1 Experimental Materials

Mango fruits of variety Bomby Green and hybrids Mallika and Ratna were obtained from UAS orchards and ripened in paddy straw. The following physico-chemical constituents of mature and ripe mango fruits of the above three varieties were studied during the course of present investigation.

3.2.1.1 Physical parameters

For this study, 10 fruits of each variety were selected randomly and the observations were recorded on the following physical characteristics.

3.2.1.1.1 Weight of fruit

Individual fruit was weighed on sensitive electronic balance and average weight of ten fruits was recorded in grams.

3.2.1.1.2 Volume of fruit

The volume of fruit was determined by water displacement method and recorded in millilitres.

3.2.1.1.3 Specific gravity

Specific gravity is a single non-destructive test that can be employed for judging fruit maturity and was determined by dividing the value of fresh weight of fruit by that of volume of the fruit.

3.2.1.1.4 Length of fruit

The length of the fruit from stalk end to the apex of fruit was determined with the help of vernier callipers in centimeter.

3.2.1.1.5 Breadth and Width of fruit

The maximum linear distance between two shoulders of the fruit was considered as the breadth of fruit while the linear distance between the cheeks considered as width of fruit and was determined with the help of vernier callipers in centimeter.

3.2.1.1.6 Colour of the peel

The peel colour of representative mango fruit was compared with Horticultural colour chart issued by British Colour Council, London and respective colour values were recorded.

3.2.1.1.7 Colour of the pulp

A homogenate of the representative fruit pulp sample was compared with Horticultural Colour Chart issued by British Colour Council, London and respective colour values were recorded.

3.2.1.1.8 Weight of peel

The pulp free peel of the fruit was weighed separately on sensitive electronic balance and average weight of ten fruits was recorded in grams.

3.2.1.1.9 Weight of stone

The pulp free stone was weighed separately on sensitive electronic balance and average weight of ten fruits was recorded in grams.

3.2.1.1.10 Weight of pulp

The pulp was weighed on sensitive electronic balance and average weight of ten fruits was recorded in grams.

3.2.1.1.11 Pulp : Stone ratio

The pulp to stone ratio was calculated by dividing the weight of pulp by weight of stone,.

3.2.1.1.12 Length of stone

The length of stone from stalk base to the apex was determined with the help of vernier callipers in centimeter.

3.2.1.1.13 Breadth of stone

The maximum distance between the shoulders of the stone was taken as the breadth and was determined with the help of vernier callipers in centimeter.

3.2.1.1.14 Width of stone

The maximum distance between the cheeks of the stone was taken as the width and was determined with the help of vernier callipers in centimeter.

3.2.1.1.15 Firmness of fruit

The firmness of raw as well as ripe ten representative fruits was measured in terms of pressure required to rupture through the fruit in Kg/cm^2 using hand penetrometer (Ogawa Sakei Japan 0-12 kg/cm^2 range).

3.2.1.2 Chemical composition of mango fruit and its products

The followng chemical constituents were determined from the mango fruit and its products.

3.2.1.2.1 Moisture

The percentage of moisture was estimated by oven drying a known weight of sample at 55-60^{0}C to a constant weight (A.O.A.C., 1975).

3.2.1.2.2 Total soluble solids (TSS)

Total soluble solids were recorded by using an 'Erma' hand refractometer and values were corrected at 20^{0}C using temperature correction chart (Ranganna, 1977).

3.2.1.2.3 Total Titratable Acidity

Acidity in per cent citric acid was analysed as described earlier in case of citrus fruits.

3.2.1.2.4 Sugars

Reducing, non reducing and total sugars were estimated by using Lane and Eynon (1923) method with modification suggested by Ranganna (1979) as described for citrus juices in earlier chapter.

3.2.1.2.5 pH

The pH of mango fruits and its products was determined by using a digital pH meter.

3.2.1.2.6 Ascorbic acid

Ten grams pulp of the representative fruit was blended with three per cent metaphosphoric acid to make final volume of 100 ml and then filtered by using filter paper. Ten ml aliquot was titrated against 2, 6 Dichlorophenol indophenol dye to a pink colour end point. The ascorbic acid content was expressed as mg per 100 gms of pulp.

3.2.1.2.7 Carotenoid pigments as β-carotene

The total carotenoid pigments (expressed as β-carotene) were determined with the method described by Roy (1973). The carotenoid pigments were extracted from the sample with light petroleum ether and acetone mixture (3 : 2 by volume) by grinding with acid washed sand. The extracts were decanted off into a 100 ml volumetric flask. Total carotenoids in the clear extract were determined by using spectrophotometer at 450 nm. The results were expressed in terms of β-carotene as µg/100 g of the sample.

3.2.1.2.8 Canning of slices

Trials were conducted for canning of mango slices. Fully mature fruits were harvested and allowed to ripen by conventional method with paddy straw at ambient temperature. Sound and uniformly ripe fruits were selected for processing.

3.2.2 Experimental details

3.2.2.1 Treatments

1. Three varieties of mango Ratna, Mallika and Bombay Green

No. of Replications	=	3
No. of cans in each replication	=	20
Size and type of can	=	A2½ OTS plain cans

3.2.2.1.1

Design of the experiment – Factorial R.C.B.D.

3.2.2.1.2 Observations

After canning the mango slices in sugar syrup with the above treatments, the canned product was analysed periodically at regular intervals for keeping quality, improvement in quality if any, texture, flavour, colour, firmness of the slices, physical and chemical parameters and overall acceptability.

3.2.2.1.2.1 Following observations were recorded at 3, 6 and 8 months storge at room temperature.

A. Visual observation - For spoilage

B. Cut-out analysis of cans -

1. Vacuum in(inches / cm^2)
2. Head space(cm)
3. Drained weight of slices gm(%)
4. Texture of slices(kg /cm^2)
5. Net weight of slices (gm)
6. Corrosion of can if any visual
7. Breakage of slices %.

3.2.2.1.2.2 Observation on physico-chemical parameters

1. T.S.S. (^{0}Brix of syrup and slices)
2. β-carotene μg/100g
3. Titratable acidity %
4. pH
5. Ascorbic acid mg/100 g slices

3.2.2.1.2.3 Organoleptic Parameters

1. Colour of fruit slices
2. Taste and flavour
3. Mouth feel of fruit slices
4. Taste and flavour of syrup
5. Colour of syrup
6. Consistency of slices / syrup

3.2.3 Flow chart for Canned mango slices in sugar syrup

For processing canned mango slices in sugar syrup the following steps were followed :

Flow chart No. 1 for canned slices in sugar syrup

Selection of fruits
|
Washing
|
Preparation of fruits (Peeling)
|
Cutting into slices (with s.s.steel knives)
|
Preparation of 40_0 Brix syrup +
Addition of citric acid to the syrup @ 0.25 %
|
Filling the product in sterilized cans (size A2½)
|
Addition of boiling sugar syrup
|
Exhausting for 10 minutes
|
Sealing
|
Processing in boiling water for 25 minutes
|
Cooling and labelling
|
Storing the product at a cool dry place for 8 months

3.2.3.1 Canning of mangoes

Canning trial was conducted by selecting sound, healthy, ripe but firm mango fruits. Fruits were washed with water and hand peeled by using s.s. Steel peeling knives. The fruits were cut into 5 to 6 longitudinal slices by keeping the knife very close to the stone. Slices obtained from ripe fruits were weighted before filling into A 2 ½ size plain OTS cans at the rate of 540 to 550 g/can.

Sugar syrup of 4o^0 Brix strength with 0.25 per cent acid was prepared by adding cane sugar and citric acid to the boiling water. The syrup containing citric acid (@ 0.25 per cent) was filtered through a muslin cloth to remove impurities. Brix hydrometer was used to measure the syrup strength.

Boiling hot sugar syrup of 40^0 Brix with 0.25 per cent citric acid was added to the filled cans at the rate of 250 ml/can and the cans were clinched. These cans were exhausted for 10 minutes. As soon as the temperature at the centre of the can reached 80^{0}C, they were sealed using hand operted double can seamer. Sealed cans were processed in boiling water for 25 minutes followed by prompt cooling in running water. Cans were labelled and finally kept at room temperature for further observations on the quality of the canned slices and organoleptic evaluation. The product was analysed at every 3, 6 and 8 months interval during storge.

3.2.4 Organoleptic evaluation

The organoleptic evaluation of canned slices for quality characters such as appearance, colour, flavour and texture and overall acceptance was assessed by a panel of 7 judges using a Hedonic scale (Amerine *et al.*, 1965). The following chart was used for evaluation of the products.

3.2.4.1 Organoleptic evaluation score card for canned mango slices

Product : Canned mango slices

Date : Name :

Using the Hedonic scale on display would you please rate each of the samples by placing a number in the appropriate column. Rank the samples from higher to lower score in descending order of acceptability.

Sl. No.	Sample code	Quality assurance			
		Appearance	Flavour	Texture	Overall acceptability
1					
2					
3					
4					
5					
-					
-					
15					

Hedonic scale

Like extremely	10	Dislike slightly	5
Like very much	9	Dislike moderately	4
Like moderately	8	Dislike very much	3
Like slightly	7	Dislike extremely	2
Neither like nor disliked	6		

Signature with date
and designation

3.2.4.2 Storage of mango products

Canned mango slices prepared (tinned) were stored at ambient temperature to study the chemical and physical changes such as colour and extent of spoilage for a period of eight months and observations were recorded at an internal of 3 months in all the samples. However, product could not be stored for more than 8 ½ months, hence last observation was recorded at the end of 8th month.

3.2.4.3 Change in colour

The colour change of the products was recorded by visual observations and grouped into the following categories : Original characteristic colour, slight change in colour and complete change in colour from its original.

3.2.4.4 Spoilage

The spoilage of the products was recorded as follows : No spoilage, slightly spoiled and fully spoiled.

3.2.4.5 Statistical Analysis

The data obtained from the observations of various parameters in three replications were subjected to two way analysis of variance with interaction as suggested by Fisher (1963) and Suderraj *et al*. (1972).

IV. EXPERIMENTAL RESULTS

4.1 ORANGE

Results obtained through various experiments / trials conducted over a period of 3 years are presented in this chapter under the following headings.

4.1.1 Evaluation of post harvest problems causing loss due to various reasons

4.1.1.1 Losses at field level during harvest

Results from table 1 indicate that fruits at field level during harvest were subjected to losses due mainly to disease, bruises and rindbreak. Of the total quantity of fruits harvested (3032 kg), the percentage of diseased fruits ranged from 3.13 to 5.06 per cent, that of bruised fruits from 1.66 to 2.25 percent. Out of the total 3032 kg fruits harvested, 55.50 kg were found to be bruised amounting to 1.95 per cent loss. Rind break losses were found to be 1.39 percent, (12.57 kg lost due to rind break from a total of 46.20 kg). The total average losses were calculated at 7.37 per cent. It was observed that Mrig season crop that is monsoon blossom crop had more losses as compared to Ambia bahar oranges.

4.1.1.2 Losses in oranges during transport (over long distance of 1055 KM)

A mini lorry loaded with 500 kg fruits without any packaging and transported loose over a cushion of paddy straw and covering a long distance of road journey caused a loss of 60 kg fruits amounting to 12 percent during the trial. During the subsequent trials, these losses were 11.00 % and 9.6 %. Thus the average mean losses were more than 10.86 per cent. When the same mini lorry was loaded with 200 kg oranges packed in corrugated fibre board boxes (Type CFB-1). The losses recorded were only 15 kg of fruit or 7.50 per cent. When 220 kg of fruits were packed in corrugated fibre board boxes (type

Plate 1a : Oranges packed in wooden boxes. Condition of boxes after unloading from truck

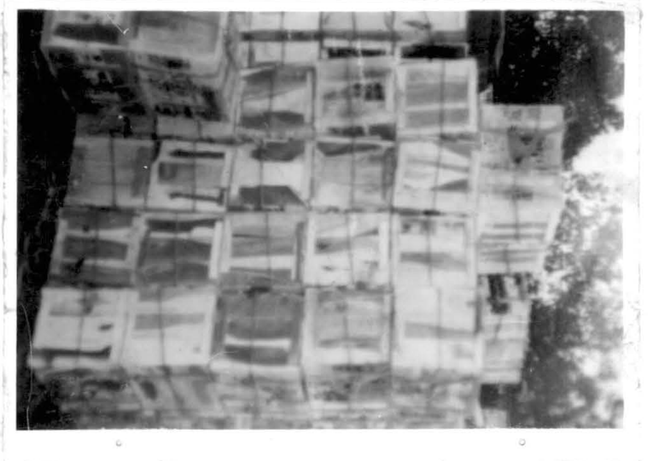


Table 1: Losses in Oranges at field level

Year	Season	Harvested (Kg)	Diseased		Bruised		Rind Break	
			Qty(Kg)	% lost	Qty(Kg)	% lost	Qty(Kg)	% lost
1994-95	A	435	17.5	4.02	9.0	2.06	5.0	1.14
	M	550	22.00	4.0	11.0	2.0	7.0	1.27
1995-96	A	385	16.0	4.15	8.0	2.07	6.7	1.74
	M	316	26.0	5.06	6.0	1.88	6.8	2.15
1996-97	A	406	20.0	4.92	7.0	1.72	2.7	0.66
	M	355	12.0	3.38	8.0	2.25	8.0	2.25
1997-98	A	330	12.0	3.63	5.5	1.66	6.0	1.80
	M	255	8.0	3.13	5.0	1.86	4.0	1.50
			Mean =	4.03%	Mean =	1.95%	Mean =	1.39%

A=Ambia, M=Mrig

Average losses at field level = 7.37%

Total Losses = 14.74 %

Plate 1b : Oranges packed in CFB boxes. Condition of boxes after unloading from truck

CFB-2), only 14 kg fruits were lost causing only 6.3 per cent loss. The total mean losses were recorded at 9.29 per cent.

4.1.1.3 Losses at whole sale level

Table 3 depicts the losses in mandarin oranges at (a) whole sale level and (b) at retail level. The losses were recorded at four whole sale markets and four retail markets. Total average losses at whole sale markets were found to be 3.91 % due to disease, 2.52% due to bruising, 1.95 % due to rind break and 1.26 % due to over ripened fruits. Thus a total of 9.68 % losses occurred at whole sale market alone.

4.1.1.4 Losses at retail level

On an average 8.1 % losses were recorded (Table 3). Losses at retail level were comparatively lesser than at wholesale level. Like at wholesale level, fruits had to be variously discarded due to diseases, bruises rind break or due to over ripening. The respective losses due to these factors are in the range of 1.75% to 2.70% due ro diseases, 2.10% to 3.50% due to brusing of fruits, 1.4 % to 2.25 % due to rind break and 1 % to 1.6 percent due to over ripe fruits. thus a total of 8.1% fruits were lost at retail level.

4.1.2 Physical characteristics of Nagpur mandarins

4.1.2.1 Weight of the fruit

The average weight of the fruit was found to be 152.25 g. The fruit weight was in the range of 148 g to 156 g per fruit.

4.1.2.2 Size and shape of the fruit

Table 4 dipicts the size and shape of the fruit. The characteristics shape of all the season fruits was found to be Oblate i.e, flattened at the stalk end and depressed at the stigma end. The fruit had a pronounced lip at the stalk end, Plate : 2a : Oranges with TBZ treatment after the storage from 43 days with CFB-1 packaging

Table 2: Losses in Orange during transport (1055 KM)

Transport mode	Type of placement	Quantity (Kg)	Quantity lost (Kg)	% lost
Mini lorry	Paddy straw	500	60.0	12.0
Mini lorry	Paddy straw	360	40.0	11.0
Mini lorry	WB+ Paddy straw	250	24.0	9.0
Mini lorry	C.FB 1	200	15.0	7.5
Mini lorry	C.FB 2	220	14.0	6.36
				Mean = 9.29%

Total losses in Orange during transport = 9.29

Table 3: Losses in Orange at

a. Whole sale level — b. Retail level

	a. Whole sale level								b. Retail level							
	Market 1		Market 2		Market 3		Market 4		Market 1		Market 2		Market 3		Market 4	
	Qty (Kg)	% loss	Qty (Kg)	% loss	Qty (Kg)	% loss	Qty (Kg)	% loss	Qty (Kg)	% loss	Qty (Kg)	% loss	Qty (Kg)	% loss	Qty (Kg)	% loss
Quantity unloaded	800		1200		1000		500		500		400		480		500	
Quantity discarded																
Diseased	32	4.0	44.4	3.70	37.5	3.7	21.0	4.2	13.5	2.7	8.0	2.0	8.64	1.8	8.75	1.75
Bruised	8.4	2.3	19.8	1.65	30	3.0	16.5	3.3	17.5	3.5	9.4	2.35	10.08	2.1	12.5	2.5
Rind Break	16	2.0	32.8	1.90	19.0	1.9	10.0	2.0	11.25	2.25	5.4	1.35	6.72	1.4	7.5	1.5
Over ripe	8.0	1.0	12.6	1.05	16.0	1.6	7.0	1.4	10.0	2.0	6.8	1.7	7.2	1.5	10.0	2.0
Total (%)		9.3		8.3		10.25		10.90		10.45		7.4		6.8		7.75

Total average losses at wholesale level : 9.68%

Total average losses at retail sale level : 8.10%

Plate 2b : Oranges with TBZ treatment after the storage of 43 days with CFB-2 packaging

Table 4: Physical characteristics of Nagpur mandarin oranges harvested at different seasons

Season/Month of harvest at full maturity	Fruit diameter (Cm)	Fruit length (Cm)	Fruit weight (g)	Fruit firmness Kg/cm^2	Peel thickness (mm)	Peel colour
1st crop April	6.2	6.9	155	2.9	3.0	Deep orange
2nd crop July	6.8	6.5	152	3.2	2.8	Yellowish green
3rd crop Dec.	7.5	6.4	148	2.8	2.6	Yellowish green
January	7.2	6.8	156	2.6	2.9	Deep orange

which added to the dimensions of the polar diameter. The average diameter was found to be 6.92 cm. The average fruit length was found to be 6.45 cm.

4.1.2.3. Peel Colour

Peel colour was visually observed and recorded (Table 4). It was seen that oranges harvested during the months of January – April had a deep orange colour, while fruits harvested during July had yellowish green colour. December crop had yellowish orange colour.

4.1.2.4 Fruit firmness (Texture)

Fruit firmness was recorded (Table 4) with the help of a fruit pressure tester as described in the previous chapter. It was found to be in the range of 2.6 kg /cm^2 to 3.2 kg/cm^2 during the four harvests.

4.1.2.5 Weight of rag and peel

Table 5 depicts the data on the mean rag and peel weight percentage of oranges over a period of 43 days. There were significant differences among different grades during different times of the storage period. In large sized fruits, there was slight increase in rag and peel weight upto third week of storage, beyond which there was a greater decline. In case of medium sized fruits, decline in rag and peel weight was less at the third week of storage, beyond which there was greater decrease in rag and peel weight. Similarly in case of small sized fruits, there was marginal decrease in rag and peel weight content upto third week, beyond which the decrease was much greater. (Fig. No. 1) (Fig. No. 1A)

With regard to effect of packaging, the data reveals that the rag and peel weight increased steadily upto the sixth week and then decreased, in case of fruits packed in wooden boxes and the increase was felt upto 43rd day. Corrugated fibre board box-1 packaging revealed an increase in rag and peel

Table 5 : Mean and interaction effects of grading and packaging on the rag and peel weight (%) of oranges

Grade of fruit	8th day					15th day					22nd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	50.10	51.20	52.60	52.10	51.50	51.20	51.90	53.20	0.50	52.20	51.90	52.20	53.40	0.50	39.50
	(43.48)	(44.63)	(45.77)	(49.74)	(45.90)	(43.65)	(44.85)	(46.17)	(4.05)	(34.68)	(43.94)	(45.08)	(46.51)	(4.05)	(34.89)
Medium	53.60	54.10	55.20	55.40	54.60	53.90	54.30	55.90	0.50	55.10	54.40	55.10	56.20	0.50	41.60
	(46.06)	(48.41)	(48.30)	(49.16)	(47.98)	(46.80)	(49.51)	(48.64)	(4.05)	(37.25)	(47.95)	(49.80)	(48.93)	(4.05)	(37.68)
Small	55.20	56.60	56.20	56.90	56.21	55.60	56.70	56.90	0.50	56.70	56.90	57.20	57.20	0.50	43.00
	(56.75)	(57.06)	(56.13)	(56.43)	(56.60)	(57.62)	(57.94)	(58.84)	(4.05)	(44.61)	(57.94)	(57.56)	(60.48)	(4.05)	(45.00)
Mean	53.00	54.00	55.00	54.80	54.10	53.60	54.30	55.33	0.50	54.70	54.40	54.83	55.60	0.50	41.33
	(48.76)	(50.03)	(50.06)	(51.78)	(50.16)	(49.36)	(50.77)	(51.21)	(4.05)	(38.85)	(49.94)	(50.81)	(51.97)	(4.05)	(39.19)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.084	0.097	0.167			0.021	0.024	0.041			0.02	0.02	0.03	
CD (0.05)		0.232	0.268	0.464			0.057	0.066	0.115			0.054	0.06	0.10	

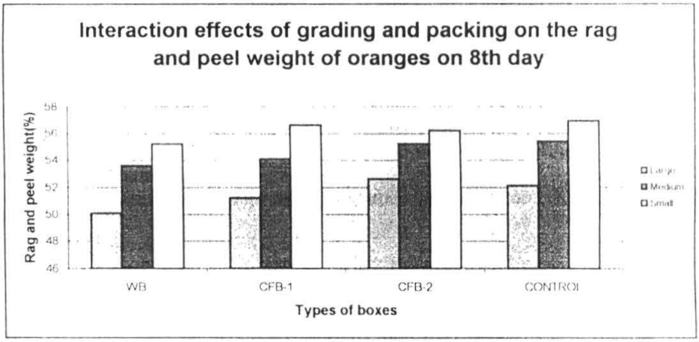
	29th day					36th day					43rd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	53.30	53.70	53.90	0.50	40.35	53.70	53.90	0.50	0.50	27.20	54.70	54.20	0.50	0.50	27.50
	(43.99)	(44.85)	(47.09)	(4.05)	(34.99)	(43.48)	(45.14)	(4.05)	(4.05)	(24.18)	(45.02)	(45.42)	(4.05)	(4.05)	(24.64)
Medium	54.90	55.50	0.50	0.50	27.90	56.20	55.90	0.50	0.50	28.30	56.70	56.80	0.50	0.50	28.63
	(48.52)	(49.91)	(4.05)	(4.05)	(26.63)	(49.51)	(50.85)	(4.05)	(4.05)	(27.11)	(50.15)	(50.67)	(4.05)	(4.05)	(27.23)
Small	57.60	57.80	0.50	0.50	29.10	57.10	57.80	0.50	0.50	29.00	57.60	58.20	0.50	0.50	29.20
	(60.35)	(58.78)	(4.05)	(4.05)	(31.80)	(60.55)	(59.49)	(4.05)	(4.05)	(32.03)	(60.75)	(60.61)	(4.05)	(4.05)	(32.36)
Mean	55.30	55.70	18.30	0.50	32.43	55.70	55.90	0.50	0.50	28.13	56.33	56.40	0.50	0.50	28.43
	(50.95)	(51.18)	(18.39)	(4.05)	(31.14)	(51.18)	(51.82)	(4.05)	(4.05)	(27.77)	(51.97)	(52.24)	(4.05)	(4.05)	(28.08)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.012	0.014	0.025			0.019	0.02	0.03			0.08	0.09	0.16	
CD (0.05)		0.035	0.040	0.069			0.05	0.06	0.10			0.232	0.26	0.46	

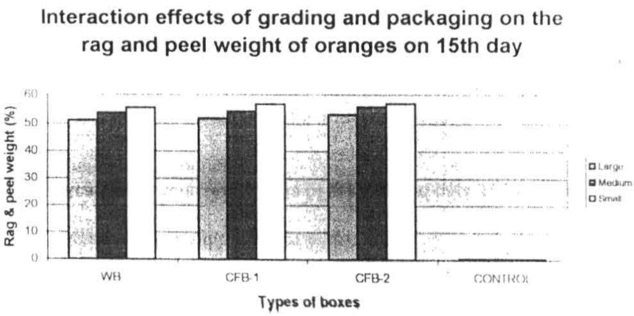
F- test significant at 5 % level   Figures in brackets are angular transformed values

Note : 1) Fruits were stored at room temperature (25 to 32°C and RH 45 to 55%)

2) Control fruits were kept in plastic crates for storage at room temperature

FIG NO. 1


Interaction effects of grading and packing on the rag and peel weight of oranges on 8th day
Rag and peel weight(%)
58
54
52
50
48
46
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small


Interaction effects of grading and packaging on the rag and peel weight of oranges on 15th day
Rag & peel weight (%)
60
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

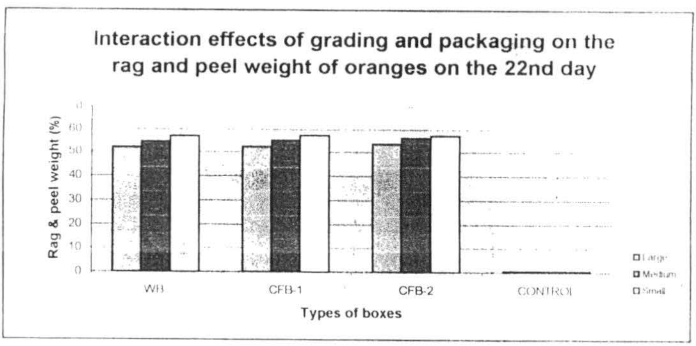
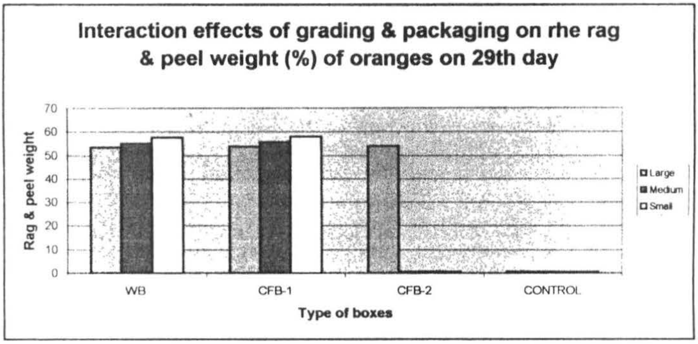
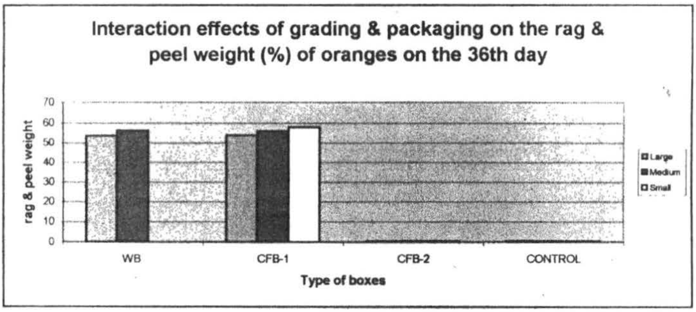
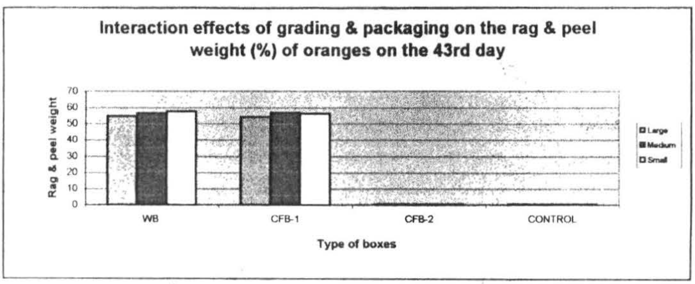

Interaction effects of grading and packaging on the rag and peel weight of oranges on the 22nd day
Rag & peel weight (%)
60
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

FIG NO. 1A


Interaction effects of grading & packaging on rhe rag & peel weight (%) of oranges on 29th day
Rag & peel weight
70
60
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Type of boxes
Large
Medium
Small


Interaction effects of grading & packaging on the rag & peel weight (%) of oranges on the 36th day
rag & peel weight
70
60
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Type of boxes
Large
Medium
Small


Interaction effects of grading & packaging on the rag & peel weight (%) of oranges on the 43rd day
Rag & peel weight
70
60
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Type of boxes
Large
Medium
Small

weight upto 21st day, while that of control fruits there was an increase in rag and peel weight upto 15th day.

The interaction of grading with packaging reveals that packaging large sized fruits in wooden boxes resulted in a graded increase in rag and peel weight upto 43rd day, while with CFB-1 boxes , the increase was noted upto 36th day. Similarly in CFB-2 box packaging and control, the increase was noted upto 29th day and 15th day, respectively. For medium sized fruits, there was graded increase in rag and peel weight upto 43rd day in case of wooden boxes and CFB-1 box packaged fruits, while CFB-2 box packaging and control recorded an increase in rag and peel weight upto 22nd day and 15th day, respectively.

For small sized fruits, wooden box packaging revealed an increase in rag and peel weight upto 43rd day while in CFB-1 boxes it was upto 43rd day. In case of CFB-2 boxes, there was increase in rag and peel weight upto 22nd day, while in control, it was upto 15th day only.

4.1.2.6 Juice content (%)

Results from Table 6 indicated a gradual decline in mean juice weight (%) of oranges during storage. In case of large sized fruits, the juice content reduced from 48 per cent in 1st week to 11.7 per cent in 6th week. On the other hand, medium sized fruits can be stored upto 21 days only with moderate loses in fruit weight, beyond which there were heavy losses in juice content. For small sized fruits, losses in juice content were moderate upto 3rd week and from 4th week the losses were beyond economic limits.(Fig. No. 2 & 2A)

With regard to packaging, in general the treatments differed significantly from each other. Packaging with wooden boxes was found to be economical with moderate losses in juice content upto 43rd day, while for

Table 6 : Mean and interaction effects of grading and packaging on juice content (%) of oranges

Grade of fruit	8th day					15th day					22nd day				
	WB	**CFB-1**	**CFB-2**	Control	Mean	**WB**	**CFB-1**	**CFB-2**	Control	Mean	**WB**	**CFB-1**	**CFB-2**	Control	Mean
Large	48.30	48.60	47.50	47.60	48.00	47.90	47.90	46.80	0.5	47.0	47.10	47.20	46.40	0.5	35.30
	(47.03)	(45.88)	(44.72)	(40.77)	(40.77)	(46.91)	(45.65)	(44.34)	(4.05)	(35.24)	(46.57)	(45.42)	(43.71)	(4.05)	(34.94)
Medium	46.20	45.80	44.60	44.20	45.20	45.90	45.20	44.10	0.5	44.75	45.50	44.80	43.90	0.50	33.68
	(44.45)	(42.04)	(42.22)	(41.35)	(41.35)	(43.71)	(41.00)	(41.87)	(4.05)	(32.66)	(42.60)	(40.72)	(41.60)	(4.05)	(32.32)
Small	44.60	43.43	43.80	42.80	43.66	44.20	43.10	42.90	0.5	43.08	43.70	42.80	42.60	0.50	32.40
	(33.75)	(33.50)	(34.43)	(34.12)	(34.12)	(33.56)	(32.62)	(31.73)	(4.05)	(25.49)	(32.62)	(33.00)	(30.11)	(4.05)	(24.95)
Mean	46.37	45.95	45.30	44.87	45.62	46.00	45.40	44.60	0.50	44.93	45.43	44.93	44.30	0.50	33.80
	(41.74)	(40.45)	(40.45)	(38.15)	(40.35)	(41.39)	(32.62)	(39.31)	(4.05)	(39.71)	(40.60)	(39.71)	(38.50)	(4.05)	(30.74)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.01	0.01	0.02			0.02	0.02	0.04			0.05	0.06	0.11	
CD (0.05)		0.03	0.03	0.05			0.051	0.06	0.010			0.15	0.17	0.30	

Grade of fruit	29th day					36th day					43rd day				
	WB	**CFB-1**	**CFB-2**	**Control**	**Mean**	**WB**	**CFB-1**	**CFB-2**	**Control**	**Mean**	**WB**	**CFB-1**	**CFB-2**	**Control**	**Mean**
Large	46.60	45.60	45.90	0.50	34.90	46.20	46.10	0.50	0.50	23.33	45.30	0.50	0.50	0.50	11.70
	(46.51)	(45.70)	(43.42)	(4.05)	(34.91)	(47.03)	(45.40)	(4.05)	(4.05)	(25.12)	(45.50)	(4.05)	(4.05)	(4.05)	(24.70)
Medium	44.70	44.20	0.50	0.50	22.48	43.90	43.50	0.50	0.50	22.18	43.20	43.20	0.50	0.50	21.90
	(42.00)	(40.60)	(4.05)	(4.05)	(22.70)	(41.00)	(39.70)	(4.05)	(4.05)	(22.20)	(40.40)	(40.02)	(4.05)	(4.05)	(22.12)
Small	43.10	42.10	0.50	0.50	21.60	42.70	41.70	0.50	0.50	21.40	11.00	10.73	0.50	0.50	5.70
	(29.60)	(32.06)	(4.05)	(4.05)	(17.43)	(30.10)	(31.10)	(4.05)	(4.05)	(17.31)	(30.00)	(30.00)	(4.05)	(4.05)	(17.00)
Mean	44.80	44.30	16.10	0.50	26.31	44.30	43.90	0.50	0.50	22.30	33.00	18.14	0.50	0.50	13.80
	(39.40)	(39.40)	(17.20)	(4.05)	(25.00)	(39.40)	(38.71)	(4.05)	(4.05)	(21.55)	(38.60)	(38.40)	(4.05)	(4.05)	(21.30)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.02	0.02	0.04			0.02	0.02	0.04			0.10			
CD (0.05)		0.06	0.03	0.10			0.05	0.10	0.10			0.21			

F- test significant at 5 % level   Figures in brackets are angular transformed values

FIG NO. 2

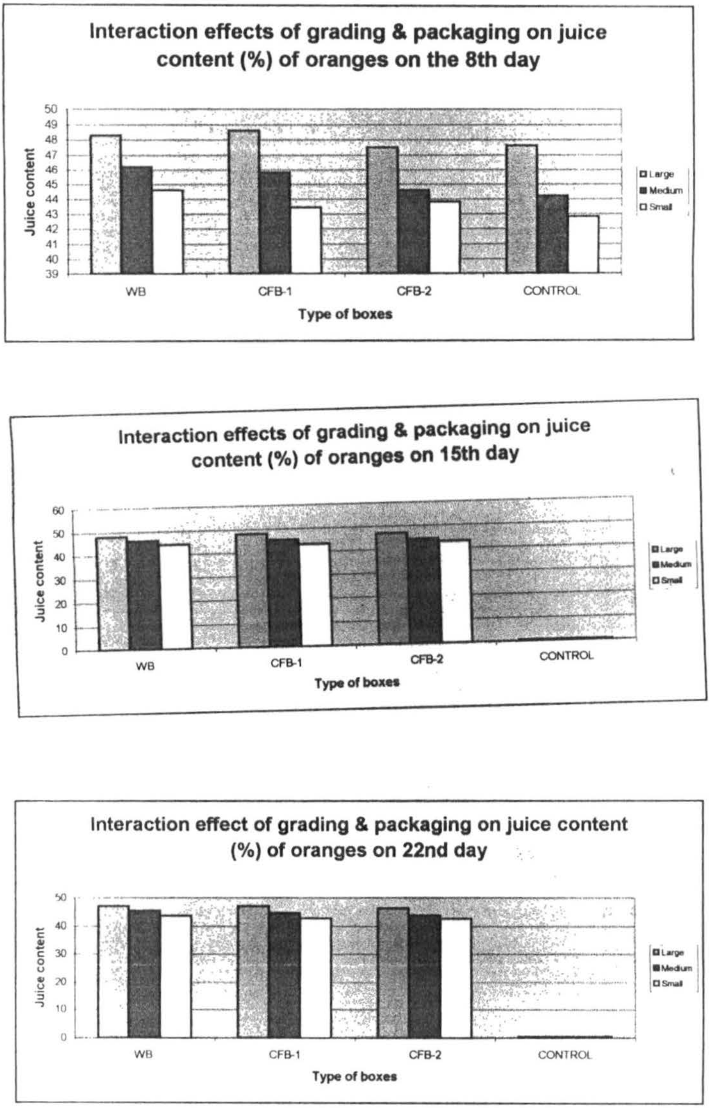
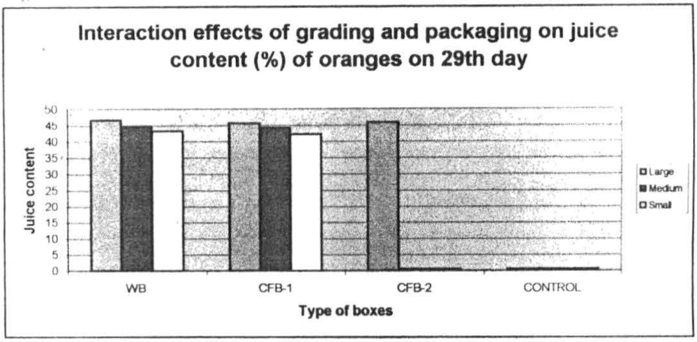
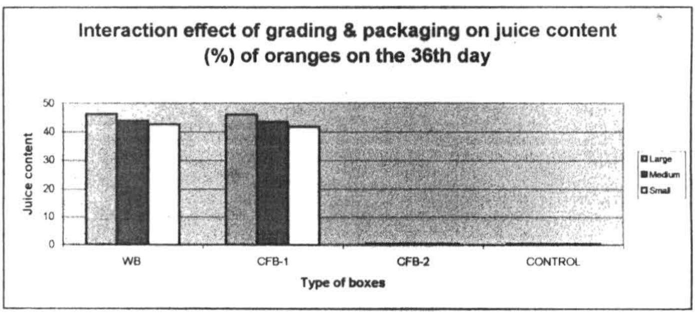

Interaction effects of grading & packaging on juice content (%) of oranges on the 8th day
Juice content
50
49
48
47
46
45
44
43
42
41
40
39
WB
CFB-1
CFB-2
CONTROL
Type of boxes
Large
Medium
Small
Interaction effects of grading & packaging on juice content (%) of oranges on 15th day
Juice content
60
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Type of boxes
Large
Medium
Small
Interaction effect of grading & packaging on juice content (%) of oranges on 22nd day
Juice content
50
40
30
20
10
0
WB
CFB-1
CFB-2
CONTROL
Type of boxes
Large
Medium
Small

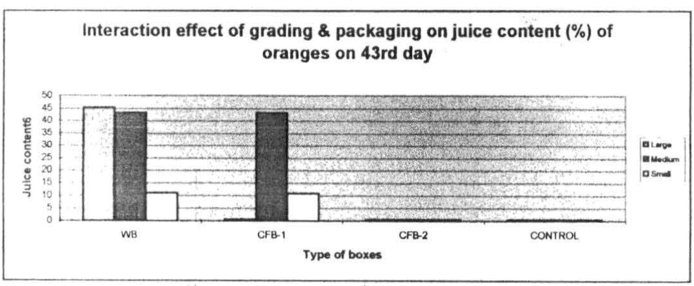
FIG NO. 2A



Interaction effects of grading and packaging on juice content (%) of oranges on 29th day



Interaction effect of grading & packaging on juice content (%) of oranges on the 36th day



Interaction effect of grading & packaging on juice content (%) of oranges on 43rd day

CFB-1 box packaged fruits, it was economical upto 35th day. Corrugated fibre box-2 packaging was also found to be economical upto 5th week of storage, while in case of control fruits, juice content was in acceptable limits upto 14th day only.

The interaction effect of grade with packaging reveals that large sized fruits responded to wooden box packaging upto 43rd day by keeping the juice content in economic limits. CFB-1 packaging was found good upto 36th day, while corrugated fibre box-2 packaged and control fruits were good in maintaining juice content in economic limits upto 29th and 15th days, respectively. In case of medium sized fruits, packaging with wooden boxes or CFB-1 boxes was equally good upto 43rd day, while corrugated fibre box-2 packaging and control were good upto 22nd day, CFB-1 box packaging were equally good upto 36th day, while corrugated fibre box-2 packaging and control were good upto 21st day and 15th day, respectively.

4.1.3 Chemical properties of Nagpur mandarin oranges

Chemical parameters analysed are recorded in Table 7. It is evident from this table that moisture present in fruits ranges from 75.80 per cent to 91.2 per cent depending upon the size of the fruits and ripening. Acidity varied from 0.43 per cent to 0.47 per cent. Reducing sugars were present in the range of 2.87 per cent to 3.52 pe cent whereas total sugars ranged between 4.97 to 5.32. Total soluble solids (T.S.S.^{0}B) recorded ranged between 10.0^{0}B to 12.5^{0}B and the average was 11.25^{0}B. Brix / acid ratio was ranging between 13.03 to 16.74. Ascorbic acid (Vitamin C) was recorded in the range of 26.18 to 42.20 mg/100 g juice.

Table 7 Chemical parametetrs of Nagpur Mandarin oranges at harvest

SR NO	Chemical parameters	Range	Average
1	Moisture percentage	75.80 to 91.12	83.46
2	T.S.S ^{0} Brix	10.00 ^{0}B to 12.5 ^{0}B	11.25
3	Acidity percentage	.43 to .47	.45
4	Reducing sugars percentage	2.87 to 3.52	3.19
5	Total sugar percentage	4.87 to 5.31	5.14
6	Ascorbic acid mg/100g juice	26.18 to 42.2	34.19
7	Total carotenoid pigments ug/100g juice	408.90 to 1080.5	744.7
8	^{0}Brix : Acid ratio	13.03 to 16.74	14.07

4.1.4 Effect of size grading and improved packaging on transportation and storability of oranges

4.1.4.1 Effect of size grading and packaging on physiological loss of weight.

Data presented in Table 8 on the mean physiological loss of weight index showed significant differences among different sizes of fruits at every stage of sampling during storage. In general there was a decline in the physiological loss of weight with progress in storage. On most of the days of sampling, small sized fruits showed more physiological loss of weight compared to other sizes. With regard to the effect of packaging material on physiological loss of weight, it was observed that the untreated fruits lost more weight till 8 days, beyond which fruits were unfit for storage. Among other packaging materials, the loss gradually increased upto 36 days with packaging in wooden boxes, 43 days with CFB-1 boxes, while CFB-2 box showed a decline after 21 days as shown in(Fig. NO 3) .

The interaction of grade with packaging material indicated a gradual increase in physiological loss of weight only with large sized fruits packed in wooden boxes with progressive increase in duration till 43rd day. For medium and small sized fruits similar trend could be observed till 43rd and 36th day, respectively. (Fig. NO.3A)

4.1.4.2 Effect of size grading and packaging on the firmness (texture) of fruits

Results from Table 9 depicting changes in texture or firmness of oranges indicated that there was a gradual decline in the texture expressed as forced required to penetrate the fruit in kg/cm^2 as the time progressed and fruits softened irrespective of the size or grade of the orange. Texture of large sized fruits in general was higher. When large and medium sized fruits could be stored upto 43 days and beyond and more than 36 days, respectively. It was

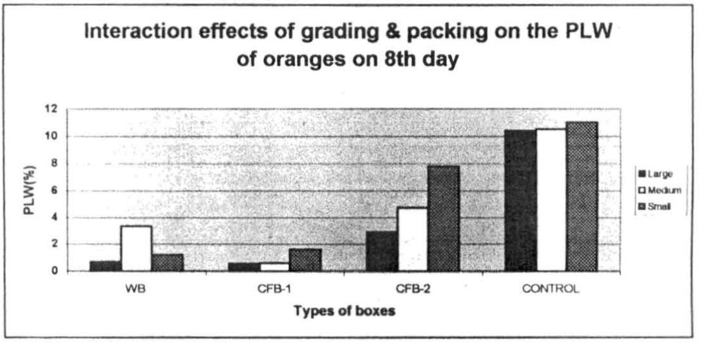
Table 8 : Mean and interaction effects of grading and packaging on the PLW (%) of oranges

Grade of fruit	8th day					15th day					22nd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	0.70	0.56	2.90	10.40	3.64	2.60	2.20	6.91	0.5	3.04	3.50	3.41	10.33	0.5	4.42
	(4.80)	(3.92)	(9.71)	(18.77)	(9.30)	(9.21)	(8.46)	(15.23)	(4.05)	(9.24)	(10.69)	(10.63)	(18.73)	(4.05)	(11.03)
Medium	3.34	0.60	4.70	10.50	4.78	4.73	1.52	10.30	0.50	4.30	6.40	2.30	10.71	0.50	5.00
	(10.51)	(4.27)	(12.53)	(18.86)	(11.54)	(12.55)	(7.07)	(18.68)	(4.05)	(10.59)	(14.58)	(8.65)	(19.09)	(4.05)	(11.59)
Small	1.17	1.60	7.80	11.03	5.40	3.72	3.51	10.30	0.5	4.50	5.50	5.50	10.61	0.50	5.52
	(6.22)	(7.17)	(16.17)	(19.53)	(12.28)	(11.11)	(10.79)	(18.70)	(4.05)	(11.16)	(13.50)	(13.56)	(19.00)	(4.05)	(12.53)
Mean	1.74	0.90	5.11	10.60	4.60	3.70	2.40	9.16	0.50	3.93	5.10	3.73	10.60	0.50	5.00
	(7.18)	(5.12)	(12.80)	(19.06)	(11.04)	(10.95)	(8.77)	(17.53)	(4.05)	(10.33)	(12.93)	(10.95)	(18.94)	(4.05)	
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.009	0.01	0.01			0.007	0.008	0.013			0.005	0.005	0.009	
CD (0.05)		0.02	0.02	0.04			0.01	0.021	0.037			0.013	0.014	0.025	

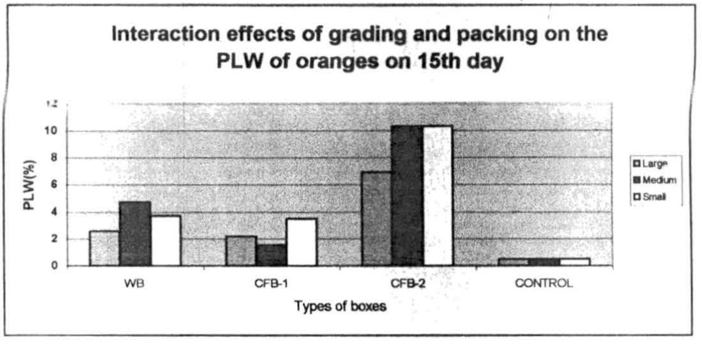
	29th day					36th day					43rd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	4.70	4.50	10.60	0.50	5.07	5.74	5.91	0.50	0.50	3.20	8.13	7.40	0.50	0.50	4.12
	(12.44)	(12.20)	(18.98)	(4.05)	(11.92)	(13.85)	(14.06)	(4.05)	(4.05)	(9.00)	(16.55)	(15.72)	(4.05)	(4.05)	(10.09)
Medium	7.41	4.30	0.50	0.50	3.20	8.75	2.62	0.50	0.50	3.84	10.40	8.81	0.50	0.50	5.04
	(15.79)	(11.92)	(4.05)	(4.05)	(8.95)	(17.18)	(13.70)	(4.05)	(4.05)	(9.74)	(18.76)	(17.25)	(4.05)	(4.05)	(11.03)
Small	6.93	7.20	0.50	0.50	3.80	10.42	8.41	0.50	0.50	5.00	10.60	10.20	0.50	0.50	5.50
	(15.26)	(15.52)	(4.05)	(4.05)	(9.72)	(18.82)	(16.84)	(4.05)	(4.05)	(10.94)	(18.97)	(18.64)	(4.05)	(4.05)	(10.85)
Mean	6.33	5.31	3.90	0.50	4.00	8.30	6.70	0.50	0.50	4.00	9.70	8.80	0.50	0.50	4.90
	(14.49)	(13.21)	(9.03)	(4.05)	(10.20)	(16.61)	(14.87)	(4.05)	(4.05)	(9.89)	(18.09)	(17.20)	(4.05)	(4.05)	(10.85)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.01	0.01	0.02			0.004	0.005	0.008			0.003	0.003	0.005	
CD (0.05)		0.03	0.03	0.06			0.01	0.01	0.02			0.007	0.08	0.014	

F- test significant at 5 % level　　Figures in brackets are angular transformed values

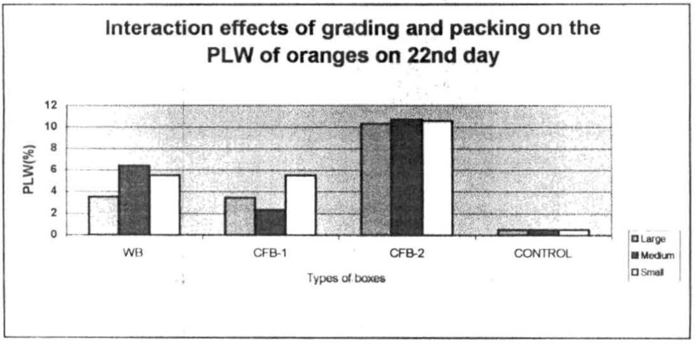
FIG NO. 3



Interaction effects of grading & packing on the PLW of oranges on 8th day
PLW(%)
12
10
8
6
4
2
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

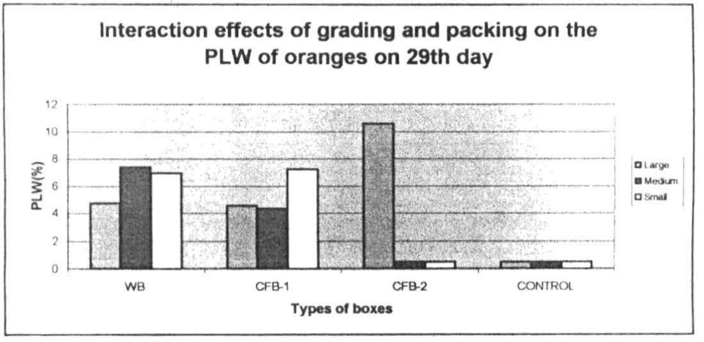


Interaction effects of grading and packing on the PLW of oranges on 15th day
PLW(%)
10
8
6
4
2
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Medium
Small

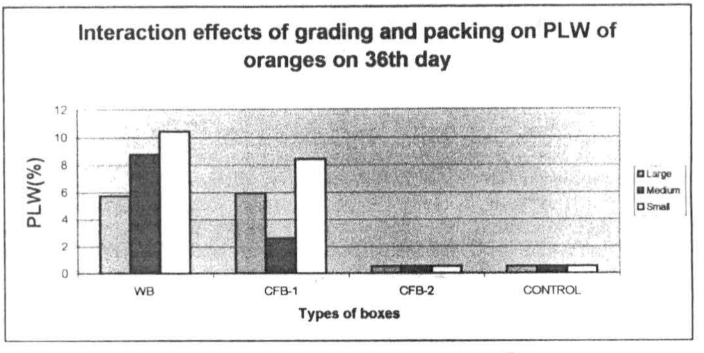


Interaction effects of grading and packing on the PLW of oranges on 22nd day
PLW(%)
12
10
8
6
4
2
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

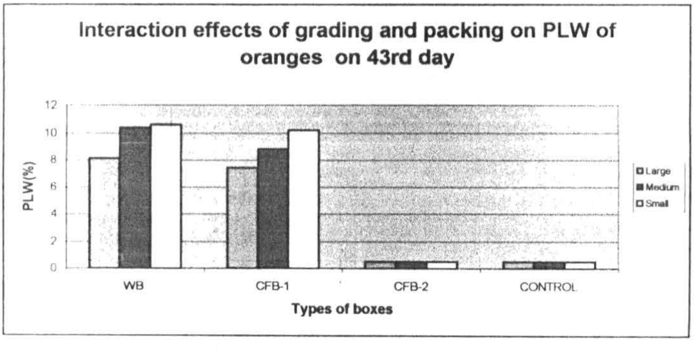
FIG NO. 3a



Interaction effects of grading and packing on the PLW of oranges on 29th day
12
10
8
6
4
2
0
PLW(%)
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small



Interaction effects of grading and packing on PLW of oranges on 36th day
12
10
8
6
4
2
0
PLW(%)
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small



Interaction effects of grading and packing on PLW of oranges on 43rd day
12
10
8
6
4
2
0
PLW(%)
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

Table 9 : Mean and interaction effects of grading and packaging on the firmness (kg/cm²) of oranges

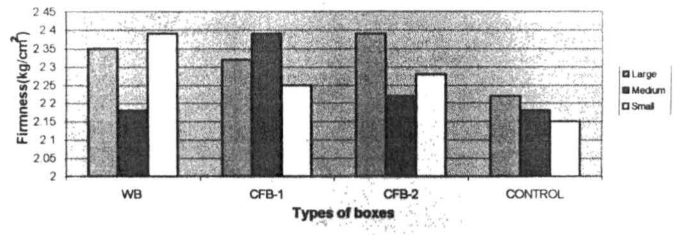
Grade of fruit	8th day					15th day					22nd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	2.35	2.32	2.39	2.22	2.32	2.25	2.25	2.35	--	1.54	2.28	2.32	2.25	--	1.54
	(1.69)	(1.68)	(1.70)	(1.65)	(1.68)	(1.66)	(1.66)	(1.69)	(0.70)	(1.43)	(1.67)	(1.68)	(1.66)	(0.70)	(1.43)
Medium	2.18	2.39	2.22	2.18	2.25	2.22	2.42	1.81	--	1.46	2.15	2.39	--	--	0.89
	(1.64)	(1.70)	(1.65)	(1.64)	(1.66)	(1.65)	(1.71)	(1.52)	(0.70)	(1.40)	(1.63)	(1.70)	(0.70)	(0.70)	(1.18)
Small	2.39	2.25	2.28	2.15	2.28	2.25	2.25	2.12	--	1.48	2.25	2.28	--	--	0.89
	(1.70)	(1.66)	(1.67)	(1.63)	(1.67)	(1.66)	(1.66)	(1.62)	(0.70)	(1.41)	(1.66)	(1.67)	(0.70)	(0.70)	(1.18)
Mean	2.32	2.32	2.28	2.18	2.28	2.25	2.32	2.09	--	1.48	2.25	2.32	0.54	--	1.08
	(1.68)	(1.68)	(1.67)	(1.64)	(1.67)	(1.66)	(1.68)	(1.61)	(0.70)	(1.41)	(1.66)	(1.68)	(1.02)	(0.70)	(1.26)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.00	0.00	0.01			0.00	0.01	0.01			0.00	0.00	0.01	
CD (0.05)		0.01	0.01	0.02			0.01	0.01	0.03			0.01	0.01	0.02	

	29th day					36th day					43rd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	2.28	2.25	2.32	--	1.54	2.25	2.15	--	--	0.86	2.18	2.12	--	--	0.86
	(1.67)	(1.66)	(1.68)	(0.70)	(1.43)	(1.66)	(1.63)	(0.70)	(0.70)	(1.17)	(1.64)	(1.62)	(0.70)	(0.70)	(1.17)
Medium	1.93	2.28	--	--	0.84	1.84	2.25	--	--	0.82	1.84	2.18	--	--	0.79
	(1.56)	(1.67)	(0.70)	(0.70)	(1.16)	(1.53)	(1.66)	(0.70)	(0.70)	(1.15)	(1.53)	(1.64)	(0.70)	(0.70)	(0.79)
Small	2.22	2.25	--	--	0.89	2.15	2.18	--	--	0.86	2.12	2.18	--	--	0.86
	(1.65)	(1.66)	(0.70)	(0.70)	(1.18)	(1.63)	(1.64)	(0.70)	(0.70)	(1.17)	(1.62)	(1.64)	(0.70)	(0.70)	(0.86)
Mean	2.12	2.25	0.56	--	1.06	2.09	2.18	--	--	0.74	2.06	2.15	--	--	0.84
	(1.62)	(1.66)	(1.03)	(0.70)	(1.25)	(1.61)	(1.64)	(0.70)	(0.70)	(1.16)	(1.60)	(1.63)	(0.70)	(0.70)	(1.16)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.00	0.01	0.01			0.00	0.00	0.01			0.00	0.00	0.01	
CD (0.05)		0.01	0.02	0.03			0.01	0.01	0.02			0.01	0.01	0.02	

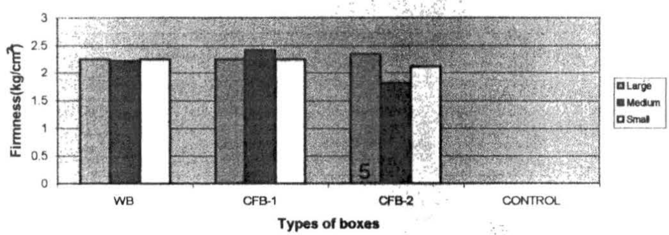
F- test significant at 5 % level Figures in brackets are angular transformed values

FIG NO. 4

Interaction effects of grading and packing on the firmness of oranges on 8th day



Interaction effects of grading and packing on firmness of oranges on 15 th day



Interaction effects of grading and packing on the firmness of oranges on 22nd day

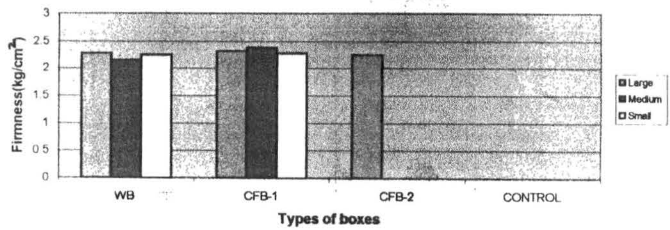
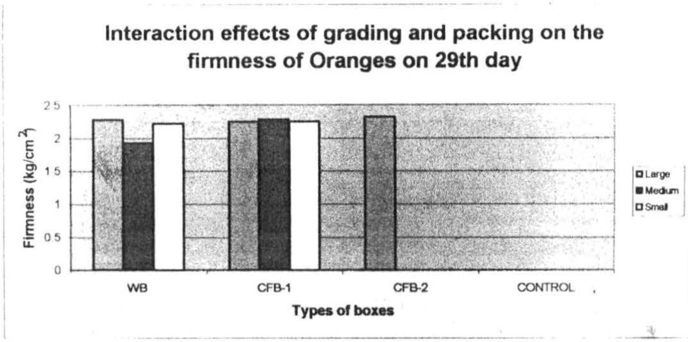
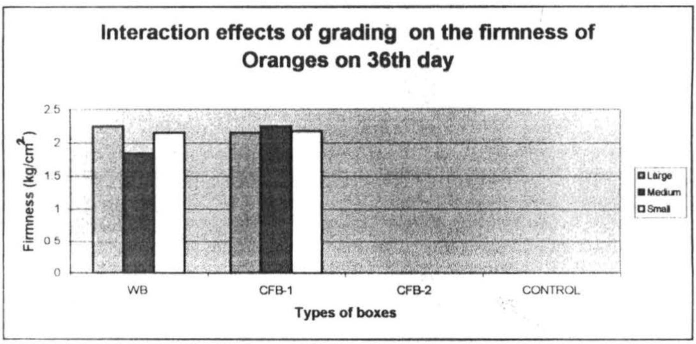


FIG NO. 4a


Interaction effects of grading and packing on the firmness of Oranges on 29th day
Firmness (kg/cm2)
2.5
2
1.5
1
0.5
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small


Interaction effects of grading on the firmness of Oranges on 36th day
Firmness (kg/cm2)
2.5
2
1.5
1
0.5
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

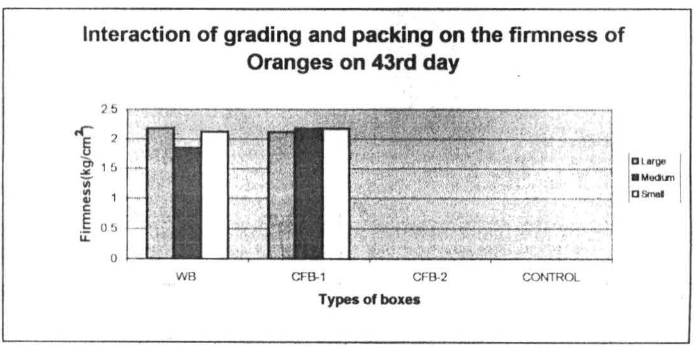

Interaction of grading and packing on the firmness of Oranges on 43rd day
Firmness(kg/cm2)
2.5
2
1.5
1
0.5
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

Table 10 Mean and interaction effects of grading and packaging on TSS °B of Oranges

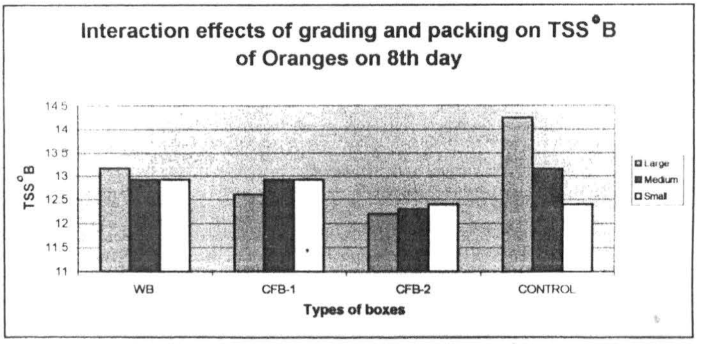
Grades	8th Day					15th Day					22nd Day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	13.16 (5.32)	12.60 (5.22)	12.20 (5.14)	14.24 (5.52)	13.04 (5.30)	13.58 (5.40)	15.12 (5.68)	14.78 (5.62)	14.64 (1.40)	9.20 (4.52)	14.78 (5.62)	16.28 (5.88)	15.92 (5.82)	- (1.40)	9.94 (4.68)
Medium	12.92 (5.24)	12.92 (5.24)	12.30 (5.16)	13.14 (5.32)	12.92 (5.24)	14.78 (5.62)	13.58 (5.40)	14.78 (5.62)	- (1.40)	9.20 (4.52)	15.92 (5.82)	15.12 (5.68)	14.78 (5.62)	- (1.40)	9.76 (9.02)
Small	12.92 (5.24)	12.92 (5.24)	12.40 (5.18)	12.40 (5.18)	12.52 (5.20)	13.58 (5.62)	7.58 (5.40)	12.72 (5.24)	- (1.40)	8.50 (4.36)	13.90 (5.46)	14.34 (5.54)	14.12 (5.50)	- (1.40)	9.20 (4.48)
Mean	12.84 (5.26)	12.92 (5.24)	12.30 (5.16)	13.24 (5.34)	12.82 (5.26)	14.00 (5.48)	14.12 (5.50)	14.12 (5.50)	- (1.40)	8.94 (4.46)	14.90 (5.64)	15.24 (5.70)	14.90 (5.64)	- (1.40)	
SE		G 0.0	P 0.0	G x P 0.02			G 0.0	P 0.0	G x P 0.0			G 0.0	P 0.0	G x P 0.02	
CD (0.01)		0.02	0.02	0.04			0.02	0.02	0.02			0.02	0.02	0.04	

F-test significant at 5%level. Figures in brackets are squared transformed values

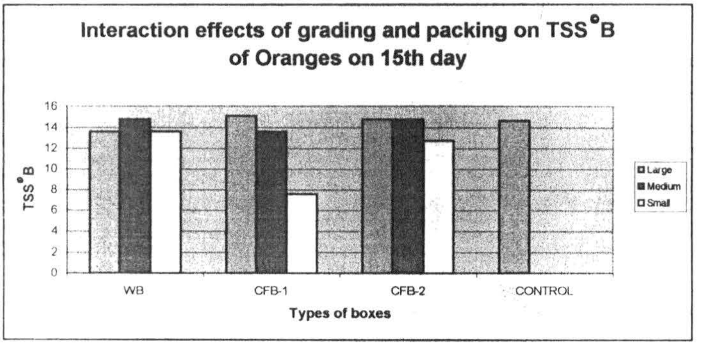
Grades	29th Day					36th Day					43nd Day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	16.28 (5.88)	16.76 (5.96)	17.12 (6.02)	* (1.40)	10.60 (2.82)	20.50 (6.56)	17.24 (6.12)	- (1.40)	- (1.40)	3.22 (3.86)	24.34 (7.12)	17.48 (6.08)	- (1.40)	- (1.40)	7.00 (4.0)
Medium	21.04 (6.64)	16.04 (5.84)	- (1.40)	- (1.40)	6.28 (3.82)	22.52 (6.86)	17.36 (6.06)	* (1.40)	* (1.40)	6.68 (3.92)	23.08 (6.94)	18.70 (6.28)	* (1.40)	* (1.40)	7.00 (4.0)
Small	16.04 (5.84)	16.04 (5.84)	- (1.40)	- (1.40)	5.54 (3.62)	17.60 (6.10)	17.48 (6.08)	* (1.40)	* (1.40)	5.98 (3.74)	18.14 (6.40)	20.38 (6.54)	* (1.40)	* (1.40)	6.76 (3.94)
Mean	17.72 (6.12)	16.28 (5.88)	3.32 (2.94)	* (1.40)	7.32 (4.08)	20.24 (6.52)	17.36 (6.06)	- (1.40)	* (1.40)	6.36 (3.94)	22.24 (6.82)	18.84 (6.30)	* (1.40)	* (1.40)	6.92 (3.98)
SE		G 0.02	P 0.02	G x P 0.04			G 0.0	P 0.0	G x P 0.0			G 0.0	P 0.0	G x P 0.02	
CD (0.01)		0.06	0.08	0.12			0.02	0.02	0.02			0.02	0.02	0.04	

F-test significant at 5%level. Figures in brackets are squared transformed values

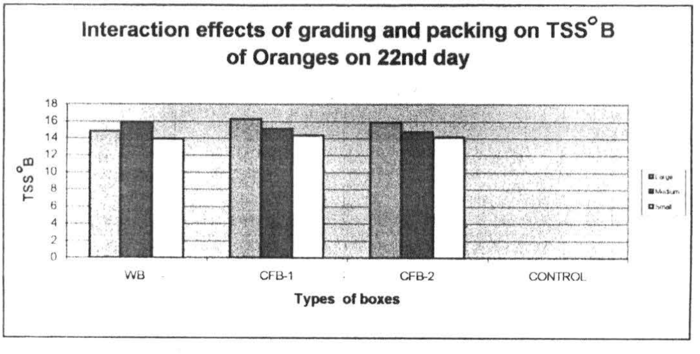
FIG NO. 5



Interaction effects of grading and packing on TSS°B of Oranges on 8th day
TSS°B
14.5
14
13.5
13
12.5
12
11.5
11
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

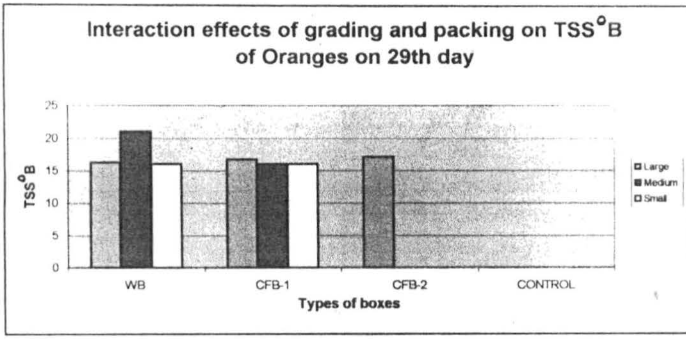


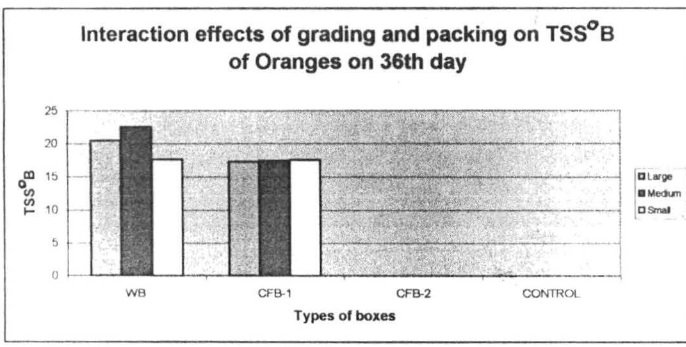
Interaction effects of grading and packing on TSS°B of Oranges on 15th day
TSS°B
16
14
12
10
8
6
4
2
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

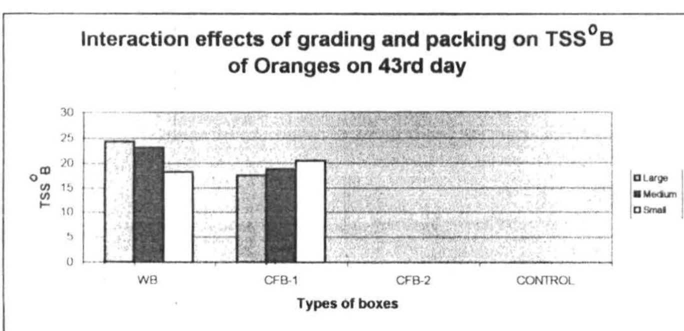


Interaction effects of grading and packing on TSS°B of Oranges on 22nd day
TSS°B
18
16
14
12
10
8
6
4
2
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes

FIG NO. 5a


Interaction effects of grading and packing on TSS°B of Oranges on 29th day
TSS°B
25
20
15
10
5
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small


Interaction effects of grading and packing on TSS°B of Oranges on 36th day
TSS°B
25
20
15
10
5
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small


Interaction effects of grading and packing on TSS°B of Oranges on 43rd day
TSS°B
30
25
20
15
10
5
0
WB
CFB-1
CFB-2
CONTROL
Types of boxes
Large
Medium
Small

not possible to store small sized fruits beyond 36 days in respect to maintaining the texture quality of fruits within reasonable limits.

With respect to the packaging, it was observed in general that traditional wooden boxes proved to be significantly superior to CFB-1 type of cartons only in respect of texture of the fruits. CFB-2 type of cartons were found to be very good. Control fruits recorded significantly lower texture, where it was not possible to store fruits beyond eight days. Fruits in corrugated fibre board boxes (type 1) could not retain the best texture beyond 29 days.

The data on interaction of grading and packaging showed that for large sized fruits the firmness of the fruits can be maintained upto 43 days with wooden packages, while in initial stages (say upto 29 days), packaging with any type of container proved equally good and significantly superior to control. The firmness of medium sized fruits can be retained upto 43 days by packing them with CFB-1 type of boxes followed by that with wooden boxes. The corrugated fibre box-2 packaging was as poor as untreated control for medium sized fruits after 14 days. On the other hand, small sized fruits could be preserved with acceptable texture with any packaging material up to 15 days, followed by either packaging with CFB-1 boxes or wooden boxes upto 43 days. Any packaging material had no relevance in maintaining firmness beyond 43 days.(Fig.No4, Fig.No4A)

4.1.4.3 Effect of grading and packaging on total soluble solids of fruits

Results presented in Table-10 on the TSS content of orange show that the TSS was significantly higher in large sized fruits over other sizes during most of the period in storage, followed by medium sized fruits. While TSS content of large sized fruits increased upto 43rd day respectively, in case of medium and small sized fruits, it increased upto 36th and 29th day. The TSS content of fruits gradually increse upto 43rd day by adopting wooden boxes, while CFB-1 box packing could promote higher TSS content beyond 43 days. On the other hand corrugated fibre box-2 packing could retain higher TSS till 21st day, while in control it was possible only till 8th day.

The interaction effect of grade with packaging highlighted that medium and large sized fruits can be stored under ambient conditions maintaining high TSS values without any type of packaging material upto 8 days. The large sized fruits could be effectively stored upto 43 days in CFB-1 box packaging and upto 28th day with corrugated fibre box-2 packaging. However, this group significantly responded well to TSS content even with wooden boxes packaging from 36th to 43rd day, whereas medium sized fruits indicated TSS content from 14th to 43rd day. Highest TSS content was recorded with large sized fruits packed with wooden boxes after 43 days storage. (Fig. No.5 ,5A)

4.1.4.4 Effect of grading and packaging on acidity of oranges

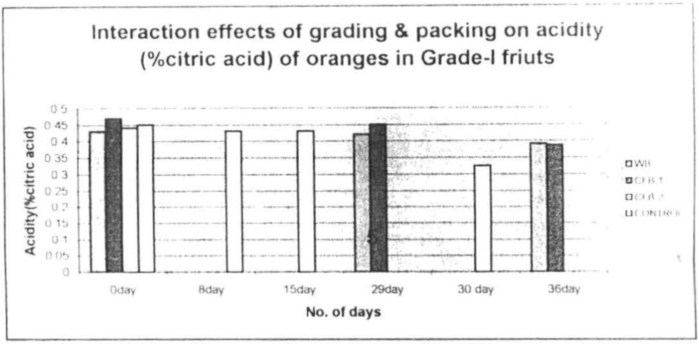
Results from Table 11 on the changes in acidity during storage revealed that in general there was reduction in acidity during the entire storage period. In case of large sized fruits, with wooden box packaging, the acidity reduced from the initial 0.43 to 0.39 per cent at the end of storage period ; for CFB-1 packaged fruits, the reduction was from initial 0.47 to 0.39 per cent after 43 days ; and for corrugated fibre box-2 packaged fruits the reduction in acidity was from initial 0.44 to 0.324 per cent on 29th day, while in untreated control fruits the reduction was from initial 0.45 to 0.43 per cent on 7th day.

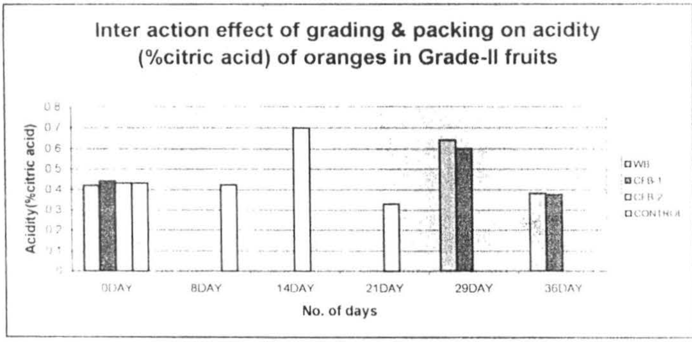
Similar trend in reduction in acidity was observed in case of medium sized fruits, where in wooden box packaged fruits recorded reduction in acidity from initial level of 0.42 to 0.30 per cent after 43 days ; with CFB-1 box packaging, the reduction was from 0.44 to 0.37 per cent on 43rd day ; with corrugated fibre box-2 packaged fruits the reduction was from initial level of

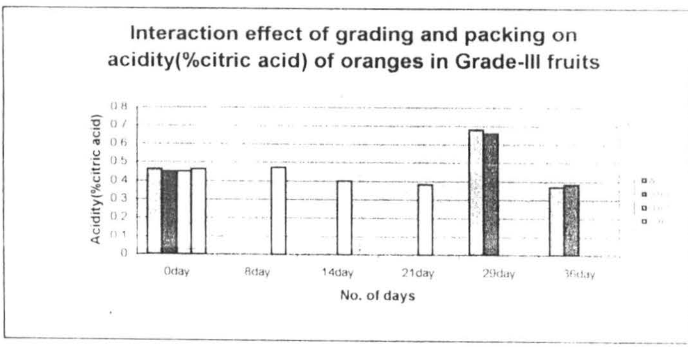
Table 11 : Interaction effect of grading and packaging on acidity (% citric acid) of oranges

Grade I fruits (Large)				Grade II fruits (Medium)				Grade III fruits (Small)			
WB	0 day 0.43	29 day 0.42	36 day 0.390	WB	0 day 0.42	29 day 0.64	36 day 0.38	WB	0 day 0.46	29 day 0.68	36 day 0.37
CFB-1	0 day 0.47	29 day 0.45	36 day 0.386	CFB-1	0 day 0.44	29 day 0.60	36 day 0.374	CFB-1	0 day 0.45	29 day 0.66	36 day 0.382
CFB-2	0 day 0.44	15 day 0.43	30 day 0.324	CFB-2	0 day 0.43	14 day 0.698	21 day 0.328	CFB-2	0 day 0.45	14 day 0.398	21 day 0.380
Control	0 day 0.45	8 day 0.430	--	Control	0 day 0.43	8 day 0.422	--	Control	0 day 0.46	8 day 0.47	

FIG NO. 6


Interaction effects of grading & packing on acidity (%citric acid) of oranges in Grade-I friuts
Acidity(%citric acid)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0day
8day
15day
29day
30 day
36day
No. of days
WB
CFB-1
CFB-2
CONTROL


Inter action effect of grading & packing on acidity (%citric acid) of oranges in Grade-II fruits
Acidity(%citric acid)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0DAY
8DAY
14DAY
21DAY
29DAY
36DAY
No. of days
WB
CFB-1
CFB-2
CONTROL


Interaction effect of grading and packing on acidity(%citric acid) of oranges in Grade-III fruits
Acidity(%citric acid)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0day
8day
14day
21day
29day
36day
No. of days

0.43 to 0.328 per cent on 22nd day. In case of untreated control fruits, the reduction was from an initial level of 0.43 to 0.42 per cent on 7th day.

Likewise, in case of small sized fruits, with wooden box packaging, acidity decreased from an initial level of 0.46 to 0.37 per cent on 43rd day. With CFB box -1 packaged fruits the reduction in acidity was from initial 0.45 to 0.38 per cent after 43 days. In case of corrugated fibre box-2 packaged fruits the reduction in acidity was from 0.45 per cent initial level to 0.38 per cent on 22nd day, while in untreated control there was a slight increase in acidity from initial 0.46 per cent to 0.47 per cent. (Fig. 6)

4.1.4.5 Effect of grading and packaging on total sugar of oranges

Results from Table-12 revealed that in general all grades of fruits under all treatments showed an increasing trend in total sugar content during the storage period.

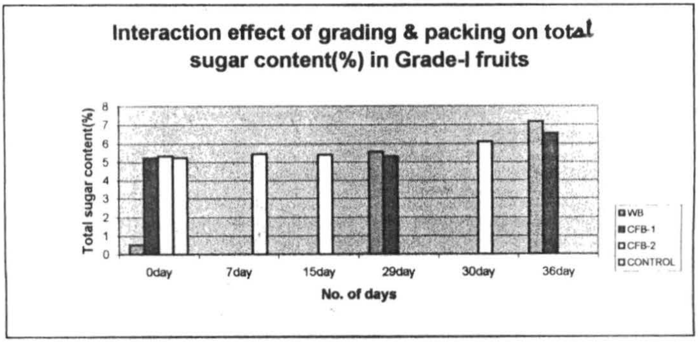
In case of large sized fruits with wooden box packaging, the total sugars content increased from an initial level of 4.97 to 7.17 per cent towards the end of storage life. Similarly, the total sugars content of CFB-1 packaged fruits increased from 5.21 to 6.54 per cent. Likewise the total sugar content of corrugated fibre box-2 packaged fruits and control fruits increased from initial levels of 5.31 per cent to 6.02 per cent (30th day) and 5.42 per cent (7th day), respectively.

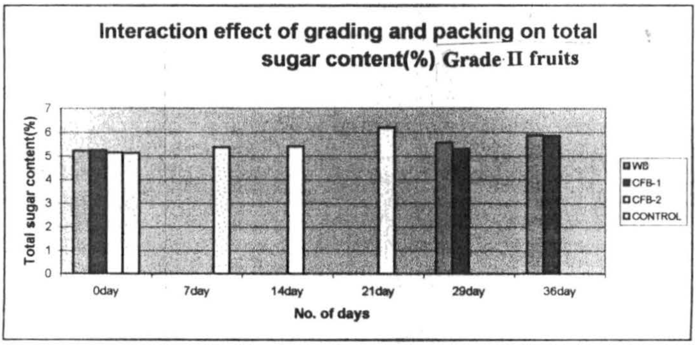
In case of medium sized fruits, with wooden box and CFB-1 packaging there was an increase in total sugars content from initial levels of 5.22 per cent and 5.25 per cent to 5.88 per cent and 5.86 per cent, respectively after 36 days. In corrugated fibre box-2 pakcaged fruits and untreated fruits, there was increase in total sugars content from 5.14 per cent and 5.12 per cent initial levels to 6.20 per cent (22nd day) and 5.38 per cent (8th day), respectively. (Fig.7)

Table 12 : Interaction effect of grading and packaging on total sugar content (%) of oranges

Grade I fruits				Grade II fruits				Grade III fruits			
	0 day	29 day	36 day		0 day	29 day	36 day		0 day	29 day	36 day
WB	4.97	5.54	7.17	WB	5.22	5.57	5.88	WB	5.10	5.60	6.81
	0 day	29 day	36 day		0 day	29 day	36 day		0 day	29 day	36 day
CFB-1	5.21	5.29	6.54	CFB-1	5.25	5.30	5.86	CFB-1	5.12	5.31	5.89
	0 day	15 day	30 day		0 day	14 day	21 day		0 day	14 day	21 day
CFB-2	5.31	5.37	6.07	CFB-2	5.14	5.41	6.20	CFB-2	5.21	5.39	6.12
	0 day	7 day			0 day	7 day			0 day	7 day	
Control	5.21	5.42	--	Control	5.12	5.38	--	Control	5.22	5.41	

FIG NO. 7


Interaction effect of grading & packing on total sugar content(%) in Grade-I fruits
Total sugar content(%)
0
1
2
3
4
5
6
7
8
0day
7day
15day
29day
30day
36day
No. of days
WB
CFB-1
CFB-2
CONTROL


Interaction effect of grading and packing on total sugar content(%) Grade II fruits
Total sugar content(%)
0
1
2
3
4
5
6
7
0day
7day
14day
21day
29day
36day
No. of days
WB
CFB-1
CFB-2
CONTROL

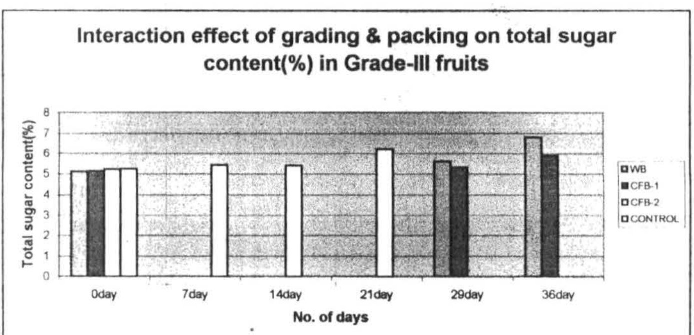
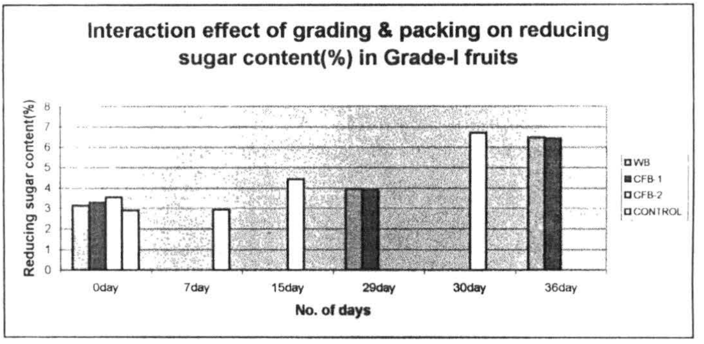
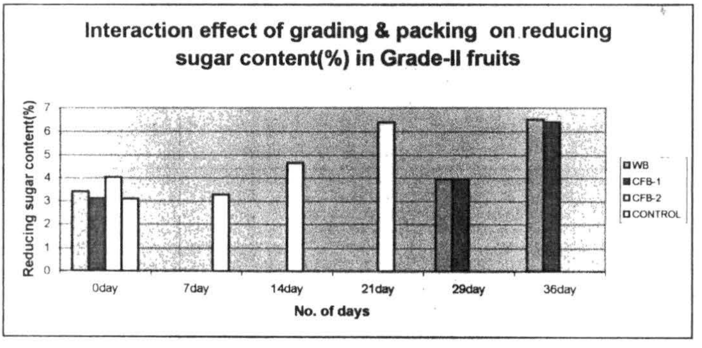
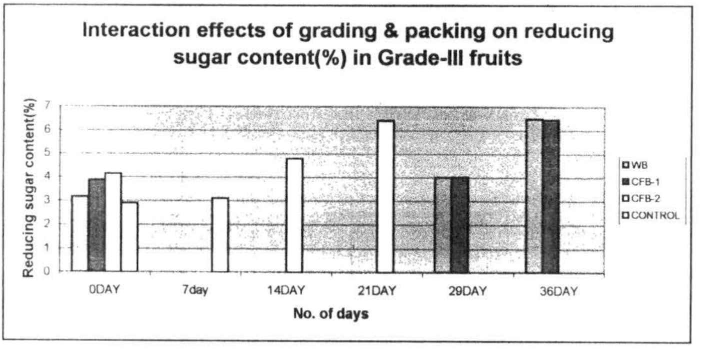

Interaction effect of grading & packing on total sugar content(%) in Grade-III fruits
Total sugar content(%)
0
1
2
3
4
5
6
7
8
0day
7day
14day
21day
29day
36day
No. of days
WB
CFB-1
CFB-2
CONTROL

FIG NO. 8


Interaction effect of grading & packing on reducing sugar content(%) in Grade-I fruits
Reducing sugar content(%)
0
1
2
3
4
5
6
7
8
0day
7day
15day
29day
30day
36day
No. of days
WB
CFB-1
CFB-2
CONTROL


Interaction effect of grading & packing on reducing sugar content(%) in Grade-II fruits
Reducing sugar content(%)
0
1
2
3
4
5
6
7
0day
7day
14day
21day
29day
36day
No. of days
WB
CFB-1
CFB-2
CONTROL


Interaction effects of grading & packing on reducing sugar content(%) in Grade-III fruits
Reducing sugar content(%)
0
1
2
3
4
5
6
7
0DAY
7day
14DAY
21DAY
29DAY
36DAY
No. of days
WB
CFB-1
CFB-2
CONTROL

Likewise, in case of small sized fruits, total sugars content in wooden box packaged, fruits increased from initial 5.10 to 6.81 per cent on 43rd day ; fruits with CFB-1 packaging revealed that there was an increase in total sugars content from initial level of 5.12 to 5.89 per cent after 43 days, corrugated fibre box-1 packaged, fruits initial total sugar content of 5.21 increased to 6.12 per cent on 22nd day, while in case of control fruits, there was increase in total sugars content from 5.22 per cent initial level to 5.41 per cent on 8th day.

4.1.4.6 Reducing sugars

Results from Table 13 revealed that in general all grades of fruits under all treatments showed an increase in reducing sugars content during their storage period.

Large sized fruits with wooden box packaging revealed an increase in reducing sugars content from initial level of 3.12 per cent to 6.47 per cent after 36 days ; while CFB-1 packaged fruits showed an increase in total sugar content from initial 3.26 per cent to 6.43 per cent also after 50 days. Corrugated fibre box-1 packaged fruit showed an increase in reducing sugar content from an initial level of 3.52 per cent to final level of 6.70 per cent on 30th day. Reducing sugar content in control fruits increased from an initial level of 2.87 per cent to 2.91 per cent on 8th day.

In case of medium sized fruits, packaging with wooden boxes resulted in an increase in reducing sugar content from initial 3.41 per cent to 6.51 per cent after 36 days, while in CFB-1 box packaged fruits, it increased from initial 3.12 per cent to 6.49 per cent also after 43 days. In case of corrugated fibre box-1 packaged fruits the reducing sugar content increased from initial level of 4.02 per cent to 6.39 per cent on 21st day. In case of control fruits, the increase in reducing sugar content was from an initial level of 3.1 per cent to 3.28 per cent on 29th day.

Table 13 : Interaction effect of grading and packaging on reducing sugar content (%)

Grade I fruits				Grade II fruits				Grade III fruits			
	0 day	29 day	36 day		0 day	29 day	36 day		0 day	29 day	36 day
WB	3.12	3.94	6.47	WB	3.41	3.96	6.51	WB	3.17	3.99	6.50
	0 day	29 day	36 day		0 day	29 day	36 day		0 day	29 day	36 day
CFB-1	3.26	3.91	6.43	CFB-1	3.12	3.97	6.49	CFB-1	3.87	4.02	6.46
	0 day	15 day	30 day		0 day	14 day	21 day		0 day	14 day	21 day
CFB-2	3.52	4.42	6.70	CFB-2	4.02	4.64	6.39	CFB-2	4.12	4.78	6.42
	0 day	7 day			0 day	7 day			0 day	7 day	
Control	2.87	2.91	--	Control	3.10	3.28	–	Control	2.89	3.10	

With regard to small sized fruits, in case of wooden box packaged fruits the increase in reducing sugar content was from initial 3.17 to 6.50 per cent on 36th day, while in case of CFB-1 packaged fruits it increased from initial 3.87 to 6.46 per cent at the end of storage. Likewise, in case of corrugated fibre box-2 packaged fruits, the reducing sugar content increased from initial 4.12 to 6.42 per cent on 21st day ; while in case of control fruits, the increase was from 2.89 to 3.1 per cent on 8th day.(Fig. No 8)

4.1.5 Organoleptic evaluation

Data presented in Table 14 on the changes in scoring showed marked superiority on large sized fruits followed by medium sized fruit at most stages of storage. However, acceptable scoring was observed only upto 8th day in respect of all the grades.

On the other hand, packaging of fruits either with wooden boxes or with CFB-1 boxes could result in superior rating upto 43rd day. The corrugated fibre box-2 packaging was also significantly superior till 15th day while control was best only upto 8th day as can be seen in Table 14.

Data on interaction of grading and packaging indicated that fruits in control scored highest points only upto 8th day. Ratings were at par in large and medium sized fruits and were significantly superior to small ones.

The corrugated fibre box-2 packaging resulted in significantly superior rating with respect to medium sized fruits, followed by large sized fruits till 29th day, while for small fruits this packaging was significantly effective only till 15th day.

Table 14 : Mean and interaction effects of grading and packaging on the organoleptic scoring of oranges

Grade of fruit	8th day					15th day					22nd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	2.81	2.77	3..07	3.9	3.14	3.14	3.26	3.18	-	2.12	3.74	3.86	4.03	-	2.52
	(1.82)	(1.81)	(1.89)	(2.12)	(1.91)	(1.91)	(1.94)	(1.92)	(0.70)	(1.62)	(2.06)	(2.09)	(2.13)	(0.70	(1.74)
Medium	2.95	2.81	4.03	3.03	3.18	3.30	3.23	4.12	--	2.35	3.62	3.66	--	--	1.38
	(1.86)	(1.82)	(2.13)	(1.88)	(1.92)	(1.95)	(1.94)	(2.15)	(0.70)	(2.35)	(2.03)	(2.04)	(0.70)	(0.70)	(1.37)
Small	2.63	2.81	4.03	3.07	3.11	2.84	3.11	4.20	--	2.22	3.11	3.74	--	--	1.29
	(1.77)	(1.82)	(2.05)	(1.89)	(1.90)	(1.83)	(1.90)	(1.17)	(0.70)	(2.22)	(1.90)	(2.06)	(0.70)	(0.70)	(1.34)
Mean	2.77	2.77	3.70	3.34	3.14	3.11	3.22	3.82	--	2.22	3.50	3.74	0.80	--	1.465
	(1.81)	(1.81)	(2.04)	(1.90)	(1.91)	(1.90)	(1.93)	(2.08)	(0.70)	(2.22)	(2.00)	(2.06)	(1.17)	(0.70)	(1.48)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.01	0.01	0.01			0.00	0.01	0.01			0.00	0.01	0.02	
CD (0.05)		0.02	0.02	0.03			0.01	0.02	0.03			0.02	0.03	0.05	

	29th day					36th day					43rd day				
	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean	WB	CFB-1	CFB-2	Control	Mean
Large	3.62	4.34	3.54	-	2.49	4.07	4.07	-	-	1.51	4.16	4.16	-	-	1.54
	(2.03)	(2.20)	(2.01)	(0.70)	(1.73)	(2.14)	(2.14)	(0.70)	(0.70)	(1.42)	(2.16)	(2.16)	(0.70)	(0.70)	(1.43)
Medium	3.91	3.95	-	-	1.46	4.16	4.07	-	-	1.54	4.16	4.29	-	-	1.57
	(2.10)	(2.11)	(0.70)	(0.70)	(1.40)	(2.16)	(2.14)	(0.70)	(0.70)	(1.43)	(2.16)	(2.19)	(0.70)	(0.70)	(1.44)
Small	3.62	4.12	-	-	1.43	4.42	4.42	-	-	1.63	4.42	4.38	-	-	1.63
	(2.03)	(2.15)	(0.70)	(0.70)	(1.39)	(2.22)	(2.22)	(0.70)	(0.70)	(1.46)	(2.22)	(2.21)	(0.70)	(0.70)	(1.46)
Mean	3.70	4.12	0.79	-	1.78	4.25	4.20	-	-	1.57	4.25	4.29	-	-	1.57
	(2.05)	(2.15)	(1.14)	(0.70)	(1.51)	(2.18)	(1.17)	(0.70)	(0.70)	(1.44)	(2.18)	(2.19)	(0.70)	(0.70)	(1.44)
		G	P	G X P			G	P	G X P			G	P	G X P	
SE		0.01	0.01	0.01			0.00	0.01	0.01			0.00	0.01	0.01	
CD (0.05)		0.02	0.02	0.04			0.01	0.01	0.03			0.01	0.02	0.03	

CFB-1 box packaging of fruits was effective for larger and medium sized fruits up to 43 days. While small fruits retained their admissible rating till 43rd day when packaged with CFB-1 boxes.

With respect to the effect of packaging with wooden boxes it was effective for large, medium and small sized fruits till 36, 29 and 22nd days, respectively.

4.2 MANGO

The experimental results of trials on processing by pre-treatments of Ratna, Bombay green and Mallika varieties of mango are presented as follows.

4.2.1 Physical characteristics of mango fruits at harvest and on ripening

4.2.1.1 Physical parameters at harvest

The data on various physical parameter studied are presented in Table 15.

4.2.1.1.1 Weight of fruit

On perusal of the data, it is observed that Mallika fruits were characterised with maximum fruit weight in both the years (340.00 g and 325.70 g, respectively) followed by Bombay green (280.00 g and 225.88 g) while Alphonso fruits recorded the minimum (225.90 g and 245.00 g).

4.2.1.1.2 Volume of fruit

The pattern in the volume of fruit belonging to different varieties was more or less similar to that of fruit weight. The variety Mallika recorded maximum volume (330.50 ml) followed by Bombay green (204.60 ml) and minimum was recorded in Ratna (225.90 ml) during 1995, similar trend was observed for the volume of fruit in the year 1996.

Table 15 : Physical characteristics of different varieties of mango at harvest during 1995 and 1996 (Average of 10 fruits)

Particulars	Ratna		Bombay green		Mallika	
	1995	1996	1995	1996	1995	1996
Weight of fruit (g)	228.22	225.80	280.00	295.88	340.00	325.70
Volume of fruit (ml)	225.90	245.00	204.60	210.00	330.50	308.00
Specific gravity	1.00	1.00	1.03	1.03	1.02	1.02
Length of fruit (cm)	9.20	9.64	12.00	13.25	15.40	16.08
Breadth of fruit (cm)	5.50	7.50	8.00	7.80	6.60	6.70
Width of fruit (cm)	6.80	7.25	8.00	7.75	8.60	8.50
Colour of peel	SG 86ϕ	SG 86ϕ	SG 86ϕ	SG 86ϕ	SG 86ϕ	SG 86ϕ
Colour of pulp	YW	YW	FY	FY	YW	YW
Firmness of fruit (kg / cm^2)	30.00	30.00	28.00	29.00	30.00	29.00

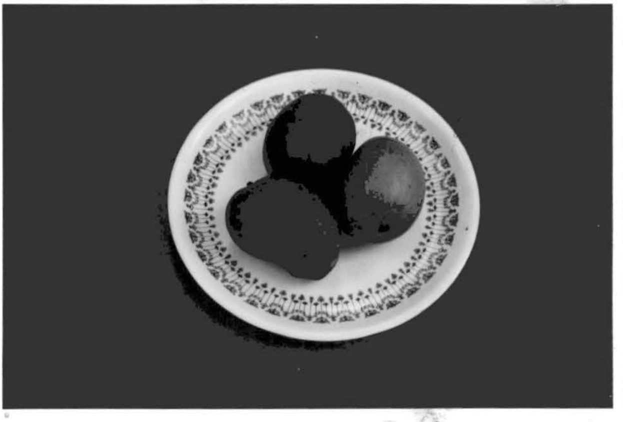
Note :

SG : Scheeles Green

YW : Yellowish white

FY : Faint yellow

Plate 3a : Mango hybrid Ratna at Harvest



4.2.1.1.3 Specific gravity

In all the varieties studied, the specific gravity was more than 1.00 and it ranged between 1.03 (Bombay green) and 1.00 (Ratna) (Table 15) during both the years of study. Further, very little differences in specific gravity were noticed among the varieties.

4.2.1.1.4 Length of fruit

The data from Table 15 reveal that the Mallika fruits recorded maximum fruit length (15.40 cm and 16.08 cm) followed by Bombay green (12.00 cm and 13.25 cm). However, Ratna fruits were characterised by the minimum fruit length (9.20 and 9.64 cm) at harvest in both the years of study.

4.2.1.1.5 Breadth of fruit

Distance between the cheeks represents the breadth of fruit which was higher in Bombay green fruits (8.00 and 7,80 cm) and lowest, in Mallika fruits (6.60 cm and 6.70 cm) during 19095 and 1996, respectively.

4.2.1.1.6 Width of fruit

It is clear from the Table 15 that Mallika fruits recorded maximum width (8.60 cm and 8.50 cm) while minimum was recorded in Ratna (6.80 and 7.25 cm) at harvest during 1995 and 1996, respectively.

4.2.1.1.7 Colour of peel

The data pertaining to the colour of peel (Table 15) depicted that at harvest Ratna and Mallika fruits were characterised by Scheeles green colour while little lighter Scheeles green was recorded for Bombay green variety in both the years of study.

4.2.1.1.8 Colour of pulp

The change in the colour of the pulp of all the varieties is given in Table 15. It was observed that Ratna and Mallika fruits were similar with respect to pulp colour at harvest, while Bombay green variety exhibited faint yellow colour during both the years of study.

4.2.1.1.9 Firmness of fruit

The data of the firmness of fruit of different varieties are given in Table 15. The maximum firmness was observed in Ratna (30.00 kg/cm^2 and 30.00 kg/cm^2) while, variety Bombay green recorded minimum (28.00 kg/cm^2 and 29.00 kg/cm^2) during 1995 and 1996.

4.2.1.2 Physical parameters on ripening

Data representing the physical parameters on ripening are indicated in Table 16.

4.2.1.2.1 Weight of peel

It is evident from the data presented in Table 16 that the Bombay green mango fruits on ripening recorded highest weight of peel (35.15 g and 40.00 g) followed by Mallika (35.00 g and 34.80 g) whereas, Ratna fruits were characterised by the lowest weight of peel (25.50 g and 30.00g) during 1995 and 1996.

4.2.1.2 .2 Weight of pulp

The data corresponding to the weight of pulp of mango fruits on ripening (Table 16) indicated that the Mallika fruits produced higher quantity of pulp (210.70 g and 220.78 g, respectively) followed by Bombay green (200.00 g and 205.46 g) while lower pulp weight was observed in Ratna fruits (150.80 g and 140.90 g) in 1995 and 1996.

4.2.1.2.3 Weight of stone

It is evident from the data presented in Table 16 that the weigh of stone of Mallika fruits was maximum (40.10 g) followed by Bombay green and

Plate 3b : Mango hybrid Ratna on Ripening

Table 16 : Physical characteristics of different varieties of mango on Ripening during 1995 and 1996

Particulars	Ratna		Bombay green		Mallika	
	1995	1996	1995	1996	1995	1996
Weight of peel (g)	25.50	30.00	35.15	40.00	35.00	34.80
Weight of pulp (g)	150.80	14090	200.00	205.46	210.70	220.78
Weight of stone (g)	25.10	28.30	36.90	30.90	40.10	38.12
Pulp to stone ratio	4.80	4.97	5.69	6.64	5.05	5.79
Pulp to peel ratio	5.91	4.69	5.97	5.13	5.80	6.21
Colour of pulp	SY	SY	IY	IY	IY	IY
Length of stone (cm)	7.50	6.80	8.20	8.30	9.98	10.54
Breadth of stone (cm)	2.00	1.50	1.80	2.00	1.80	2.15
Width of stone (cm)	2.80	1.95	3.30	2.60	3.86	4.50
Firmness of fruit (lbs/sq. inch)	18.50	17.00	12.50	12.75	16.50	16.00

Note : Average of 10 fruits

SY : Saffron yellow

IY : Indian yellow

minimum (25.10 g) was recorded in Ratna fruits during 1995. Similar pattern of weight of stone was recorded during the subsequent year, 1996.

4.2.1.2.4 Pulp to stone ratio

The values for pulp to stone ratio recorded on ripening of fruits are presented in Table –16.

The data revealed that Bombay green recorded maximum pulp to stone ratio (5.69) followed by Mallika (5.05) and minimum was observed in Ratna (4.80) during 1995. However, in 1996 higher values of 6.64, 5.79 and 4.97 were observed in Bombay green, Mallika and Ratna varieties, for pulp to stone ratio, respectively.

4.2.1.2.5 Pulp to peel ratio

It is clear from the Table 16 that the variety Mallika ranked first (5.80) followed by Bombay green and last was Ratna (5.971) during 1995. Slightly higher values were recorded during 1996.

4.2.1.2.6 Colour of the pulp

The data presented in Table 16 reflects that the pulp of Ratna variety exhibited Saffron yellow colour which is most desirable while Bombay green and Mallika varieties were characterised by Indian yellow colour on ripening during both the years.

4.2.1.2.7 Length of stone

The data furnished in the Table 16 indicated that the length of stone on ripening ranged from 7.50 cm in Ratna to 9.98 cm in Mallika during 1995. Whereas in the subsequent year it varied from 6.60 in Ratna to 10.54 cm in Mallika.

4.2.1.2.8 Breadth of stone

Maximum breadth (2.00 cm) was recorded in Ratna followed by Mallika and Bombay green and the minimum (1.80 cm) was noticed in Bombay green and Mallika during 1995. Not much differences were found in the subsequent year 1996 (Table 16).

4.2.1.2.9 Width of stone

Table 16 reveals that the width of the stone on ripening was highest in Mallika fruit (3.86 and 4.50 cm) followed by Bombay green and the lowest width was recorded by Ratna fruits (2.80 and 1.95 cm) during 1995 and 1996.

4.2.1.2. 10 Firmness of fruit

The data of firmness of Ratna, Bombay green and Mallika as influenced by ripening are given in Table 16.

The maximum firmness (18.50 lbs/ sq. inch) was observed in Ratna variety followed by Mallika (16.50 lbs/sq. inch) and the minimum (12.50 lbs/sq. Inch) was observed in Bombay green during 1995. Similar pattern was observed in the subsequent year for firmness of fruits of different varieties under study.

4.2.2 Chemical composition of mango fruits at harvest and on ripening

4.2.2.1 Chemical composition of mango fruits at harvest

The data pertaining to the chemical composition of mango varieties at harvest are presented in Table 17.

4.2.2.1.1 Moisture

The variety Ratna recorded maximum moisture content (82.90 %) followed by Bombay green (78.20 %) while Mallika fruits recorded the minimum (75.80 %) during 1995. Similar trend was observed during 1996.

Plate 4a : Mango variety Bombay green at harvest

Table 17 : Chemical composition of different mango varieties at Harvest during 1995 and 1996

Particulars	Ratna		Bombay green		Mallika	
	1995	1996	1995	1996	1995	1996
Moisture (%)	82.90	83.10	78.20	79.30	75.80	75.90
TSS (^{0}B)	7.90	8.50	9.00	10.50	6.50	7.00
Titratable acidity (%)	3.40	3.30	1.25	1.30	2.80	2.60
Reducing sugars (%)	1.80	1.50	2.00	1.90	1.30	1.20
Total sugars (%)	2.90	2.75	3.40	3.30	2.30	2.15
Sugar-acid ratio	0.80	0.80	2.92	2.53	0.82	0.82
pH	2.85	2.75	2.60	2.70	2.95	2.85
Ascorbic acid (mg/100g)	80.60	90.50	145.50	148.50	35.00	36.70
β-Carotene (μg/100g)	425.00	350.80	80.80	85.70	310.00	320.00

4.2.2.1.2 Total soluble solids

Total soluble solids of mangoes, a measure of maturity index, is an important parameter since it forms a guide to utilize the mango for processing into different products are presented in Table 17.

The TSS of mango fruits at harvest ranged from 6.5^0B (Mallika) to 9.0^0B (Bombay green) during 1995. However, in 1996 it ranged from 7.0^0B in Mallika to 10.50 ^{0}B in Bombay green .

4.2.2.1.3 Titratable acidity

Maximum titratable acidity of fruits at harvet was recorded in Ratna fruits (3.40 per cent and 3.30 per cent) followed by Mallika fruits (2.80 per cent and 2.60 per cent) whereas the minimum was recorded in Bombay green (1.25 and 1.30 %) during 1995 and 1996.

4.2.2.1.4 Reducing sugars

At harvest (1995) the variety Bombay green recorded the highest reducing sugars (2.0 %) followed by Ratna (1.80 %) and the lowest (1.30 %) was recorded in variety Mallika (Table 17). Similar observations were seen during the subsequent year, 1996.

4.2.2.1.5 Total sugars

Maximim total sugar content at harvest was recorded in Bombay green (3.40 %), while the minimum was recorded by variety Mallika (2.30 %) in the year 1995.

During 1996, the total sugars among the different varieties varied from 2.15 per cent (Mallika) to 3.30 per cent (Bombay green).

4.2.2.1.6 Sugar / acid ratio

Table 17 reveals that the variety Bombay green with higher reducing and total sugars recorded higher value for sugar acid ratio (2.92) while the minimum value was recorded by Ratna (0.80) during 1995. Not much differences were observed in 1996 in all the varieteis.

4.2.2.1.7 pH

Hydogen ion-concentration i.e, pH of mango fruits at harvest as reflected from the data presented in Table 17 ranged from 2.60 in Bombay green to 2.95 in Mallika in 1995 while during 1996 it ranged from 2.70 in Bombay green to 2.85 in Mallika.

4.2.2.1.8 Ascorbic acid

Table 17 revealed that the ascorbic acid content of mango fruits at harvest was found maximum in Bombay green fruits (145.50 mg/100 g) followed by Ratna fruits (80.60 mg/100g), while the minimum was recorded in Mallika fruits (35.00 mg/100g). In the subsequent year also Bombay green recorded the highest (148.50 mg/100g) followed by Ratna 90.50 mg/100g) while the minimum was noticed in Mallika (36.70 mg/100g).

4.2.2.1.9 Total carotenoid pigment expressed as β-carotene

At harvest the carotenoid content was maximum in variety Ratna (425.00 μg/100g) followed by Malliak (310.0μg/100g) and the minimum was in variety Bombay green (80.80 μg/100g) during 1995. Similar trend was observed during the year 1996.

4.2.2.2 Chemical composition of mango fruits on ripening

The data regarding the chemical composition of mango fruits on ripening of Ratna, Bombay green and Mallika varieties are presented in Table 18

Plate 4b : Mango variety Bombay green on Ripening

4.2.2.2.1 Moisture

The moisture content declined on ripening of fruits. Optimum ripe Ratna fruits showed the maximum moisture content (78.80 %) while, Bombay green fruits showed the minimum (72.40 %) during 1995. In the year 1996 also Ratna recorded the highest moisture content (80.85 %) followed by Bombay green (76.20 %) and the minimum was found in Mallika (74.50 %).

4.2.2.2.2 Total soluble solids

On ripening of fruits at optimum stage the total soluble solids increased in all the varieties (Fig.) . The maximum total soluble solids were observed in vareity Mallika (21.5 0g) during 1995. During the year 1996 also Mallika recorded highest total soluble solids (22.5^0 B) followed by Ratna (18.80^0B) and the lowest was seen in Bombay green (18.5^0B).

4.2.2.2.3 Titratable acidity

Titratable acidity (Table 18) decreased from harvest to ripe stage. The maximum titratable acidity of fruits after ripening was found in Ratna (0.40 %) while minimum was recorded in Bombay green (0.30 %) during 1995. In the subsequent year titratable acidity ranged from 0.28 per cent in Bombay green to 0.40 per cent in Mallika.

4.2.2.2.4 Reducing sugars

The data regarding change in reducing sugars are also presented in Table 18.

Higher values for reducing sugars were recorded in all the varieties after they were ripened for processing as compared to at harvest time. Mallika ranked first (5.40 %) followed by Ratna (5.32 %) and the last in order was Bombay green (2.95 %) during 1995. In the year 1996 the reducing sugars content ranged from 3.00 per cent (Bombay green) to 5.70 per cent (Mallika).

Table 18 : Chemical composition of different mango varieties on Ripening during 1995 and 1996

Particulars	Ratna		Bombay green		Mallika	
	1995	1996	1995	1996	1995	1996
Moisture (%)	78.80	80.85	72.40	76.20	73.75	74.50
TSS (^{0}B)	17.80	18.80	17.75	18.50	21.50	22.50
Titratable acidity (%)	0.40	0.37	0.30	0.28	0.30	0.40
Reducing sugars (%)	5.32	5.54	2.95	3.00	5.40	5.70
Total sugars (%)	16.20	15.90	15.50	16.00	17.50	18.80
Sugar-acid ratio	40.50	42.97	51.66	57.10	58.33	47.00
PH	4.20	4.15	3.90	3.80	5.35	5.45
Ascorbic acid (mg/100g)	80.30	85.25	135.50	140.00	25.25	28.80
Total Carotenoids B-Carotenoids (µg/100g)	13350.0	13225.0	4250.0	3990.0	8950.0	9500.0

4.2.2.2.5 Total sugars

Variety Mallika exhibited maximum total sugars (17.50 %) while minimum was recorded in Bombay green (15.50 %) in 1995. During 1996, it ranged from 15.90 per cent (Ratna) to 18.80 per cent (Mallika).

4.2.2.2.6 Sugar / Acid ratio

Table 18 showed that variety Mallika ranked first (58.33 %) for sugar / acid ratio while variety Ratna appeared to be the last (40.50). In the subsequent year, sugar /acid ratio ranged from 42.97 (Ratna) to 57.10 (Bombay green).

4.2.2.2.7 pH

High pH values were recorded after the fruit were ripe, as compared to pH values at harvest. On ripening Mallika fruits showed maximum pH of 5.35 and 5.45, respectively during the years 1995, 1996, while Bombay green recorded maximum (3.90 and 3.80, respectively) during the two years.

4.2.2.2.8 Ascorbic acid

On ripening Bombay green recorded maximum values (135.50 mg / 100g) followed by Ratna (80.30 mg/100g) and the minimum was seen in Mallika fruits (25.25mg/100g) during 1995. In the year 1996 similar trend was noticed for the ascorbic acid content on ripening of different varieties.

4.2.2.2.9 Total carotenoid pigments expressed as β-carotene

It could be seen from the data presented in Table 18 that total carotenoid (β-carotene) content increased from harvest to the ripe stage. There was a manyfold increase in the carotenoid content at the ripe stage . Ratna fruits exhibited the maximum carotenoid content on ripenign (13350 μg/100g and 13225 μg/100g) followed by Mallika (8950 μg/100g and 9500 μg/100g) while the minimum was recorded by Bombay green (4250 μg/100g and 3990 μg/100g) during both the years of study.

4.2.3 Chemical composition of mango slices during storage

4.2.3.1 Cut out analysis of canned mango slices

4.2.3.1.1 Physical characters of canned Ratna, Bombay green and Mallika mango slices in syrup at initial, three, six and eight months of storage are depicted in Table 19

4.2.3.1.1.1 Vacuum

From the Table 19 it is clear that there was no substantial loss of vacuum during storage for both the years. Since it is seen that there was significant difference among the varieties for vacuum except at six months of storage during 1995, a vacuum of 11.6 to 13.2 inches was observed in all the varieties tested, which was due to the fact that proper temperature was maintained for the preservation of slices.(Fig.9)

4.2.3.1.1.2 Head space

Table 19 depicted that the head space was uniform in all the canned samples during both the years of study. The head space ranged from 7.0 mm (Mallika) to 7.80 mm (Bombay green) at initial stage while at eight months of storage, it was slightly increased with non-significant difference and ranged from 7.4 mm (Mallika) to 7.75 mm (Bombay green and Ratna) during 1995. During the year 1996, variety Bombay green recorded maximum head space (8.60 mm) followed by Mallika (8.40 mm) and the minimum was noticed in variety Ratna (8.00 mm). Similar trend was also seen at the end of eight months of storage period.(Fig.10)

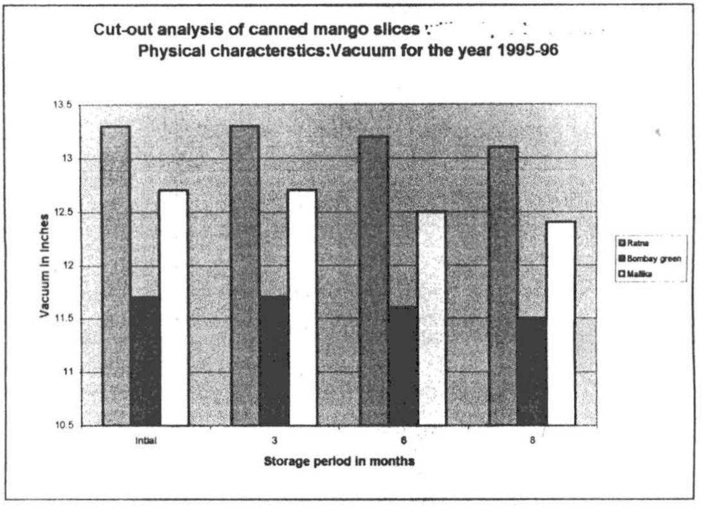
4.2.3.1.1.3 Drained weight

The results of the cut-out examination of the canned slices summarised in Table 20 indicate that there were significant differences in drained weight of the canned slices in all the varieties during 1995. The drained weight was almost uniform in all the samples and the percentage ranged from 49.60 to 52.82 per cent in Bombay green, 54.15 to 56.80 per cent in Ratna and 53.78 to 55.84 per cent in Mallika. There were non-significant differences during 1996

Table 19 : Cut-out analysis of canned mango slices(physical characteristics)

Parameter	Variety	1995-96				1996-97			
		Initial	Storage period (months)			Initial	Storage period (months)		
			3	6	8		3	6	8
Vacuum	Ratna	13.30	13.30	13.20	13.10	12.60	12.60	12.20	11.00
(inches)	Bombay green	11.70	11.70	11.60	11.50	13.60	13.60	13.40	13.40
	Mallika	12.70	12.70	12.50	12.40	13.00	12.80	12.60	12.50
	F-test	*	*	NS	NS	*	*	*	NS
	CD at 5 %	1.19	1.19	--	--	0.62	0.72	0.65	--
Head space	Ratna	7.20	7.20	7.70	7.75	8.00	8.30	8.50	8.50
(mm)	Bombay green	7.80	7.80	7.75	7.75	8.60	8.60	8.60	8.60
	Mallika	7.00	7.10	7.40	7.40	8.40	8.60	8.40	8.40
	F-test	*	*	*	*	NS	NS	NS	NS
	CD at 5 %	1.94	2.14	2.11	--	--	--	--	--

FIG NO. 9


Cut-out analysis of canned mango slices
Physical characterstics:Vacuum for the year 1995-96
13.5
13
12.5
12
11.5
11
10.5
Vacuum in inches
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

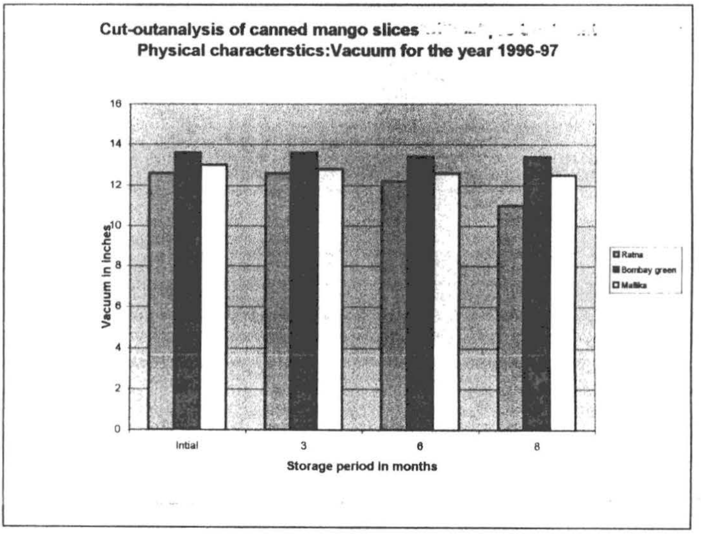
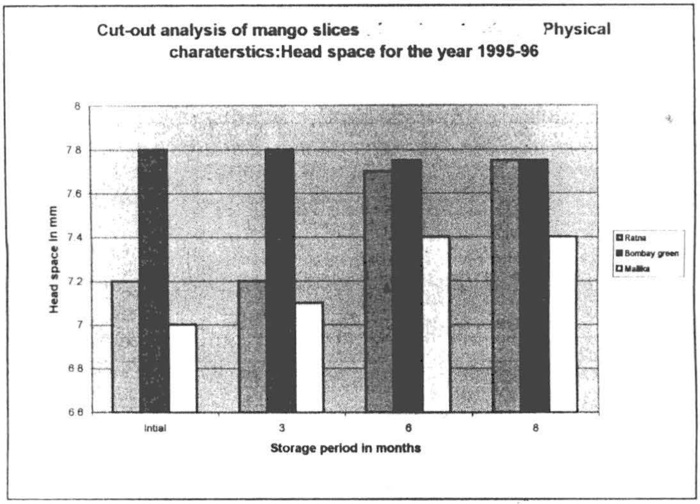
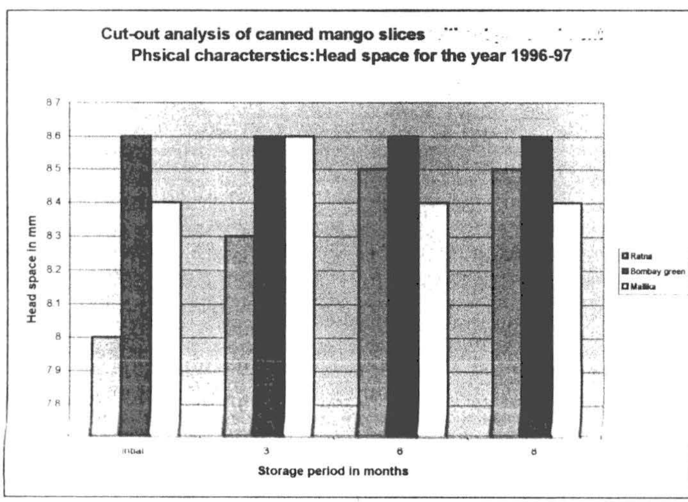

Cut-outanalysis of canned mango slices
Physical characterstics:Vacuum for the year 1996-97
16
14
12
10
8
6
4
2
0
Vacuum in inches
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

FIG NO. 10


Cut-out analysis of mango slices Physical
charaterstics:Head space for the year 1995-96
Head space in mm
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika


Cut-out analysis of canned mango slices
Phsical characterstics:Head space for the year 1996-97
Head space in mm
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

in drained weight and there was a gradual increase in the drained weight percentage in both the years. (Fig.11)

4.2.3.1.1.4 Internal condition of can

Table 20 revealed that all the varieties initially and upto three months of storage period showed normal appearance of the can after cut-out analysis, however, at eight months of storage slight feathering was noticed in the cans of Ratna and Mallika and heavy feathering in Bombay green variety. Similar trend was observed during 1996.

4.2.3.1.1.5 Clarity and colour of syrup

It is evident from the data presented in Table 20 that the varieties which retained shape and texture of the slices without distingrating on canning gave clear syrup and original colour to the canned produt. Fairly clear yellow colour of syrup was observed in the varieties Ratna and Mallika till six months of storage ; while at eight months of storage at ambient conditions it could not retain the clarity as it was in the initial stages during both the years. Variety Bombay green showed the clarity of syrup and yellow colour till only three months of storage period while later the syrup turned turbid.

4.2.3.1.2 Cut-out examination of canned mango slices : chemical parameters

Chemical parameters of canned mango slices of different varieties are summarised in Table 21.

4.2.3.1.2.1 Total soluble solids of slices

The data presented in Table 21 indicate that the variety Mallika showed highest TSS (31.34^{0}B) followed by variety Ratna (31.0^{0}B) and the lowest was observed in variety Bombay green (28.15^{0}B). During storage, the difference was not perceptible and it ranged from 0.10 to 0.20 per cent. In both the years

Plate 5a : Mallika hybrid mango after ripening

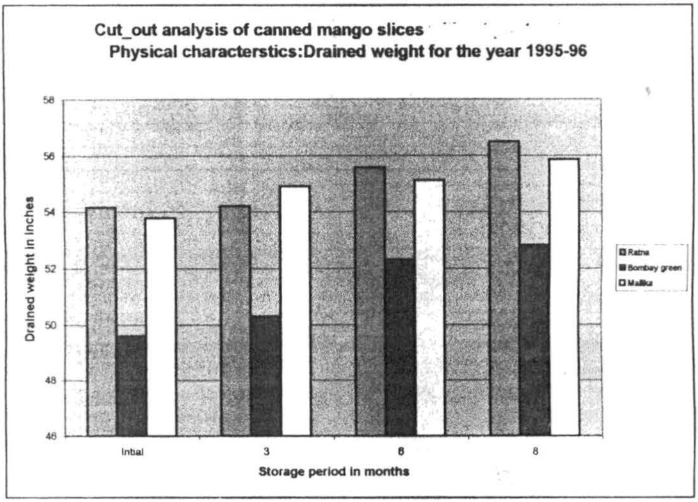
Table 20 : Cut-out analysis of canned mango slices physical characteristics

Parameter	Variety	1995-96 Initial	1995-96 Storage period (months)			1996-97 Initial	1996-97 Storage period (months)		
			3	6	8		3	6	8
Drained wt. (inches)	Ratna	54.15	54.20	55.57	56.50	52.49	53.98	54.98	56.80
	Bombay green	49.60	50.30	52.32	52.82	51.82	53.57	54.32	55.10
	Mallika	53.78	54.90	55.10	55.84	55.84	54.58	55.68	56.68
	F-test	*	*	*	*	NS	NS	NS	NS
	CD at 5 %	1.94	2.15	2.10	--	--	--	--	--
Internal condition of the can	Ratna	Normal	Normal	Normal	S.F	Normal	Normal	S.F.	H.F
	Bombay green	Normal	Normal	S.F.	H.F.	Normal	Normal	S.F	H.F.
	Mallika	Normal	Normal	Normal	S.F.	Normal	Normal	Normal	S.F
Clarity and colour of the syrup	Ratna	FCY	FCY	FY	TB	FCY	FCY	FY	TB
	Bombay green	FCY	CY	TB	TB	CY	CY	JB	JB
	Mallika	FCY	FCY	FY	TB	FCY	FCY	FY	TB

Note :

SF : Slight feathering
HF : Heavy feathering
FCY : Fairly clear yellow
FY : Fairly yellow
CY : Clear yellow
TB : Turbid

FIG NO. 11


Cut_out analysis of canned mango slices
Physical characterstics:Drained weight for the year 1995-96
58
56
54
52
50
48
46
Drained weight in inches
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

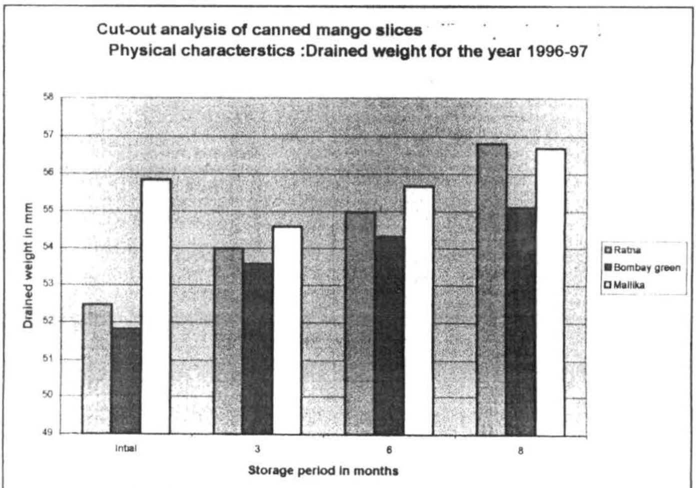
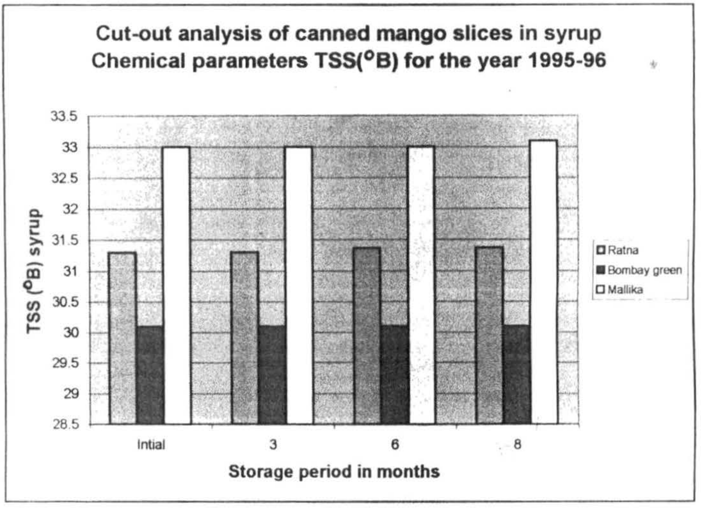

Cut-out analysis of canned mango slices
Physical characterstics :Drained weight for the year 1996-97
58
57
56
55
54
53
52
51
50
49
Drained weight in mm
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

Table 21 : Cut-out analysis of canned mango slices in syrup chemical parameters

Parameter	Variety	1995-96				1996-97			
		Initial	Storage period (months)			Initial	Storage period (months)		
			3	6	8		3	6	8
TSS (^{0}B), Slices	Ratna	31.00	31.00	31.20	31.40	30.58	30.56	31.60	31.00
	Bombay green	28.15	29.12	29.25	29.27	31.25	31.25	31.40	31.40
	Mallika	31.34	31.40	31.41	31.40	30.83	27.87	30.86	30.86
	F-test	*	*	*	NS	NS	*	*	NS
	CD at 5 %	0.82	0.82	0.80	-	NS	0.53	0.28	NS
TSS (^{0}B) Syrup	Ratna	31.30	31.30	31.36	31.37	31.80	31.80	32.20	32.21
	Bombay green	30.10	30.10	30.10	30.10	32.50	32.50	32.60	32.59
	Mallika	33.00	33.00	33.00	33.10	32.56	32.64	33.12	33.12
	F-test	*	*	*	*	NS	NS	NS	NS
	CD at 5 %	0.89	0.89	0.91	--	--	--	--	--

FIG NO. 12


Cut-out analysis of canned mango slices in syrup
Chemical parameters TSS(°B) for the year 1995-96
TSS (°B) syrup
33.5
33
32.5
32
31.5
31
30.5
30
29.5
29
28.5
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

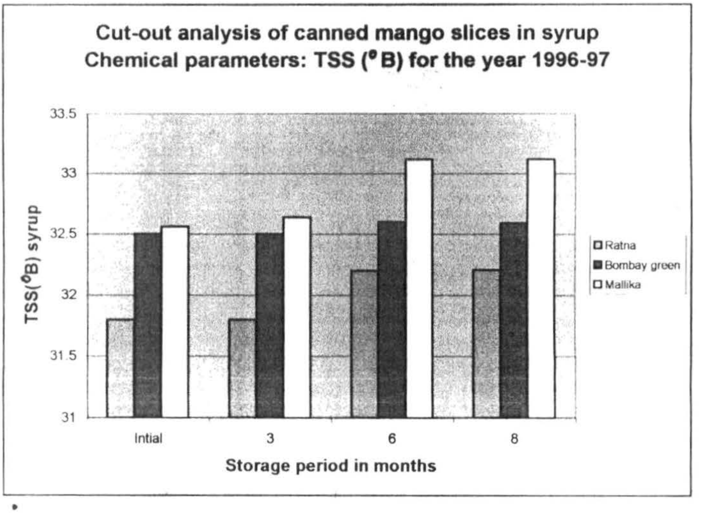
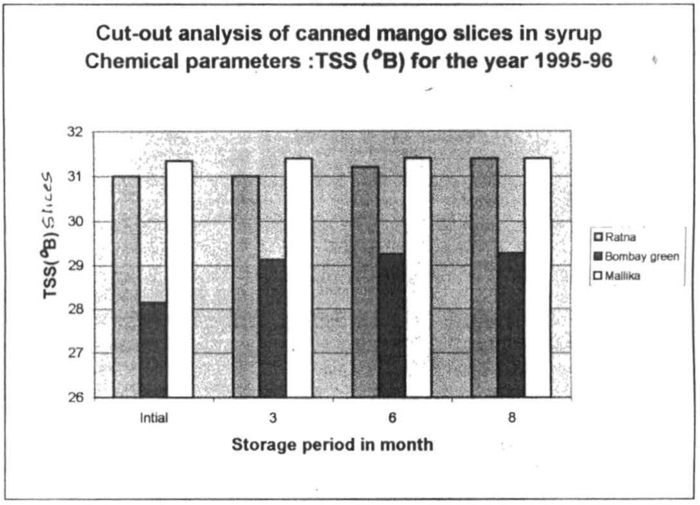
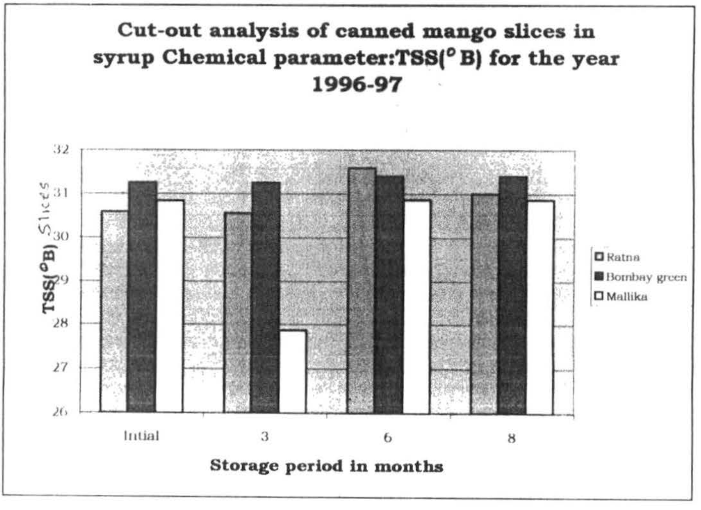

Cut-out analysis of canned mango slices in syrup
Chemical parameters: TSS (°B) for the year 1996-97
TSS(°B) syrup
33.5
33
32.5
32
31.5
31
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

FIG NO. 13


Cut-out analysis of canned mango slices in syrup Chemical parameters :TSS (°B) for the year 1995-96
32
31
30
29
28
27
26
TSS(°B) Slices
Intial
3
6
8
Storage period in month
Ratna
Bombay green
Mallika


Cut-out analysis of canned mango slices in syrup Chemical parameter:TSS(° B) for the year 1996-97
32
31
30
29
28
27
26
TSS(°B) Slices
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

significant results were observed for TSS of slices except at initial stages of 1995. However, the trend was slightly increasing in both the years of study.

4.2.3.1.2.2 Total soluble solids of syrup

In respect of TSS of syrup, slightly higher values were recorded and there was a gradual increase in TSS during storage in 1995 and 1996. Significant differences were observed during 1995 with the TSS of syrup and it ranged from 30.10 (Bombay green) to 33.00^{0}B (Mallika) at initial stages of analysis while at eight months of storage period it varied from 30.1^{0}B (Bombay green) to 33.10^{0}B (Mallika). During 1996, slight differences in TSS were recorded in the varieties. Maximum being Mallika (32.56^{0}B) and minimum being Ratna (31.80^{0}B), however, variation observed was non-significant.(Fig 12, Fig.13)

4.2.3.1.2.3 Titratable acidity of slices

The acidity content of the canned slices showed increase trend during the last phase of storage. However, the differences were non-significant during both the years of studies 1995 and 1996 (Table 22). The acidity content was low in all the three varieties and it ranged between 0.31 to 0.34 per cent. (Fig. 14)

4.2.3.1.2.4 Titratable acidity of syrup

Table 22 again shows that there was no noticeable change in the titratable acidity of the syrup. In comparison to slices the acidity values were low for the syrup during 1995 and 1996. Significant results were recorded during 1995 while in the subsequent year differences were found non-significant.

4.2.3.1.2.5 Total sugars

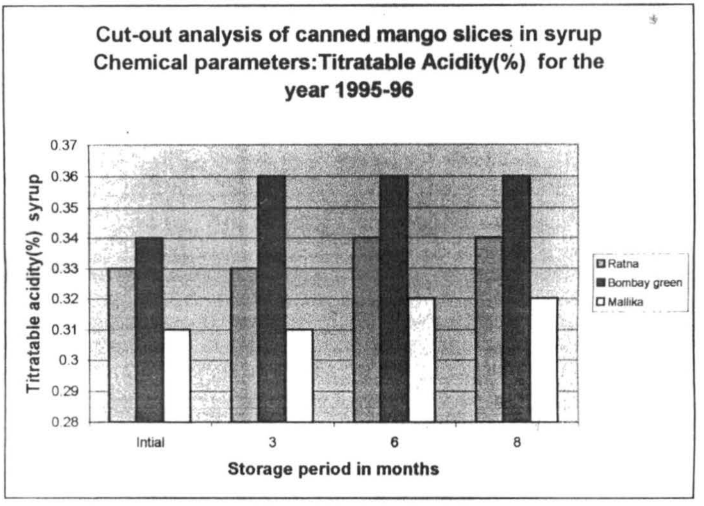
Total sugars continuoulsy increased during the storage period of eight months in both the years (Table 23). Initially, the total sugars cotnent (Fig.16)

Plate 5b : Canned Mallika slices after storage of 8 months

Table 22 : Cut-out analysis of canned mango slices in syrup chemical parameters

Parameter	Variety	1995-96				1996-97			
		Initial	Storage period (months)			Initial	Storage period (months)		
			3	6	8		3	6	8
Titratable acidity (%) Slices	Ratna	0.33	0.33	0.34	0.34	0.31	0.31	0.32	0.32
	Bombay green	0.34	0.36	0.36	0.36	0.31	0.32	0.33	0.33
	Mallika	0.31	0.31	0.32	0.32	0.32	0.32	0.33	0.33
	F-test	NS	NS	NS	NS	NS	NS	NS	NS
	CD at 5 %	--	--	--	--	--	--	--	--
Titratable Acidity (%) Syrup	Ratna	0.31	0.31	0.31	0.31	0.27	0.27	0.27	0.7
	Bombay green	0.29	0.29	0.30	0.30	0.30	0.30	0.30	0.30
	Mallika	0.30	0.30	0.30	0.30	0.28	0.28	0.28	0.28
	F-test	*	*	*	*	NS	NS	NS	NS
	CD at 5 %	0.005	0.005	0.008	--	--	--	--	--

FIG NO. 14


Cut-out analysis of canned mango slices in syrup
Chemical parameters:Titratable Acidity(%) for the year 1995-96
Titratable acidity(%) syrup
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

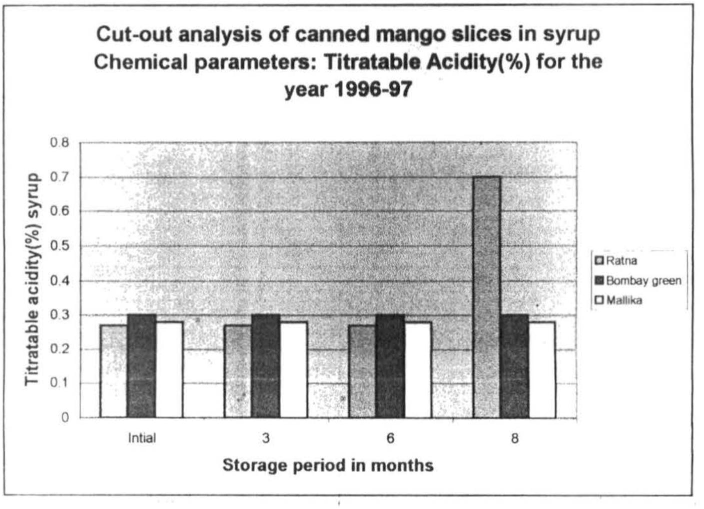
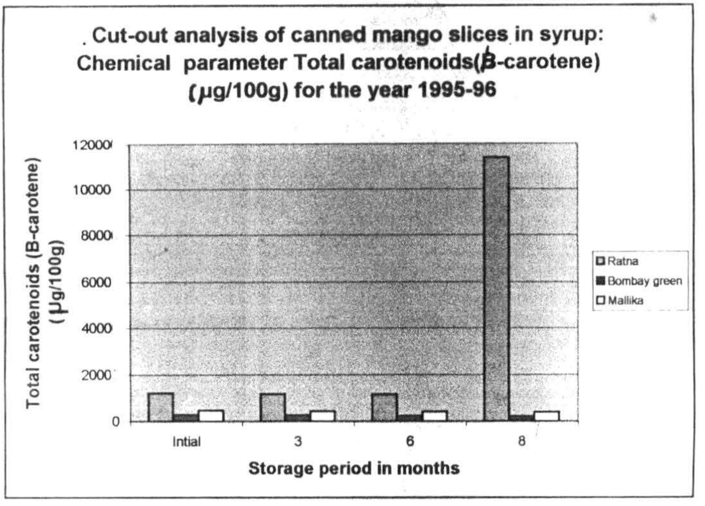
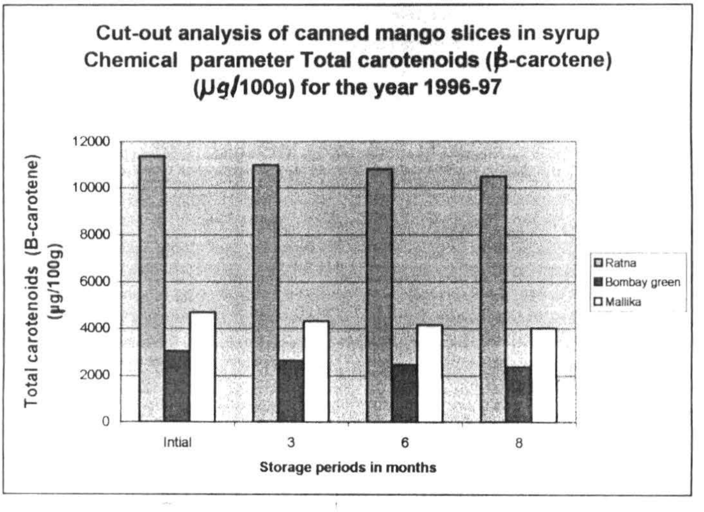

Cut-out analysis of canned mango slices in syrup
Chemical parameters: Titratable Acidity(%) for the year 1996-97
Titratable acidity(%) syrup
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

FIG NO. 15



. Cut-out analysis of canned mango slices in syrup:
Chemical parameter Total carotenoids(β-carotene)
(μg/100g) for the year 1995-96
Total carotenoids (B-carotene) (μg/100g)
12000
10000
8000
6000
4000
2000
0
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika



Cut-out analysis of canned mango slices in syrup
Chemical parameter Total carotenoids (β-carotene)
(μg/100g) for the year 1996-97
Total carotenoids (B-carotene) (μg/100g)
12000
10000
8000
6000
4000
2000
0
Intial
3
6
8
Storage periods in months
Ratna
Bombay green
Mallika

of the canned slices were observed to range from 17.59 per cent (Bombay green) to 19.84 per cent (Ratna) whereas, after eight months of storage period the total sugars content of the canned slices ranged from 19.25 per cent (Bombay green) to 20.60 per cent (Ratna). During 1996, Ratna ranked higher for total sugars (19.76 %) and lower being Bombay green (18.75 %) at initial stages of analysis while at the end of eight months storage period, Ratna recorded maximum (22.10) and Mallika recorded minimum (20.82). The results were statistically significant in both the years.

4.2.3.1.2.6 Sugar / Acid ratio

Sugar acid ratio significantly increased during both the years throughout the storage period but it was gradual (Table 23). During 1995, Ratna showed higher sugar / acid ratio of 62.79 followed by Mallika (62.07) and Bombay green recorded the least (57.55). At the end of six and eight months of storage non-significant results were noticed. In 1996, Ratna recorded highest sugar / acid ratio of 68.17 followed by Bombay green (63.18) and Mallika (62.37) after six months of storage. After eight months of storage also Ratna recorded higehst ratio of 70.00 and Bombay green minimum of 63.20. (Fig. 17)

4.2.3.1.2.7 Total carotenoids expressed as β-carotene

The data pertaining to carotenoid content of canned mango slices are presented in Table 23. In general, it is evident from the data that β-carotene content of the canned slices showed a decline (Fig.15) during eight months of storage period in both the years amongst the varieties under study. Highest carotenoid content were noticed in Ratna (12100.00 μg/100g) followed by Mallika (4800.40 μg/100g) while lowest was recorded in Bombay green (3000.00 μg/100g). However, after storage period of eight months, carotenoid content of Ratna was 114010 μg/100g and that of Bombay green 2220.00 μg/100g during 1995. Slightly lower values were recorded in the subsequent

Table 23 : Cut-out analysis of canned mango slices in syrup : Chemical parameters

Parameter	Variety	1995-96				1996-97			
		Initial	Storage period (months)			Initial	Storage period (months)		
			3	6	8		3	6	8
Total sugar (%)	Ratna	19.84	20.20	20.47	20.60	19.76	20.53	21.11	22.10
	Bombay green	17.59	18.01	18.26	19.25	18.75	19.47	19.89	20.90
	Mallika	18.79	18.09	19.47	20.50	19.32	19.69	19.83	20.82
	F-test	*	*	*	*	*	*	*	*
	CD at 5 %	--	--	--	--	--	--	--	--
Sugar acid ratio	Ratna	62.79	63.94	63.04	64.00	65.57	68.04	68.17	70.00
	Bombay green	57.55	58.91	58.18	60.00	61.71	64.14	63.18	63.20
	Mallika	62.07	62.73	62.86	63.00	61.54	62.72	62.37	63.30
	F-test	*	*	NS	NS	*	*	*	*
	CD at 5 %	2.56	2.54	--	--	3.15	3.30	2.83	2.80
Total carotenoids (B-carotene) (μg/100g)	Ratna	12100.00	11808.30	11611.00	114010.00	11377.20	10994.00	10806.40	10500.(
	Bombay green	3000.00	2737.20	2422.80	2220.00	3030.80	2645.00	2461.20	2380.0
	Mallika	4800.40	4331.20	4134.00	3940.00	4708.40	4321.20	4144.80	4000.5
	F-test	*	*	*	*	*	*	*	*
	CD at 5 %	65.30	49.41	108.28		4.50	4.50	49.92	45.60

Plate 6a : Canned Ratna slices after storage of 8 months

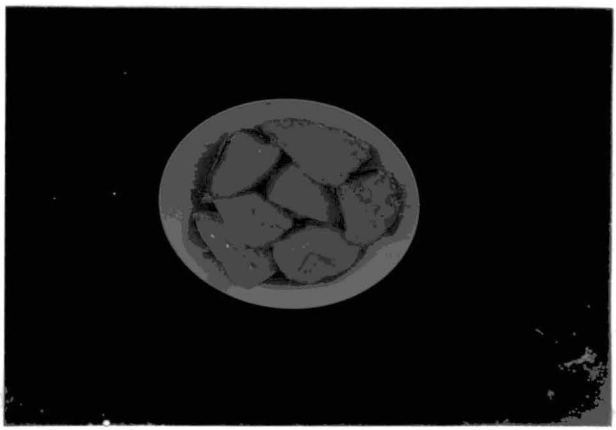
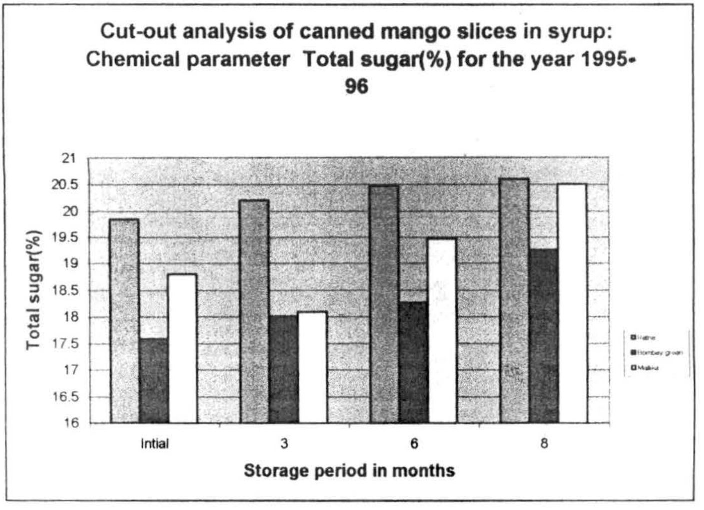


FIG NO. 16


Cut-out analysis of canned mango slices in syrup: Chemical parameter Total sugar(%) for the year 1995-96
Total sugar(%)
21
20.5
20
19.5
19
18.5
18
17.5
17
16.5
16
Intial
3
6
8
Storage period in months

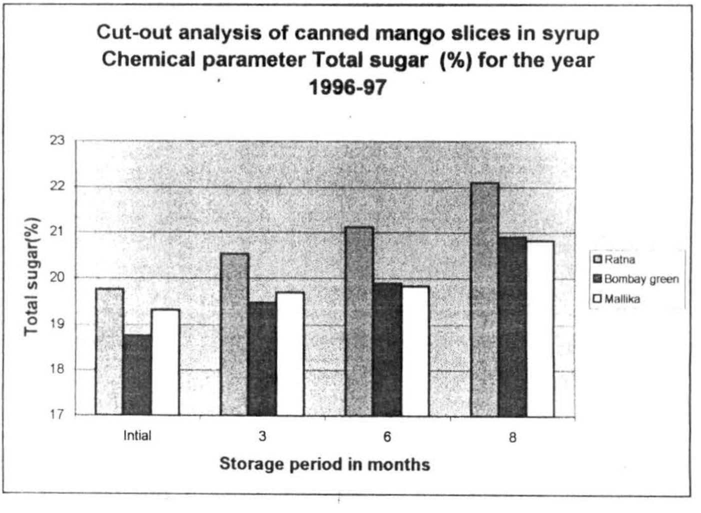
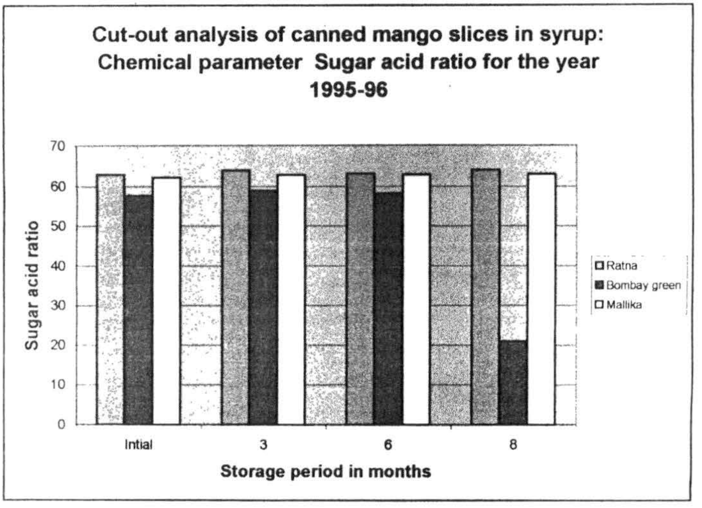
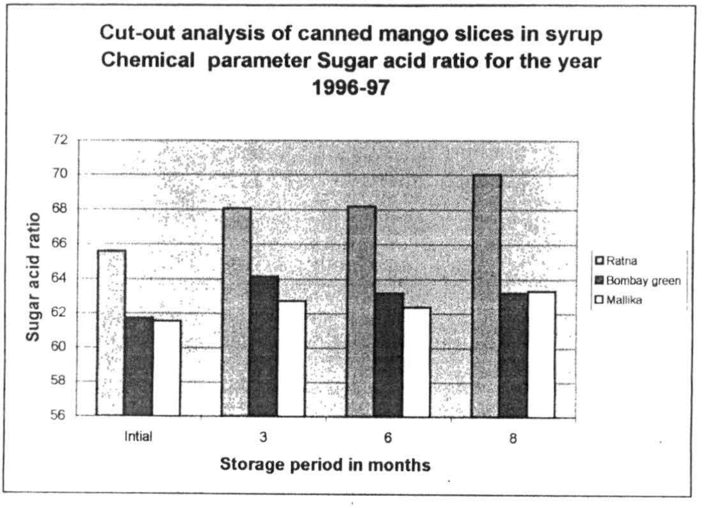

Cut-out analysis of canned mango slices in syrup Chemical parameter Total sugar (%) for the year 1996-97
Total sugar(%)
23
22
21
20
19
18
17
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

FIG NO. 17


Cut-out analysis of canned mango slices in syrup:
Chemical parameter Sugar acid ratio for the year
1995-96
Sugar acid ratio
70
60
50
40
30
20
10
0
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika


Cut-out analysis of canned mango slices in syrup
Chemical parameter Sugar acid ratio for the year
1996-97
Sugar acid ratio
72
70
68
66
64
62
60
58
56
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

year for carotenoid yet the results were highly significant among the varieties for both the years.

4.2.4 Organoleptic evaluation of Canned Mango slices

Canned mango slices were organoleptically evaluated at initial stage after processing and after eight months of storage at ambient temperature conditions (Table 24).

4.2.4.1 Appearance

From comparative organoleptic values as shown in Table 24 it is evident that Ratna and Mallika ranked best (9.70) among all the varieties tried for canning in respect of appearance at initial stage of storage till eight months. Next to Ratna and Mallika was Bombay green in order of preference with the scores 7.60. In the year 1996, also Ratna was found the best in appearance, followed by Mallika and least score was recorded in Bombay green. It was observed that there was not much decline in the score for appearance of the canned slices during storage in all the varieties.(Fig.18)

4.2.4.2 Flavour

The maximum organoleptic score for flavour was recorded by Ratna (8.80 and 8.75) followed by Mallika (8.70 and 8.75) and the minimum was found in Bombay green (7.80 and 7.70) during 1995 and 1996, respectively (Table 24). However, it was also noticed that during storage the quality score did not decline much to dislike the product of all the varieties. (Fig.18)

4.2.4.3 Texture

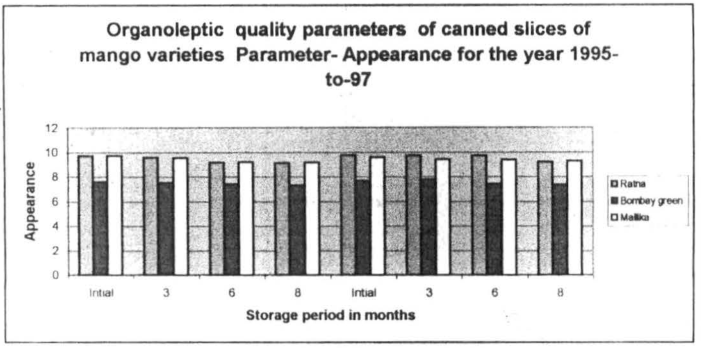
Data on texture of canned mango slices is presented in Table 25. According to the table texture of Mallika was found to be the best (4.40) followed by Ratna (4.20) and least was Bombay green (3.70) during 1995 and 1996. (Fig.18)

Plate 6b : Canned Bombay green slices after 6 months storage

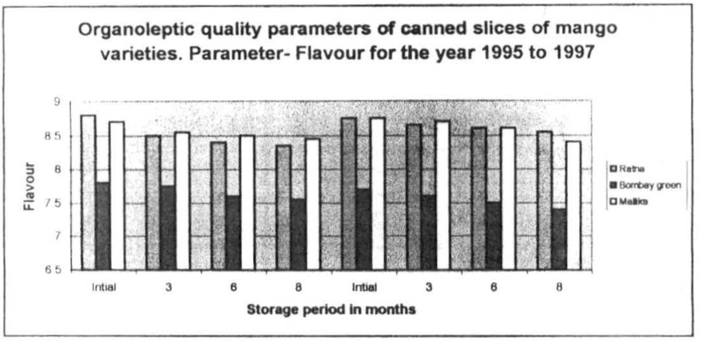
Table 24 : Organoleptic quality parameters of canned slices of mango varieties (Scores out of 10)

Parameter	Variety	1995-96				1996-97			
		Initial	Storage period (months)			Initial	Storage period (months)		
			3	6	8		3	6	8
Appearance	Ratna	9.70	9.55	9.15	9.10	9.75	9.70	9.70	9.20
	Bombay green	7.60	7.50	7.40	7.30	7.65	7.75	7.40	7.35
	Mallika	9.70	9.52	9.20	9.15	9.58	9.38	9.35	9.25
Flavour	Ratna	8.80	8.50	8.40	8.35	8.75	8.65	8.60	8.55
	Bombay green	7.80	7.75	7.60	7.55	7.70	7.60	7.50	7.40
	Mallika	8.70	8.55	8.50	8.45	8.75	8.70	8.60	8.40
Texture	Ratna	9.80	9.70	9.65	9.60	9.75	9.70	9.65	9.60
	Bombay green	7.90	7.80	7.60	7.55	7.85	7.80	7.65	7.60
	Mallika	9.68	9.65	9.64	9.60	8.80	8.78	8.75	8.73
Overall Acceptability	Ratna	9.80	9.75	9.70	9.65	9.85	9.80	9.75	9.65
	Bombay green	7.95	7.90	7.85	7.80	8.00	7.95	7.90	7.85
	Mallika	9.78	9.75	9.75	9.73	9.83	9.80	9.75	9.73

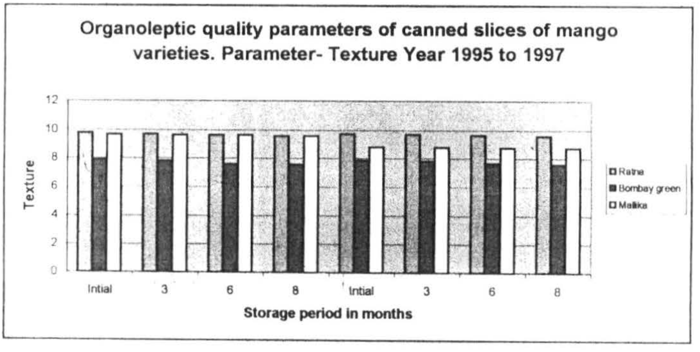
FIG NO. 18



Organoleptic quality parameters of canned slices of mango varieties Parameter- Appearance for the year 1995-to-97
12
10
8
6
4
2
0
Appearance
Intial
3
6
8
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika



Organoleptic quality parameters of canned slices of mango varieties. Parameter- Flavour for the year 1995 to 1997
9
8.5
8
7.5
7
6.5
Flavour
Intial
3
6
8
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika



Organoleptic quality parameters of canned slices of mango varieties. Parameter- Texture Year 1995 to 1997
12
10
8
6
4
2
0
Texture
Intial
3
6
8
Intial
3
6
8
Storage period in months
Ratna
Bombay green
Mallika

It was observed that the texture retention is the main criteria for the canning of slices. Ratna and Mallika performed extremely good in both the years of study, in maintaining the original texture. However, Bombay green recorded minimum values for the texture.

4.2.4.4 Overall acceptability

Overall acceptability scores are presented in Table 24 Ratna was adjudged best by the panelist for overall quality followed by Mallika and Bombay green during both the years of study (1995 and 1996). The overall acceptability ratings ranged from 7.95 (Bombay green) to 9.80 (Ratna) in 1995 and 8.00 (Bombay green) to 9.85 (Ratna) in 1996. There was not much decline in the score of all the varieties during storage.

4.2.5 Change in visual, characteristics of canned mango slices

Change in the sensory properties of canned mango slices was observed and the results obtained are presented in Table 25.

4.2.5.1 Colour of canned mango slices

Colour of canned mango slices was Nasturtium orange in variety Ratna and Mallika and Saffron yellow in Bombay green at initial cut-out analysis during 1995 and 1996. At eight months of storage, slight differences were noticed in variety Bombay green, where the colour was observed to be saffron yellow, whereas, Ratna and Mallika maintained original colour in both the years of study.

4.2.5.2 Microbial spoilage

The product. canned slices was completely free from the microbial spoilage till eight months of storage period in both the years of study among all the varieties.

Table 25 : Organoleptic quality parameters of canned slices of mango varieties

Variety	1995-96				1996-97			
	Initial	Storage period (months)			Initial	Storage period (months)		
		3	6	8		3	6	8
Colour								
Ratna	NO	NO	NO	NO	NO	NO	NO	NO
Bombay green	SY	SY	SY	SY	SY	SY	SY	SY
Mallika	NO	NO	NO	SY	NO	NO	NO	SY

Note : NO : Nasturtium orange 610
SY : Saffron yellow 7

Variety	1995-96 Initial	3	6	8	1996-97 Initial	3	6	8
Texture of slices (lbs/sq. inch)								
Ratna	4.20	4.20	4.00	4.00	4.20	4.20	4.00	4.00
Bombay green	3.70	3.70	3.60	3.60	3.70	3.70	3.56	3.50
Mallika	4.40	4.30	4.30	4.20	4.36	4.30	4.30	4.30

V. DISCUSSION

5.1 ORANGE

An investigation on evaluation and improvement in packaging, transportation and storage of Nagpur mandarin oranges (Citrus reticulata Blanco) was carried out using various types of boxes and packaging systems. The findings of the investigation and the interpretation of the data is discussed in this chapter, under various headings as follows :

5.1.1 Study of post harvest problems causing losses due to various reasons.

5.1.2 Physical properties of Nagpur mandarins

5.1.3 Chemical properties of Nagpur mandarins

5.1.4 Effect of size grading and packaging on transportation and storability of oranges.

5.1.5 Organoleptic evaluation

5.1.1 Study of post harvest problems causing losses due to various reasons.

5.1.1.1 Post harvest problems in oranges

The investigation on harvest and post harvest handling losses of Nagpur mandarin oranges revealed that total losses from field level to consumer level were found to be 34.44 per cent (Tables 1, 2 and 3).

The losses at field level were found to be 7.37 per cent. Losses occurred mainly due to diseases, bruises and rind break. A study conducted on post harvest losses in coorg mandarins revealed losses to the extent of 8.5 per cent at harvesting stage itself (Anon, 1990).

Biswas (1969) has reported transportation losses in oranges from 6 to 30.7 per cent, while Dalal (1998) has reported losses in oranges to be in the range of 2 to 13 per cent during transport.

The percentage of fruit damaged in transit was found to be 9.29 per cent which was found to be fairly low in all the season crops transported in mini lorry.

Losses at whole sale and retail market averaged 9.68 per cent and 8.1 per cent, respectively. Similar results regarding assessment of post harvest losses of 17.1 per cent and 18.36 per cent in mandarins at whole sale and retails level respectively were reported (Anon, 1990).

Losses at harvest level are caused due to diseases, , bruises and rind break while harvesting. Such fruits are treated as unmarketable fruits and discarded at farm level itself. During transport, losses are caused due to friction among the fruits themselves resulting in bruises and rind break. At wholesale and retail market levels, the fruits are treated as unmarketable if they are diseased, bruised, rink broken or overripe.

5.1.2 Physical properties of mandarin orange

5.1.2.1 Weight of fruit

The weight of the fruits harvested during different seasons / months were ranging from 148 g to 156 g and the average weight was 152.25 g. Nagpur mandarins tend to be heavier than Darjeeling fruit (Anon, 1984). Javanda and his co-workers (1973) reported a weight range for inner canopy fruit (43 g) to outer canopy fruit (96 g). It is therefore possible that the weight loss may occur in fruits exposed to temperatures above or below the optimal range (13–18^{0}C), due to growth curtailment (Samson, 1980). Growth of grapefruit in Southern Iran is reported to occur only under the protective leaf canopy (Samadi and Cochran, 1975).

5.1.2.2 External colour

The surface of the Nagpur mandarins was glossy, oil glands were visible only on the surface with a hand lens. Nagpur mandarins are harvested when there is a colour break from green to yellow. This colour break usually coincides with maturity and a satisfactory sugar-acid ratio in the fruit. In the tropics a 10 : 1 sugar acid ratio is often satisfactory (Samson, 1980). In this case, the sugar acid ratio was 11.25 : 0.45, which is nearer to that recommended for tropical oranges (Samson, 1980). It is concluded that the external colour is a good indicator for maturity of Nagpur mandarin oranges. These observations are in accordance with the observations of Gandhi (1956).

Oranges harvested during the months of January to April had a deep orange colour. This may be due to greater sunshine and higher temperatures during the day as compared to July harvested fruits, when temperatures and sunshine is less during day time.

5.1.2.3 Fruit firmness

In general there was a decrease in fruit texture or hardness of fruits of all grades in all the treatments.

Grade I Oranges : Texture was greater in corrugated fibre board box-2 stored grade I fruits upto 29 days, followed by wooden boxes and CFB-1 type boxes used for packaging. From 5th week onwards, the firmness was greater in fruits stored in wooden boxes as compared to CFB-1 type boxes. Firmness was least in untreated control fruits after 8 days itself.

Grade II : Firmness was observed to be greater in CFB-1 boxed fruits followed by fruit stored in wooden boxes upto 6[th] week of storage. Firmness of untreated control fruits was the lowest.

Grade III : During the 1[st] week, wooden box stored fruits had greater firmness, followed by corrugated fibre box -1 and CFB-2 and control fruits, respectively. During 2[nd] week, wooden box and CFB-1 stored fruits were equally firm and greater in firmness than corrugated fibre box-2 stored fruits. Form 3[rd] week onwards, the firmness in CFB-1 boxes stored fruits was greater compared to wooden box stored fruits.

Similar effect of reduction in firmness of fruits during storage has been reported by Shantha Krishnamurthy (1989) in banana and by Roberto *et al.* (1990) in guava.

The firmness of fruit tissue at harvest is mainly due to physical properties of cell wall and middle lamella, which contain pectin, a cementing material. During storage, due to ripening enhancement during early part and due to senescence at later stage, this pectin material undergoes degradation and gets converted to pectic acid, which losses the quality of keeping the tissue bound together thereby resulting in the reduction in firmness of the fruits.

5.1.2.4 Rag and Peel weight

In general it was observed that the rag and peel content of fruits increased during the storage period in all the grades under all treatments.

In general, the rag and peel weight was found to be greater in control fruits upto (1^{st} week) followed by corrugated fibre box-1, wooden box and CFB-2 stored fruits. During 3^{rd} week, the rag and peel weight was greater in corrugated fibre box-1 stored fruits followed by CFB-2 and wooden box stored fruits. There after, the rag and peel weight was found to be greater in CFB-1 stored fruits compared to wooden box stored fruits. Likewise, in general it was observed that the rag and peel weight was found to be greater in small sized fruits upto 6^{th} week ; thereafter, during 7^{th} week rag and peel weight was greater in medium sized fruits, followed by large sized fruits during 6^{th} and 7^{th} weeks.

Similar increase in rag and peel weight during storage at room temperature conditions was reported by Bal and Chohan (1983) in kinnow mandarin oranges and by Pruthi *et al*. (1984) in kinnow and malta oranges.

The rag and peel weight being higher under corrugated fibre box packaged and control conditions may be attributed to greater desiccation of moisture as compared to wooden box and CFB-1 box packaged fruits. Due to greater desiccation under control and corrugated fibre box packaged conditions, freshness could not be retained for long and hence the peel drying was faster, which resulted in greater rag and peel weight.

5.1.2.5 Juice content

In general there was a decreasing trend observed in juice content during the storage period in all the grades under all treatments.

In general, the juice content in wooden box packaged fruits was greater than in other treatments, followed by CFB-1 box, corrugated fibre board box-2 and control fruits. Juice content was greater in large sized fruits, followed by medium sized and small sized fruits.

Similar observation of decrease in juice content was reported by Singh *et al.* (1978) in mandarin and sweet oranges, Bal and Chohan (1983) in kinnow mandarin, and by Pruthi *et al.* (1984) in kinnow mandarin and malta oranges.

The higher juice content recorded during storage in all grades of fruits in wooden box packaging and CFB-1 boxed fruits, may be attributed to much lesser desiccation of moisture which was observed as compared to corrugated fibre box-2 and control fruits. Wooden box and CFB-1 packages reduced desiccation, thereby retaining freshness over longer duration and hence the juice content was probably more in wooden box and CFB-1 type box packaged fruits.

5.1.3 Chemical properties of Nagpur mandarin oranges

5.1.3.1 Moisture

It is clear from the results that the moisture content of oranges have a wide range from 75.8 per cent to 91.12 per cent. This wide range of moisture present is due to seasonal variation during the growth period, particularly the rainfall. Seasonal variation in harvesting the fruits would also affect the moisture content. For example Nagpur mandarins picked in spring will be exposed to dry and warm conditions. Desiccation of the fruit can therefore be more. Shamouti oranges loose water to the leaves in periods of water deficit, thus the soil moisture level also plays a role (Rokach, 1953). Greater moisture content is found in fruit grown in humid areas (Monsellse and Turrell, 1969). On the other hand oranges have less pulp moisture if grown in hot dry regions (Turrell *et al.*, 1964).

The differences in moisture content may therefore be connected with climatic conditions, as well as genetic determinants of post-harvest losses.

5.1.3.2 Acidity

There was a reduction in acidity during the entire storage period. During maturity and ripening the fruit acidity tends to drop, and this continues upon harvesting as the acids are continually respired (Kadota and Muira, 1983). The overall trend in reduction of acidity over a period of time has been reported by Pruthi *et al.* (1984).

5.1.3.3 Effect of grading and packaging on total sugars of oranges

Total sugars showed in increasing trend during the storage irrespective of any treatment. As it is, Nagpur mandarins posses the greatest amounts of total sugars. The average percentage initially of total sugars and the increase over a period of storage were also reported by Chopra and Joshi (1991). Total sugars also show an increasing trend because they get concentrated over a period of time due to evaporation of water from the fruit due to physiological losses in weight. The values obtained in this study are slightly higher than those obtained by Jawanda *et al.* (1973) and Bajaj and Mehata (1983).

5.1.3.4 Reducing sugars

Reducing sugars, that is mainly glucose and fructose also showed an increasing trend over a period of storage. In all types of boxes used for packaging and in all grades of fruits, reducing sugars increased during the storage. The figures obtained in this study correspond to those reported by Ramana *et al.* (1980) for coorg mandarins. Hulme (1971) reported that both total sugars and reducing sugar content rise with the fruit maturity even after harvest during storage.

5.1.3.5 Effect of growing and packaging on total soluble solids of oranges

Total soluble solids was found to be significantly higher in large sized fruits, followed by medium sized fruits. In general there was an increase in total soluble solids in all the grades of fruits in all treatments.

The total soluble solids of mandarin oranges consist of sugars, acids, water soluble pectins and polysaccharides, alcohols, free fatty acids, esters, inorganic salts, aldehydes and ketones (Hulme, 1971). Out of these constituents, sugars, water soluble pectins and polysaccharides tend to increase over a period of time considerably and therefore correspondingly there is a spurt of increase in TSS content of the fruits. The total soluble solids content rises with maturity also in citrus fruits and the ratio of total soluble solids to acidity determines picking time and optimal organoleptic assessment by consumers (Saini *et al.*, 1985). Proper temperature during maturity and ripening also increases the total soluble solids.

The differences in TSS content of large and small size fruits was also observed by Singh *et al.* (1989) in mango and by Tondon *et al.* (1989) in guava fruits. The increase in total soluble solids content in the fruits may also be due partially to hydrolysis of polysaccharides and concentration of juice as a result of moisture loss by transpiration and respiration.

5.1.4 Effect of size grading and packaging on transportation and storability of oranges

5.1.4.1 Effect of size grading and packaging on physiological loss of weight

There was a regular decline in the physiological loss in weight with progress in storage. Among the three grades of fruits, small sized fruits showed more loss of weight as compared to others. Control fruits were unfit for storage beyond 8 days. Use of wooden boxes results in increase of PLW till 36 days, whereas packaging in CFB-1 boxes took 43 days and CFB-2 boxes showed a decline after 21 days itself. Large sized fruits should not be packed in wooden boxes.

There was significant increase in percentage PLW in general in all grades of fruits with all packaging materials.

Grade I fruits : It was found that control fruits showed the highest PLW as compared to other treatments, followed by corrugated fibre box-1 stored fruits. Wooden box packaged fruits showed the least percentage PLW of all treatments, followed by CFB-1 packaged fruits.

Grade II fruits : There was an increase in PLW gradually in all the treatments. Untreated fruits showed highest PLW as compared to other treatments, followed by corrugated fibre box –1 stored fruits. The PLW was equal in wooden boxes and CFB-1 box stored fruits.

Grade III fruits : Like in the earlier cases, control fruits recorded the highest PLW compared to other treatments, followed by corrugated fibre box-1 stored fruits. The least PLW was recorded in CFB-1 box stored fruits, followed by wooden box stored fruits.

Packaging in wooden boxes or CFB box-1 significantly reduced the weight loss as compared to corrugated fibre box-2 and control in all grades of fruits. Similar effect of reducing weight loss was observed by Floyd *et al.* (1968) in Florida oranges, Sadashivam *et al.* (1972), Choudhary and Kumbhare

(1979) in sweet orange and Alfaro *et al.* (1986) in Valencia late oranges. The reduction in weight loss by keeping in wooden boxes and CFB box-1 can be attributed to the reason that these packages act as barriers for moisture loss and also created high humidity in the package there by retarding the moisture loss.

In general, PLW was found least in Grade I fruits, followed by Grade II and then Grade III.

Similar effect of maximum per cent PLW was noted in grade 'C' (smallest) while minimum in grade A (largest) was observed by Singh *et al.* (1989) in Florida oranges, Tandon *et al.* (1989) in Guava fruits. Similarly, Karmarkar and Joshi (1940) and Carlone (1951) reported higher per cent PLW in small than larger size fruits of banana, chikoo, apples etc.

Greater percentage PLW in small fruits as compared to larger fruits can be attributed to thinner peel which results in more rapid loss of water and facilitated greater gaseous exchange, thereby enhancing respiration and ripening. This may also be attributed to more surface area of larger fruits in relation to volume/weight of the fruit.

5.1.5 Organoleptic evaluation

In general, for grade I fruits, colour, flavour and freshness were retained for the longest time in case of wooden box packaging (43 days), followed by CFB-1 packaging (36 days), corrugated fibre box-2 packaging (28 days) and lastly control (7 days).

Similarly, in the case of grade II fruits, CFB-1 box packaging were found to be equally good in retaining acceptable good scores upto 36 days;

while in corrugated fibre box-2 packaging, acceptable scoring was retained upto 2nd week. In control, scoring was rated 'good' only upto 1st week.

On the other hand, for small sized fruits, CFB-1 packaging had a comparative advantage over wooden box packaging as the scoring was retained as 'good' for six weeks in the former packaging, while in the latter packaging, it was good only upto 6th week.

5.2 MANGO

In the present investigation experiments were conducted to asses the canning quality of the three mango varieties, Mallika, Ratna and Bombay Green. The results obtained over a period of 2 years, in the present investigation are critically discussed in this chapter.

5.2.1 Physical Characteristics Of Mango Fruits At Harvest And On Ripening

5.2.1.1 Physical parameters at harvest

5.2.1.1.1 Weight of fruit

The variety Mallika was characterised with higher fruit weight in both the years of study at harvest while Ratna was characterised with comparatively lower fruit weight mainly due to basic genetic variation. This type of observations were also reported by Najundaswamy *et al.* (1966a and b); Singh and Tripathi, (1974) ; Reddy and Singh (1989) ; Badiyala and Awasthi, (1990) in different varieties of mango.

5.2.1.1.2 Volume of fruit

Like the weight of fruit, volume was also maximum in Mallika and minimum in Ratna during both the years of study. The differences observed in the volume of the fruit amongst the varieties under study could be attributed to the varietal differences with respect to fruit weight and size. Palaniswamy *et al.* (1974b), Yadaw *et al.* (1984), Ranjana and Huddar (1991) also reported identical observation to these findings.

5.2.1.1.3 Specific gravity

The difference in the specific gravity of fruits at harvest could be attributed to the difference in the corresponding weight and volume of the fruit. Similar kind of observations were made by Popenoe (1960), Moti and Gangawar (1972), Garg *et al.* (1975), Dabhade and Khadekar (1980a,b), Roy and Joshi (1988) in mango.

5.2.1.1.4 Size of the fruit (length and breadth)

Length of the fruit was observed higher in Mallika fruits and it was lower in Ratna during both the years. From the present investigation, it can be concluded that length and breadth of fruits are highly variable traits and they are very much influenced by the nutritional as well as environmental factors and also the basic varietal differences amongst them. Similar trend was observed in mango varieties by several workers, Nanjundswamy *et al.* (1966b), Lodh *et al.* (1974), Sadhu and Bose (1976), Awasthi and Pandey (1979), Limaye *et al.* (1984), Reddy and Singh (1989), Badiyala and Awasthi (1990), Ranjana and Huddar (1991).

5.2.1.1.5 Colour of peel and pulp of fruit

The observation showed that the varieties Ratnma and Mallika attained Scheeles green colour whereas Bombay green recorded lighter Scheeles green shade in 1995 and 1996. Further, colour of the pulp at harvest among the varieties, Ratna, Bombay green and Malika exhibited yellowish white and faint yellow shades, due to the basic varietal differences. In both the years of study, similar colour of peel and pulp was recored that indicated the exact stage of harvest for processing into products. Observations on the colour of the peel and fruit pulp are in agreement with Joshi (1975), Nanjundaswamy et al/ (1966b), Krishnamurthy and Subramanyam (1970) and Patil (1990) in different mango varieties.

5.2.1.1.6 Firmness f fruit

The progressive decline in the firmness of fruits was due to the fact that when the fruits ripe, the pectin bound in the millions of cells in the fruit (tissues) gets converted to pectic acid and the fruits become soft and therefore the firmness of the fruit which was highest at harvest, declined on ripeing. The differences between varieties are due to the variation in the skin thickness. It may also be due to the loss of fibre, calcium pectate and hemicellulose, which keep the cells, bound together, or arrangement of cells and tye of cell et. forming the epidermis.

Similar observations on fruit , firmness have also been reported by Garg *et al.* (1975), Chikkasubbana and Huddar (1982), Verma *et al.* (1986), Medicott *et al.* (1988), Sahni and Khurdiya (1989a) and Medlicott *et al.* (1990).

5.2.1.2 Physical parameters on ripening

5.2.1.2.1 Weight of peel

Bombay green was characterised with higher weight of peel while variety Ratna exressed lower weight of peel. This suggests that on ripening there was corresponding decrease in the weight of peel and hike in the proportion of weight of pulp, such differences in the physical traits could be attributed to the basic verietal characteristics. Teotia and Awasthi (1966), Suryaprakash Rao *et al* (1968), Roy *et al.* (1972), Bhatnagar and Subramanyam (1973), Rodgrignez (1977), Reddy and Singh (1989) and Patil (1990), Ranjana and Huddar (1991) also recorded identical observations on this line.

5.2.1.2.2 Weight of pulp

The present investigation revealed that Mallika fruits produced higher pulp followed by Bombay green and the lowest was recorded in variety Ratna. This may be due to the fact that basically the weight and size of the fruits as well as the skin contributed to the weight of pulp. It could be also reasoned that the loss of moisture on ripening differed significantly among the varieties studied. Nanjundaswamy *et al.* (1966b), Satyavati *et al.* (1972), Kulkarni and Rameshwar (1981), Ghosh *et al.* (1985) and Patil (1990) also recorded the observation *anologous* to these findings.

5.2.1.2.3 Weight of Stone

Variety Mallika possessed maximum weight of stone followed by Bombay green and minimum was recorded in variety Ratna. The variation in stone weight amongst the varieties under study appeared to be due to the basic genetic variation amongst them. The result similar to these findings were also reported by Palaniswamy *et al.* (1974b), Shukla and Bajpai (1978), Kulkarni and Rameshwar (1981) and Patil (1990) in different mango varieties.

5.2.1.2.4 Pulp to stone ratio

The data revealed that variety Bombay green recorded as high as 5.69,pulp to stone ratio while as low as 4.80 was recorded in variety Ratna. In the subsequent year all the varieties recorded higher values of pulp to stone ratio. This might be due to the effect of variety and season. Identical results were also reported by Garg *et al.* (1975), Sya mal and Mishra (1987), Reddy and Singh (1989) and Patil (1990), Ranjana and Huddar (1991).

5.2.1.2.5 Pulp to peel ratio

Mallika ranked first in pulp to peel ratio while Ratna ranked last, due to basic differences in the varieties. The pulp to peel ratio observed in the present study were well within the range of those reported by Rivas *et al.* (1984).

5.2.1.2.6 Length of stone

The variation in length of the stone in all the varieties all the varieties observed in both the years of study could be attributed to the varietal variation among the mango varieties. Similar kind of reports were aslo made the by Sadhu and Bose (1976),Ghosh *et al.* (1985), Naik (1985) and Patil (1990) Ranjana and Huddar (1991)

5.2.1.2.7 Breadth of stone

Breadth of stone was observed highest in Bombay green followed by Ratna and lowest was seen in Mallika in 1995 and 96. The distance between the shoulders which was lowest in Mallika indicated its higher pulp content and immense benefit to the processing for canning to get bigger slices. However, other varieties did not differ much in the breadth of stone. Sadhu and Bose (1976), Naik (1985), Patil (1990) and Ranjana and Huddar (1991) have also obtained the same results in mango.

5.2.1.2.8 Width of stone

Variety Bombay green recorded maximum width and minmum was recorded in Ratna during 1995 and 1996. These basic varital differences contributing to the width of stone were also recorded by Sadhu and Bose (1976), Naik (1985) Patil (1990) and Ranjana and Huddar (1991).

5.2.2 Chemical composition of sound and fully mature mango fruits at harvest and on ripening

5.2.2.1 Moisture

Ranta showed maximum moisture content both at unripe and ripe stage followed by Bombay green and minimum was recorded in Mallika. The amount of moisture content varied among the different varieties at harvest and on ripening. Higher values were recorded during 1995 while lower values were recorded in 1996. This might be due to the effect of variety and season. The decline in the moisture content from harvest to the ripe stage could be attributed to the loss of moisture due to respiration and transpiration of the fruit during storage. The results reported were in conformity with the results of Lakshminarayana *et al* (1970) ; Satyavati *et al.* (1972) ; Elahi and Khan (1973); Roy *et al.* (1970) ; Tandon and Kalra (1983) and Patil (1990).

5.2.2.2 Total soluble solids

The TSS of fruits at harvest and on ripening registered a significant enhancement during the period of ripening. The data of TSS indicated that at harvest variety Mallika showed higher values while lower TSS was observed in Bombay green in both the years of study. Similar pattern was seen in the next year of study. However, on ripening, Mallika recorded highest TSS and more or less similar values were recorded by both Ratna and Bombay green varieties.

An increase in the TSS during ripening process of the mango fruits could be attributed to the hydrolysis of starch into sugars. Soule and Hatton

(1955) and Srinivasan and Shanmugavelu (1971) studied the changes in total soluble solids content of mature and ripe mango fruit and they also have reported the similar kind of results. In addition, Krishnamurthy *et al.* (1960), Roy and Biswas (1981) and Patil (1990) also have reported on similar findings.

5.2.2.3 Titratable acidity

The investigation showed that maximum titratable acidity of fruits at harvest was recorded in Ratna whereas the minimum was recorded in Bombay green. On ripening also similar trend was observed. In both the years of study, the values were more or less similar. Teotia *et al.* (1968), Kapur (1974), Pande *et al.* (1974), Rangawala (1975) and Sahni and Khurdiya (1989a) have also reported on similar line of work.

The major organic acids of mangoes are malic and citric acid which constitute 90 per cent of titratable acidity of mangoes. A gradual decrease in the titratable acidity was observed in all the varieties from harvest to the ripe stage in both the years. This decrease could be due to (i) increase in respiration rate (ii) dilution of acids due to increased volume of fruits (iii) reduction in translocation of acids from leaves to fruits and synthesis of carbohydrates from organic acids.

5.2.2.4 Reducing sugars

The results in the present investigation revealed that there was a continuous increase in the reducing sugar content of mango fruits from harvest to ripe stage irrespective of varieties. At harvest the Bombay green fruits recorded the maximum reducing sugars followed by Ratna and the lowest was recorded in Mallika in both the years of study. In contrast to this, on ripening

Mallika ranked higher and Bombay green ranked lower in the reducing sugars content during 1995 and 1996.

The study also revealed that the percentage of reducing sugars to total sugars was less at harvest as well as on ripening of the fruits irrespective of the variety. It was also observed, higher the reducing sugars higher the sweetness. Similar reports have been quoted by Teotia and Awasthi (1966), Elahi and Khan (1973), Baldry *et al.* (1976), Awasthi and Pande (1979, 1980), Prasad (1984) and Sahni and Khurdiay (1989a).

5.2.2.5 Total sugars

Variety Bombay green recorded highest total sugars while Mallika recorded the lowest. After ripening variety Mallika exhibited highest total sugars along with higher total soluble solids. The increase in the total sugar content can be attributed to the conversion of starch and other pectinaceous matter into sugars during ripening. Sugars accumulate in the fruit due to high rate of enzyme activity compared with the rate of utilization in respiration as opined by Eskin *et al* (1971). The results obtained in the present investigation are in conformity with those obtained by Krishnamurthy *et al.* (1960), Garg *et al.* (19710, Fuchs *et al.* (1980), Joshi and Roy (1985b) and Patil (1990).

5.2.2.6 Sugar / Acid Ratio

Sugar acid ratio consistantly increased from unripe stage to fully ripe stage in all varieties. The increase was not only consistent but also was several fold more and significant in both the years for all the varieties. The observed differences in sugar / acid ratio between two years of study in Ratna, Bombay green and Mallika varieties are attributable to the increasd magnitude of sugars as well as the decrease in the acids as the fruits advanced from harvest to ripening. Ratna ranked first with maximum sugar / acid ratio which indicated that it is a very good variety for processing since higher sugar acid ratio is the most desirable character required for processing.

Reports on similar line have been quoted by Sarkar *et al* (1979), Ghosh *et al* (1985), Pal *et al*. (1987) and Amba Dan *et al*. (1988).

5.2.2.7 pH

It was reflected from the data that the pH of mango fruit increased from harvest to ripe stage. As expected, there was variation in pH of fruits among the different varieties on ripening, however, at harvest not much variation was seen. The increase in pH during storage could be due to corresponding decrease in acidity caused by degradation of organic acids during ripening.

In the present study, it was noticed that there was one and half to two fold increase in the pH of fruits between different varieties in both the years of study. These findings are in accordance with Krishnamurthy and Subramanyam (1970), Thomas (1975), Joshi (1983), Godoy and Rodrignez (1989), Sahni and Khurdiya (1989a) and Patil (1990).

5.2.2.8 Ascorbic acid

Variety Bombay green appeared to show maximum ascorbic acid content while Mallika showed minimum ascorbic acid content. On ripening also similar trend was observed with respect to ascorbic acid content of different varieties. Ascorbic acid content went on declining as the fruits were ripening, since ascorbic acid was involved in respiration. Thus, a decreasing trend from harvest till ripening can be ascribed due to oxidation of ascorbic acid as it is a reducing agent. It is reported by Hulme (1970), that the rate at which this change occurs is largely conditioned by pH. As the pH increased, the ascorbic acid conten decreased. Identical observations were also reported by Shani and Khurdiya (1989a), Thomas and Oke (1980) and Patil (1990).

5.2.2.9 Carotenoids as β-carotene

Total carotenoids expressed as β-carotene were found to be maximum in Ratna at both harvest and on ripening during 1995 and 1996. There was many fold rise in the carotenoids content at ripe stage in all the varieties compared to harvest. The values of β-carotene were responsible to give the favourable and most pre-dominant orange colour for Ratna whereas in Bombay green due to lower carotenoids content the colour was not desirable. Mallika variety was between these two vareties with comparatively better carotenoids in both the years of study.

In the year 1995 slightly higher value of β-carotene were recorded while during 1996 a little lower range was recorded. This is evidently due to the effect of season and also the variety. The development of carotene and gradual disappearance of green chlorophyll during ripening has been explained by Goodwin (1952) that although there is no appreciable direct conversion of chlorophyll into carotene, phytol from sugars, other than chlorophyll, might be in intermediate in carotene formation.

The results obtained in this investigation are in line with investigations of Jacob *et al.* (1970), Roy (1973), Lodh *et al.* (1974), Passera and Ali (1978), Verma *et al.* (1986), Sahni and Khurdiya(1989a) and Patil (1990).

5.2.3 Physical characteristics of canned mango slices

5.2.3.1 Vacuum

The investigation revealed that there was no substantial loss of vacuum during the storage of canned mango slices of all varieties in 1995 and 1996. The uniformity in all the varieties tested for vacuum indicated that proper temperature was maintained during processing of slices. Similar findings were also reported by Siddappa and Bhatia (1955), Nanjundaswamy *et al* (1966a), Teotia and Awasthi (1966), Satyavati *et al.* (1972), Palaniswamy *et al.* (1973), Garg *et al.* (1975), Awasthi and Pande (1980), Kulwal (1980) and Khurdiay and Roy (1986), but contradictory to these results Adsule and Roy (1975) reported downward trend for vacuum till nine months of storage in canned mango pulp.

5.2.3.2 Head space

The results of the cut out examination revealed that there were significant differences among the varieties for head space during 1995 and 1996. However, the slight increase in head space was observed at eight months of storage in all the varieties. The results are in accordance with Mehta *et al.* (1971) and Adsule and Roy (1975).

5.2.3.3 Drained weight

Significant differences were noted in drained weight of slices among the varieties tested during 1995. During 1996, the differences were non-significant among the varieties. There was a gradual increase in drained weight of slices till eight months of storage. The present results were also reported by earlier workers, Siddappa and Bhatia (1955), Palaniswamy *et al.* (1973) and Khurdiya and Roy (1986).

5.2.3.4 Internal condition of can

All the cans among the varieties were normal and there was no visible corrosion of the cans. It was also noticed that variety Bombay green showed slight feathering of cans at eight months of storage during 1995 and 1996. The results obtained in this investigation could be supported by the results obtained by Satyavathi *et al.* (1972) and Palaniswamy *et al.* (1973).

5.2.3.5 Clarity and colour of syrup

The liquid portion exhibited fairly clear yellow colour in variety Ratna and Mallika even upto eight months of storage in both the years. However, variety Bombay green showed slight turbidity of the syrup. The clarity of syrup depended upon fruit texture at canning and also on variety. Ratna and Mallika varieties retained shape and texture of slices on canning and resulted in clear yellow colour of syrup. These findings are similar to the results obtained by Satyavathi *et al.* (1972), Palaniswamy *et al.* (1973) and Amba Dan *et al.* (1988).

5.2.4 Chemical parameters of cut out examination of canned mango slices

5.2.4.1 Total soluble solids of slices

Variety Mallika showed highest TSS of slices and Ratna was next in order during 1995 to 1996. Significant increase was observed for the total soluble solids during storage among all the varieties but the differences were not perceptible. This variation in the total soluble solids could be due to the varietal differences. Similar magnitude of increase in total soluble solids was observed by Palaniswamy *et al.* (1973), Kapur (1975), Garg *et al.* (1975), Awasthi and Pande (1975) and Khurdiya and Roy (1988).

5.2.4.2 Total soluble solids of syrup

The results revealed significant differences among the varieties for TSS of syrup with increased trend during both the years of study. However, non-significant trend was observed in the subsequent year for the TSS of syrup. This could be due to the basic varietal differences and the effect of season.

Similar observations were made by Adsule and Roy (1975), Kapur *et al.* (1985) and Khurdiya and Roy (1988).

5.2.4.3 Titratable acidity of slices

Acidity of the slices was more or less uniform till six months of storage however, it increased at the end of eight months period in all the varieties. The differences were found to be non-significant and there was no specific trend of titratable acidity in both the years of study. However, increased acidity could be due to genetical differences. Similar increase in per cent acidity have also been reported by Nanjundaswamy *et al.* (1966a) and Patil (1990) in mango pulp.

5.2.4.4 Titratable acidity of syrup

Investigation showed that there was not much variation in the titratable acidity of syrup. However, variety Ratna recorded highest acidity during 1995 while Bombay green recorded highest titratable acidity in 1996. The varieties did not show any specific trend and also varied significantly in one season and non-significantly in another season. This could be due to the influence of season and variety. Similar findings were also reported by Nanjundaswamy *et al.* (1966a) and Khurdiya and Roy (1986).

5.2.4.5 Total sugars

Total sugars were higher in variety Ratna over a period of eight months storage during 1995 and 1996. Next in order of preference was variety Mallika followed by Bombay green. There was a gradual but significant increase in the total sugar content of all the varieties under study. This may apparently be due to the hydrolysis of polysaccharides and inversion of non-reducing sugars to reducing sugars and on the whole accounting for increased total sugars. The results are in conformity with those reported by earlier workers, Adsule and Roy (1975) and Amba Dan et al. (1988).

5.2.4.6 Sugars/ acid ratio

The results presented connote that the variety Ratna expressed higher sugar/ acid ratio from initial to eight months of storage followed by Mallika. The varieties differed significantly in both the years of study. Variety Bombay green and Mallika ranked second for the sugar / acid ratio overtaking Mallika. The higher sugar/ acid ratio would be contributing to an excellent product with characteristic flavour, attractive colour, taste and texture as reported by Garg et al (1975). The results of the findings were in confirmity with Amba Dan et al. (1988).

5.2.4.7 Total carotenoid expressed as β - carotene

The carotenoid pigments in plants are chiefly β- carotene and its derivatives. Results from the data show that the variety Ratna contained highest amount of carotenoid pigments followed by Mallika and the lowest was recorded in Bombay green. With higher carotenoids naturally Ratna yielded an excellent product with characteristic mango colour.

The findings further revealed that there wre significant variations among the varities and as the storage period prolonged there was loss of carotenoids. This decrease was more pronounced in varieties having initially high carotenoid contents i.e., Ratna. The loss in the carotene content of the fruit slices was marked during the first six months of storage and thereafter it continued at a slower rate. The decline in carotenoid pigment could be mainly due to the presence of residual oxygen. These results are in agreement with those reported by Bose and Das (1958), Adsule and Roy (1975), Garg *et al.* (1975) and Amba Dan *et al.* (1988).

5.2.5 Organeleptic evaluation of canned mango slices

5.2.5.1 Overall acceptability of canned mango slices

5.2.5.1.1 Appearance

Differences were observed for the appearance of the canned mango slices of different varieties. It was observed that variety Ratna peformed the best. Next to Ratna higher magnitude of appearance was observed in variety Mallika. These differences could be attributed to the basic varietal character.

5.2.5.1.2 Flavour

There was considerable difference among the varieties for flavour rating. It is clear from the organoleptic score that Ratna was adjudged superior to the rest of them in 1995 and also in 1996. This high quality rating may be due to more appropriate sugar / acid blend in that variety which might have increased the taste and palatability. Variety Mallika was found to be second best in flavour rating, while Bombay green obtained minimum score. This may be due to the fact that Bombay green has slight terpentine flavour which is not liked by majority of judges. These results are in conformity with Bose and Das (1958).

5.2.5.1.3 Texture

Texture retention is the main criteria for the canning of slices in which Ratna performed the best. The score rating was comparatively higher than Mallika and Bombay green. The investigation also revealed that variety Bombay green showed very good texture though less than the other two varieties inspite of a lot of fibrous pulp which did not get disintegrated during processing. Similar observations were recorded in both the years of study.

5.2.5.1.4 Overall acceptability

The study revealed that variety Ratna obtained highest score of 9.80 and 9.85 in 1995 and 1996 for overall acceptance by the judges. The variety Ratna acquired the best qualities of appearance, flavour and texture whereas Mallika appeared to be second with high magnitude of texture retention. Variety Bombay green was also on par with other varieties. The overall acceptance of canned mango slices variety wise depended on the individuals choices for a particular variety.

5.2.6 Change in visual characteristics of canned mango slices

5.2.6.1 Colour of canned mango slices

Canned mango slices stored at ambient temperature for eight months did not affect the colour of Ratna and Bombay green varieties. Mallika showed slight change from nasturtium orange to saffron yellow after 8 months of storage, due to reduction of carotenoid pigments during storage. This is in accordance with the report of Sahni and Khurdiya (1989b).

5.2.6.2 Microbial spoilage

There was no microbial spoilage of canned slices of all the varieties during storage for eight months due to the fact that proper precautions were taken during processing pertaining to time and temperature and also due to presence of high concentration of sugar which prevented the growth of micro-organisms by osmosis (Frazier and Westoff, 1978).

VI. SUMMARY

6.1 ORANGE

Nagpur mandarin oranges are famous all over India and abroad for its excellent qualities for fresh as well as for processing. The Vidarbha region of Maharashtra where the production of Nagpur mandarin oranges is concentrated because of the most ideal soil and climatic conditions most congineal to citrus is called California of Maharashtra. The demand for Nagpur oranges which has market not only in India but also in the far fetched parts of eastern countries, requires long distance transport which necessitates proper grading and packaging which could maintain the garden fresh quality to match with the demands of the consumer.

The prevailing system of bulk transport and transport in wooden boxes without proper grading and improper sizes of boxes do not comploy with the requirements. Moreover use of wood is being objected to by several environment protection groups who are against the destruction of forests for such purposes. Use of wooden boxes also results in damage to the fruits quite considerably. Wooden boxes cause bruising of fruits because of their abrasive surface as against the smooth surface demanded by the delicate skin of the fruits. Secondly, the non-processed biological material of the jungle wood offers a congineal substratum for micro organisms which inflict damages to the oranges, deteriorating their quality.

Keeping the above considertaions in mind, the present investigation on packaging and transportation of Nagpur mandarin oranges was undertaken at the Regional Fruit Research Station Katol, Dr. Panjbrao Deshmukh Krishi Vidyapeeth, Akola in collaboration with the US-AID/CTD, Centre for processed foods, Division of Horticulture, University of Agricultural Sciences, GKVK, Bangalore during the years 1995-98. The objectives of the investigation were :

1. To standardize the post harvest treatments for safe transportation and storage of fruits.
2. To study the changes in the fruit during storage.
3. To control the spoilage by various means.

The highlights of the present investigation are summarised in this chapter.

6.1.1 Study of post-harvest problems and physico-chemical properties of Nagpur mandarin Oranges

6.1.1.1 Post harvest losses in Nagpur mandarin Oranges

The losses in orangs at field level were found to be 7.37 per cent due to diseases, bruised and rind break. Average losses during transportation to long distances without any packaging were found to be 10.66 per cent whereas oranges packed in CFB-1 type card board cartons and transported over long distance had only 7.5 per cent losses. When orages were packed is carrugated fibre board boxes-type 2, the losses were estimated to be only 6.3 per cent. Total average losses at whole sale level were recorded to be 9.68 per cent and total average losses at retail level amounted to 8.1 per cent. Total post harvest losses in oranges were thus found to be 3444 per cent. (Table 1+2+3)

6.1.1.2 Physical properteis of Nagpur mandarin oranges

The average fruit diameter of oranges was recorded as 6.92 cm and the length of the fruits was 6.65 cm, depicting a typical orange shape of frut. The average fruit weight was recorded as 152.75 g, fruit firmness was recorded in the range of 2.6 kg/cm^2 to 3.2 kg/cm^2 the average being 2.87 kg/cm^2. Peel thickness ranged between 2.6 mm to 3 mm, whereas peel colour was ranging from yellowish green, yellowish orange to deep orange depending upon the season of harvesting.

6.1.1.3 Physico-chemical changes in Nagpur mandarin oranges during transportation and storage

For grade I fruit wooden box packaging was found to be best since fruits could be retained in good condition for upto 43 days. Corrugated fibre board box-1 packaged fruits could be retained upto 36 days without any marked changes in quality but beyond 36 days, the quality was little affected. Control fruits were in good condition only upto 8 days.

For grade II fruits wooden box packaging and CFB-1 and CFB-2 boxes were found to be equally good with little variation in quality, which was maintained till 43 days of storage. Control fruits could not be stored beyond 8 days.

With regard to grade III fruits, CFB-2 box packaging was found the best as it retained fruits in good condition upto 56 days, while wooden box packaging was good only upto 42 days. Control fruits deteriorated after 8 days.

6.2 MANGO

The investigation on canning of mango slices (*Mangifera indica* L.) cvs. Ratna, Bombay green and Mallika (Hybrid) were carried out at the processing laboratory at Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during the years 1995-96 and 1996-97 with the following objectives :

1. To study the change in quality attributes particularly texture of slices due to processing and storage over a period of time.
2. To study the comparative acceptability of canned mango slices after a long period of storage upto 8 months.
3. To evaluate the varietal response of Ratna, Bombay green and Mallika to canning as slices in sugar syrup.

The findings of the investigation are summarised below ;

6.2.1 Physical characteristics of mango fruits at harvest and on ripening

The physical characteristics such as weight, volume specific gravity, size of fruit (Length and Breadth), colour of peel and pulp, firmness of fruit were recorded at harvest. The average weight of fruit was highest in Mallika (332.50 g) and it was lowest in Ratna (227.01 g) during the two years 1995 and 1996. Volume of fruit was maximum in Mallika (319.65) and minimum in Ratna (235.45 ml). The specific gravity among the varieties varied from 1.00 (Ratna) to 1.03 (Bombay green). Mallika recorded maximum average length of fruit (15.74 cm) and Ratna recorded minimum (9.42 cm). The breadth of Bombay green was found highest (7.90 cm) and that of Ratna was lower in both the years. The average width of Mallika fruit (8.55 cm) was higher and Ratna recorded the lowest of (7.02 cm).

At harvest Bombay green recorded scheeles green colour of the peel during both the year of studies. Scheeles green colour of peel was recorded in Ratna and Mallika, respectively. Firmness was found to be highest in Ratna at harvest during 1995 and 1996 while on ripening also Ratna recorded highest firmness.

On ripening the weight of peel was highest in Bombay green (35.15 g), weight of pulp and stone was highest in Mallika (210.70 g and 40.10 g, respectively), during 1995. In the year 1996 similar trend was observed. The pulp to stone ratio was maximum in Bombay green and the pulp to peel ratio was maximum in Mallika in both the years of study. On ripening the variety Ratna exhibited saffron yellow colour while Bombay green and Mallika exhibited Indian yellow colour. The length and width of stone was higher in Mallika and breadth of stone was higher in Bombay green.

6.2.2 Chemical composition of sound and fully matured mango fruits at harvest and on ripening

During the process of ripening, total soluble solids, reducing and total sugars, sugar/acid ratio, pH and β-carotene content increased and attained a peak at ripe stage in both the years in all varieties under study. The moisture content, titratable acidity and ascorbic acid content showed a decline in all the varieties under study on ripening.

6.2.3 Change in chemical composition of canned mango slices

Total soluble solids, acidity and pH of slices and syrup were found to increase during storage in all the three varieties of mango studied during the two years. There was a significant increase in reducing sugars, total sugar and sugar /acid ratio after canning and storage for 8 months. However, the carotenoid pigments significantly decreased over a period of storage during both the years of study in all three varieties.

6.2.4 Organoleptic evaluation of canned mango slices

With higher organoleptic score for appearance, flavour, texture and overall acceptability the variety Ratna produced an excellent canned product among the varieties tried. Mallika also scored well for overall acceptance as compared to Bombay green during the storage of eight months in both the years of study.

Recommendations : Oranges

As a result of these studies, a "Systematic Flow Chart" of various operations to be carried out right from the time of harvest of oranges, their curing, washing, sorting and grading which has to be done without fail has been standardised. For successful transportation and safe and longer storage of oranges they must be treated with 1000 ppm of Thiobendazole along with waxing, and packed in corrugated Fibre Board Boxes for long distance transport.

Future line of work : Standardise "The Cool-chain"

It will be worthwhile to standardise the complete chain of operations for successful long distance transportation using C.F.B. boxes for packaging of Nagpur Mandarin oranges under refrigerated transport system (Refer Trucks).

Mango

Alphonso mangoes are becoming increasingly scarce for processing. Mallika hybrid, Ratna hybrid and Bombay green mangoes could be used for processing very successfully. Some research work on other products viz., mango nectar, mango juice and canned mango pulp for export can be undertaken.

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* Original Not Seen

APPENDIX I

Meteorological data from July, 1995 to March, 1996

Regional Fruit Research Station Katol

Met. Week	Month	Dates	Temperature			Relative Humidity			Rainfall	No.of Rainy
			Max.	Min.	Avg.	Morn.	Even.	Avg.	(mm)	Days
26.	June 1995	25-1	31.1	23.7	27.40	86	68	77	70.9	4
27.	"	2-8	36.0	23.5	29.75	77	48	62.5	4.6	1
28.	"	9-15	29.3	22.9	26.10	88	72	80.0	65.2	4
29.	"	16-22	32.1	23.5	27.80	80	54	67.0	2.0	Nil
30.	"	23-29	34.0	23.3	28.65	85	61	73.0	19.8	3
31.	August	30-5	29.9	22.6	26.25	92	82	87	143.3	7
32.	"	6-12	28.4	22.0	25.50	86	76	81	19.3	4
33.	"	13-19	30.1	21.5	25.80	85	62	73.5	5.2	1
34.	"	20-26	31.4	20.9	26.16	85	48	66.5	Nil	Nil
35.	September	27-2	34.2	22.6	23.40	84	47	65.5	12.0	2
36.	"	3-9	33.6	22.2	27.90	77	47	64.0	Nil	Nil
37.	"	10-16	33.1	23.1	28.10	88	56	72.0	26.1	1

Met. Week	Month	Dates	Temperature			Relative Humidity			Rainfall	No.of Rainy Days
			Max.	Min.	Avg.	Morn.	Even.	Avg.	(mm)	
38.	“	17-23	32.1	22.2	27.15	90	59	74.5	79.2	3
39.	“	24-30	33.7	22.6	28.15	89	61	75.0	36.0	1
40.	October	1-7	34.1	21.9	28.00	84	44	64.0	Nil	Nil
41.	“	8-14	35.6	19.5	27.50	76	32	54.0	Nil	Nil
42.	“	15-21	35.9	19.9	27.70	68	26	47.0	Nil	Nil
43.	“	22-28	34.1	19.1	26.80	71	35	53.0	Nil	Nil
44.	November	29-4	34.3	18.3	26.30	66	30	48.0	Nil	Nil
45.	“	5-11	33.2	17.4	25.30	73	21	47.0	Nil	Nil
46.	“	12.18	31.6	19.2	25.40	69	35	52.0	1.8	1
47.	“	19.25	33.9	20.0	26.95	73	21	52.0	4.4	1
48.	December	36-2	28.5	18.4	23.45	87	58	72.0	27.4	3
49.	“	3-9	29.3	15.3	22.30	79	32	55.5	Nil	Nil
50.	“	10-16	29.5	12.9	21.20	65	28	46.5	Nil	Nil
51.	“	17-23	27.9	15.6	21.25	91	51	71.0	8.1	2

Met. Week	Month	Dates	Temperature			Relative Humidity			Rainfall	No.of Rainy
			Max.	Min.	Avg.	Morn.	Even.	Avg.	(mm)	Days
52.	"	24-31	29.6	11.6	20.60	74	31	52.5	Nil	Nil
1	Jan. 1996	1-7	28.7	14.8	21.75	83	51	57.0	16.4	2
2	"	8-14	30.1	15.1	22.60	82	31	56.5	Nil	Nil
3	"	15-21	32.1	14.0	23.30	74	26	49.5	Nil	Nil
4	"	22-28	31.4	14.4	22.4	69	24	46.5	Nil	Nil
5	February	29-4	30.4	14.2	22.3	58	25	41.5	Nil	Nil
6	"	5-11	31.1	13.9	22.5	46	19	32.5	Nil	Nil
7	"	12-18	33.7	15.1	24.4	46	19	32.5	Nil	Nil
8	"	19-25	36.3	15.1	26.0	43	14	28.5	Nil	Nil
9	March	26-4	36.4	16.9	26.65	45	12	28.5	Nil	Nil
10	"	5-11	35.2	16.9	26.05	40	14	27.0	Nil	Nil
11	"	12-18	37.3	20.3	28.80	40	16	28.0	Nil	Nil
12	"	19-25	39.5	21.2	30.35	33	14	23.5	Nil	Nil

APPENDIX II

Monthly Temperature and relative humidity as recorded at USAID / CTD Laboratory, Division of Horticulture, UAS, GKVK, Bangalore during experimentation.

Year	Month	Temperature °C		RH (%)
		Maximum	Minimum	Mean
1995	May	28	20	65
	June	23	18	70
	July	24	19	70
	August	25	19	68
	September	24	18	75
	October	21	18	70
	November	23	21	68
	December	21	19	67
1996	January	24	17	63
	February	22	18	54
	March	26	19	53
	April	27	21	60
	May	28	22	62
	June	25	22	70
	July	24	21	71
	August	23	20	76
	September	24	21	71
	October	25	20	70
	November	23	21	72
	December	23	19	73
1997	January	22	18	74
	February (upto 15^{th})	23	20	71

VITA

Mr. Anant Govind Huddar was born on 8th December 1942 at Multai, district Betul, Madhya Pradesh. Son of late Shri. Govind Kesheo Huddar who was an advocate by profession and keenly interested in organic farming, Mr. Huddar followed the footsteps of his father and became keenly interested in Agriculture and Horticulture.

He obtained his BSc. Agri. and Msc. Agri (Horti) degrees from J.N.K.V.V. Jabalpur in first class and secured Gold medal of the University. C.S.I.R. offered him a Junior fellowship to study food technology at C.F.T.R.I. Mysore. He completed his fellowship training programme at C.F.T.R.I. Mysore and was appointed as a scientist at the same Institute. In 1974 Mr. Huddar joined as an associate professor of Fruit and vegetable technology at the University of Agricultural Sciences, Bangalore and was promoted to the cadre of Professor of Horticulture (PHT) during the year 1994.

During his career at U.A.S. Bangalore he secured Netherlands Govt. fellowship for advance studies in Horticultural food science at International Agricultural Centre, Wageningen for one year. In the year 1984-85 he was selected for a FAO-UNDP fellowship to study post harvest technology of Fruits & vegetables at C.S.I.R.O. Division of food Research, Sydney Australia. After returning from Australia, he was instrumental in securing a US-AID project funding to establish a state of art Laboratories for post-harvest Technology and Analytical and Quality control Laboratory for food analysis. He is presently the Professor and Head of the same Laboratory for processed foods at the Division of Horticulture, U.A.S. G.K.V.K. Bangalore. Mr. Huddar has more than 26 years experience in research teaching and extension in the area of post harvest technology. He has guided 32 MSc. Horti (PHT) and 8 Ph.D. Horti (PHT) students as a major advisor (thesis guide)

He has published more than 65 research papers in national and international journals concerning food science and technology, and presented more than 15 papers during national and international seminars. He has 25 popular articles, 5 practical manuals and two text books at his credit.

He is particularly instrumental in securing various schemes and research projects funded by US-AID/CTD, Ministry of food processing industries and I.C.A.R. at U.A.S. of which he is the principal investigator / project coordinator.

THESIS ABSTRACT

a)	Title of the thesis	:	"STUDIES ON POST HARVEST TECHNOLOGY INCLUDING PROCESSING OF ORANGES (*Citrus reticulata Blanco.*) AND MANGO (*Mangifera indica Linn.*) FRUITS"
b)	Full name of Student	:	ANANT GOVIND HUDDAR
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d)	Degree to be awarded	:	Ph. D. (Horticulture)
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j)	Signature, Name and address of forwarding authority	:	K. T. Sadawarte 25/6/99 Dr. ~~L. V. Kulwal~~, University Head, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola 444 104

ABSTRACT

1. Nagpur Mandarin Oranges (*Citrus reticulata* Blanco) are famous all over India and abroad for its excellent qualities for fresh as well as for processing. There is a tremendous demand for Nagpur oranges for local consumption as well as for export market, which necessitate proper grading and packaging during long distance transport to maintain the quality.

2. Keeping the above consideration in mind, the present investigation on packaging and transportation of Nagpur mandarin oranges was undertaken, during the years 1995-98. The main object of the experiment was to standardise the Post harvest treatment for safe transportation and storage of fruits and to study the changes in the fruit during storage.

3. Mango (*Mangifera indica* Linn.) is another very important crop having a tremendous demand in the foreign markets in its processed form. Alphonso cultivar is by far the best variety for processing, but the demand for fresh market is so great that the cost of fruits is prohibitive for its use in processing. Therefore a varietal trial for processing of three varieties viz., Ratna, Bombay green and Mallika was undertaken to assess their suitability for processing as an alternative to Alphonso, during the year 1995-97.

4. The experimental results reveal that the losses in oranges at field level itself were found to be 7.37 per cent. Average losses during transportation to long distances without any packaging were found to be 10.66 per cent, whereas oranges packed in CFB-1 type boxes had only 7.5 per cent losses. When oranges were packed in corrugated fibre board box type-2, the losses were found to be only 6.3 per cent.

5. Grade - I fruits packed in wooden boxes kept well upto 43 days, but the same fruits packed in CFB Box-1 retained excellent qualities for 36 days. Control fruits could retain the qualities for 8 days only.

6. For grade - II fruits, wooden box packaging, as well as CFB-1 and CFB-2 box packaging were found to be equally effective in maintaining quality for upto 43 days.

7. For grade - III fruits, CFB-2 box packaging was found to be the best for retaining good qualities upto 43 days.

8. Total soluble solids, acidity and pH of slices and syrup were found to increase during storage of canned slices in all the three varieties of mango. There was a significant increase in [illegible], total sugars, and sugar/acid ratio after canning and storage for 8 months, however, carotenoid pigments significantly decreased over a period of storage in both the years of study in all the three varieties.

9. With higher organoleptic score for appearance, flavour, texture and overall acceptability, the variety Ratna produced an excellent canned product. Mallika was second best and Bombay green was also found to be equally good.

1) Signature of Student

2) Signature of Major advisor