

**EVALUATION OF BARK OF *Terminalia arjuna*  
(Roxb.) FOR PHYTOCHEMICAL TRAITS**

**THESIS**

**Submitted to  
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola  
in partial fulfilment of the requirements  
for the Degree of**

**MASTER OF SCIENCE  
IN  
FORESTRY  
(FOREST PRODUCTS AND UTILIZATION)  
(MEDICINAL AND AROMATIC PLANTS)**

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**Enrolment Number - PP-1685**

**2023**

## DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled, "**EVALUATION OF BARK OF *Terminalia arjuna* (Roxb.) FOR PHYTOCHEMICAL TRAITS**" or part thereof has neither 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 organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

**Place :** Akola

**(Tayade Priyanka Rajesh)**

**Date :**     /     /2023

Enrolment No.- PP-1685

## CERTIFICATE

This is to certify that thesis entitled “**EVALUATION OF BARK OF *Terminalia arjuna* (Roxb.) FOR PHYTOCHEMICAL TRAITS**” submitted in partial fulfilment of the requirement for the degree of “**Master of Science in Forestry (Forest Products And Utilization)**” of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Tayade Priyanka Rajesh** under my guidance and supervision.

The subject of thesis has been approved by the Student's Advisory Committee.

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE  
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**(Tayade Priyanka Rajesh)**

**Enrolment No.- PP-1685**

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## (D) List of Abbreviations

%	- Per cent
/	- Per
°C	- Degree Celsius
cm	- Centimeter
,	- Minute
„	- second
DBH	- Diameter at breast height
r	- Pearson correlation coefficient
<i>et al.</i>	- et alia (and others)
etc.	- Etcetera
Fig	- Figure
g	- gram
hr.	- Hours
i.e.	- id est. (that is)
J	- Journal
m	- Meter
MB	- Malkapur Block
ml	- milliliter
mm	- millimeter
NAG	- Nagarjun
nm	- nanometer
rpm	- Revolution per minute
DRN	- Dharani
Sr.No	- Serial Number
µg	- Microgram
<i>viz.</i> ,	- (namely)
ANG	- Anjangaon
:	- colon
°	- Degree
mg	- milligram

SHN	-	Shahanur
PTG	-	Patur Ghat
SRL	-	Shirla
GDW	-	Gondhalwadi
DDN	-	Dudhani
PPK	-	Popatkhed
KTK	-	Khatakali
MBT	-	Malkapur Beat
rpm	-	revolutions per minute
Na <sub>2</sub> CO <sub>3</sub>	-	Sodium carbonate
+	-	Presence
-	-	Absence
~	-	Approximately
DPPH	-	1,1- diphenyl -2- picrylhydrazyl
UV	-	Ultra violet
PE	-	Petroleum ether

## (E) THESIS ABSTRACT

- a) Title of the thesis : “EVALUATION OF BARK OF *Terminalia arjuna* (Roxb.) FOR PHYTOCHEMICAL TRAITS”
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## ABSTRACT

The present study entitled “Evaluation of bark of *Terminalia arjuna* (Roxb.) for phytochemical traits” was carried out in the year 2022-23 at Department of Forestry, PGI, Dr. P.D.K.V, Akola. The study was carried out with the objective to survey and select *Terminalia arjuna* trees in Akola and Amravati district of Maharashtra, to study the morphological characters of selected trees of *Terminalia arjuna* and to examine the bark of *Terminalia arjuna* for phytochemical traits. Accordingly, the trees of *Terminalia arjuna*

were selected in Akola and Amravati district and the bark of selected trees were collected for evaluation of phytochemical traits.

To achieve the objectives of the study, total twenty five trees were marked on different locations in Akola and Amravati district viz., Nagarjun Medicinal Plant Garden, Malkapur Block, Patur Ghat, Shirla, Gondhalwadi, Dudhani, Dharani, Anjangaon, Shahanur, Popatkhed, Khatakali, and Malkapur Beat were surveyed. The marked trees were studied for five morphological characters viz., height of tree, diameter at breast height, number of primary branches, thickness of bark and moisture content of bark. Four phytochemical characters viz., tannin content, total phenol, antioxidant activity and ascorbic acid in bark were studied.

In the present study, morphological characters of trees of *Terminalia arjuna* Roxb. ranged from 06.47 to 11.37 m for height of tree, 20.17 to 27.22 cm for DBH, 3 to 4 for number of primary branches, 2.27 to 4.22 mm for thickness of bark and 51.59 to 56.39 per cent for moisture content of bark. Phytochemical characters of bark ranged from 06.88 to 12.89 per cent for tannin, 08.34 to 12.89 per cent for total phenol content, 24.59 to 38.36 µg/ml for antioxidant activity and 170 to 210 mg /100 ml for ascorbic acid.

The qualitative phytochemical screening of *Terminalia arjuna* bark in methanol extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids. However, qualitative phytochemical screening of bark in petroleum ether extract showed active compound namely, terpenoids and flavonoids presence in high concentration. Whereas, qualitative phytochemical screening of bark in chloroform extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids.

Correlation studies between morphological and phytochemical characters of bark of *Terminalia arjuna* showed significant correlation of tree height with phytochemical characteristics such as tannin (0.461\*) and total phenol content (0.489\*) at 5% level of probability. Notably, a very high and positively significant correlation of 0.547 was identified between number of

primary branches and ascorbic acid. Whereas, the remaining correlations were determined to be non-significant.

Among twenty five *Terminalia arjuna* trees selected from Akola and Amravati district, Tree No. ANG-1 and ANG-2 was found superior in respect of phytochemical traits.

# CHAPTER I

## INTRODUCTION

### 1.1 Background Information

The plant kingdom includes a high number of species, producing a diversity of bioactive molecules with different chemical scaffolds. Over the centuries, the use of medicinal and aromatic plants has become an important part of daily life despite the progress in modern medical and pharmaceutical industry. They are now being progressively cosmetics, foods and teas, as well as alternative medicines. The growing interest in herbs and their ability to offer economical uses is a part of the movement towards greener economics and life styles. This movement is based on the belief that the plants have a vast potential for their use as a curative medicine. Medicinal and aromatic plants will also maintain their importance in the search for new, valuable sources of drugs and lead compounds. In view of the steadily rising demands on these important natural resources, attention should be paid to the sustainable forms of production and utilization (Ghorbanpour *et al.*, 2017).

*Terminalia arjuna* (Wight & Arn.,) popularly known as "Arjuna". *Terminalia arjuna* (*T. arjuna*) is a deciduous large sized fluted tree to 30 m tall and 2-2.5 m diameter at breast height, with an often buttressed trunk. *T. arjuna* belongs to family Combretaceae (Ramya *et al.*, 2008). Leaves are simple, born sub-opposite, coriaceous, often crenulating, oblong or elliptic. Their upper face is pale or dark green and the lower face is pale brown. Flowers are sessile and occurs in simple or panical spikes. Calyx is glabrous and has five short triangular lobes. Fruit is drupe, smooth-skinned with five hard angle or wings, fibrous-woody, about 3.0 to 4.5 long and 2.5 to 5 cm broad. Bark is smooth, pinkish-grey from outside and flakes off in large curved and rather flat pieces. Sapwood is reddish white and heartwood is brown and variegated with dark coloured streaks (Dwivedi, 2007). Flowering time is March to June and fruiting time is September to November. It is moderate shade-bearer tree species but does not tolerate dense overhead shade. Seedling are sensitive to drought and frost but grow well if moisture is available. It produces root suckers. Coppicing is satisfactory and pollards well. The tree is naturally not found in open and dry hillsides.

Arjuna is propagated by seed. Ripe fruits are collected in March either by lopping the branches or from the ground previously swept clean. The seeds retain its viability for at least one year, when stored in sealed tins. Seeds collected from previous season are directly dibbled at 7.5 cm x 8.5 cm on well-prepared raised beds, regularly watered and weeded. Germination takes place in 50-70 days and per cent germination varies from 50-60 per cent. The seedlings are ready within 2-3 months for transplanting in the field.

Arjuna is water loving species and tropical of dry deciduous forest of central India. The tree prefers humid, fertile loam and red lateritic soils. It grows in low land to hilly areas and can tolerate half submergence for a few weeks. It's bark has been used in traditional Ayurvedic herbalism for generations, primarily as a cardiac tonic (Pandey and Kori, 2011).

*T. arjuna* is widely used and known as ayurvedic plant. Physicians used it for its curative properties in different types of heart problems including hypertension, angina and blocks in arteries. It is also very useful in the treatment of any sort of pain in heart such as falls, spermatorrhoea, ecchymosis and sexually transmitted diseases as gonorrhoea and thought to be a useful astringent, cooling, aphrodisiac, cardio-tonic, and is used for ulcers, leucorrhoea, diabetes, cough, tumor, excessive perspiration, asthma, inflammation and skin disorders etc (Khan *et al.*, 2013).

Antioxidant is a molecule, which terminate the chain reaction by removing free radical intermediates. Plants and animals maintain complex system of multiple type of antioxidant; the natural plant based antioxidants are playing an important role in the maintenance of human health for the past three decades. There is an increasing interest in antioxidants, particularly in those intended to prevent the presumed deleterious effects of free radicals in the human body and to prevent the deterioration of fats and other constituents of foodstuffs. In both cases, there is a preference for antioxidants from natural rather than from synthetic sources. There is therefore a parallel increase in the use of methods for estimating the efficiency of such substances as antioxidants (Shahriar *et al.*, 2012).

Tannins and flavonoids are responsible for its anticancer properties (Jain *et al.* 2009). Decoction of bark is used as ulcer wash, while

bark ash is used in the treatment of the snakebite and scorpion sting (Dwivedi and Chopra, 2014).

In addition to flavonoids variety of tannins have been isolated from the bark of *Terminalia arjuna*. Some of the well known hydrolysable tannins from the bark are pyrocatechols, punicallin, punicalagin, terchebulin, terflavin C, castalagin, casuariin and casuarinin. Tannin are known to enhance synthesis of nitric oxide and relax vascular segment precontracted with norepinephrine. Tannin may be responsible for its astringent, wound healing and anti microbial activity (Dwivedi, 2007).

According to the World Health Organization, over 80% of the world's population or 4.3 billion people rely upon traditional plant-based systems of medicine for primary health care. In India, almost 95% of the prescriptions are plant based in the traditional systems.

## **1.2 Importance and need of the Study**

*Terminalia arjuna* is a wide spread medicinal plant. The different parts of *Terminalia arjuna* like bark, leaves and fruits etc. have different medicinal values and are used to cure various diseases.

The bark is the main part used in Ayurveda as well as in Allopathy for curing various diseases. The bark of *arjuna* tree contains calcium salts, magnesium salts and glucosides have been used in traditional ayurvedic herbalism (Tripathi and Singh1996 and Kandil and Nassar, 1998). According to vagbhata, *Terminalia* bark is cooling *kapha*, *pitta* pacifying, cardiac restorative and help in healing wounds, tuberculosis and poisoning. Chakradatta the great ancient physician, recommended it to be given as a decoction of bark with milk or as a ghrita (a preparation with ghee or butter). Decoction of the bark has been used as ulcer wash, while bark ashes have been prescribed for snakebite and scorpion sting.

The bark has been described as an astringent, demulcent, expectorant, cardiogenic, styptic, antidysenteric, urinary astringent, and has shown to be useful in fracture, ulcers, leukorrhea, diabetes, anemia, cardiopathy, and cirrhosis (Dwivedi and Chopra, 2014). Fruits are used as a

tonic and deobstruent (Kritikar and Basu, 1975) leaves are said to be the remedy for earache (Khory, 1867).

*Terminalia arjuna* is mostly found growing naturally on river banks or near dry river beds in Akola and Amravati district of Maharashtra. The bark of the arjuna species is highly valued for its medicinal properties. Keeping in view of the above medicinal value of bark of *Terminalia arjuna*, the present study was undertaken to study the different morphological and phytochemical traits of bark of *Terminalia arjuna* naturally growing in Akola and Amravati districts.

### **1.3 Objectives**

1. To survey and select *Terminalia arjuna* trees in Akola and Amravati district of Maharashtra.
2. To study the morphological characters of selected trees of *Terminalia arjuna*.
3. To examine the bark of *Terminalia arjuna* for phytochemical traits.

## CHAPTER II

### REVIEW OF LITERATURE

A review of literature is one of the important aspect in the research process. It makes the researcher up to date with the theoretical knowledge and finding of research topic in the field of investigation. In any scientific investigation, it is mandatory for research work to go in depth in to the earlier studies conducted. So, as to study the methodology adopted in past studies and to ascertain the consultancy, this helps the researcher to get acquainted with the subjected matter. It provides clues and guidance to the researcher in desirable direction. It helps to precise, specific and relevant to the subject of research.

The relevant literature pertaining to the present study on “Evaluation of bark of *Terminalia arjuna* (Roxb.) for phytochemical traits” is reviewed under the following heads.

2.1 Morphological characters

2.2 Phytochemical traits

2.3 Correlation studies

#### **2.1 Morphological characters**

Du and Deetlefs (1957) studied bark weight tables for the wattle growing areas of southern Rhodesia to investigate relationship between tree size, relative bark thickness and bark yield of black wattle trees (*Acacia mollissima wild.*) The method of least square was employed. Significant differences in the ratio of bark thickness to diameter at breast height were established for different localities from which tree were selected for stripping.

Jindal *et al.* (1987) studied genetic variability in Rohida (*Tecomella undulate*) in Western Rajasthan for different characters like height, basal diameter at breast height followed by basal diameter, diameter at breast height and branches. Similarly, the maximum coefficient of variation was recorded for diameter at breast height (60.3m) followed by basal diameter (53.7m) and tree height (32.6m).

Suryawanshi (2006) worked on moisture content for birch bark and its chemical composition in which 2 g of each group were kept in an oven at 105 °C and circulating air for about 1 hour to get a constant weight. The moisture content is assumed to be represented by the loss in weight after drying and reports as percentage of the original weight.

Williams *et al.* (2007) taken an effort to link bark thickness recorded during three ethnobotanical survey, the relationship between bark thickness and stem diameter at breast height (DBH) was investigated for six species used medicinally in South Africa. Samples of bark were removed from 207 stem and subsequently weighted and measured. Thereafter, the samples placed in a phytotron chamber to dry out over a period of 12 weeks. The change in bark thickness over time was regressed with stem diameter in order to predict stem diameter from bark thickness records. The strength of relationship between bark thickness and diameter was strongly influenced by the macroscopic bark morphology of the species.

Carbel *et al.* (2010) studied relationship of biometric parameter on the concentration of tannins in *Myracrodruon urundeuva* Allemao and *Sideroxylon obtusifolium* (Humb. Ex Roem. & Schult.) in the Northeast region of Brazil. In order to identify parameters that could assist the pharmaceutical industry and local collectors in collecting samples with high yield of tannin, this study include a biometric parameters (diameter at breast height (DBH), bark thickness and height) in relationship with the concentration of tannins in the species. The radial diffusion method was used to measure the tannin levels in all samples, and some were selected also measured using the method of Folin-Ciocalteu in order to compare results between method. They concluded that, the biometric parameters were not related to the production of tannins in the species evaluated however, the DBH and the bark thickness were positively correlated, and this relationship was more pronounced for *Sideroxylon obtusifolium*.

Singh *et al.* (2010) worked on moisture content (loss on drying) for standardization of 'Arjunarishta' formulation in which 2 gm of powdered (*T. arjuna*) drug was taken in tarred china dish. Dried in the oven at 100 °C or 105 °C, cooled in a desiccator and watch. After that the loss was recorded as

moisture. The procedure was continued for at least two common readings. 5-7 per cent moisture content was observed.

Navhale *et al.* (2011) studied variability in Hirda (*Terminalia chebula*) accession collected from the nearby area of Dapoli, Barondi, Wakawali, Murad and Anjarla. Wide variation was noticed in morphological characters exhibited by height (3.5m to 15.0m), canopy diameter (3.2m to 10.0m) and DBH (44.0cm to 126.0cm).

Rajput (2018) reported the morphological characters of trees of *Helicteres isora* and depicted the range (2.39 to 4.23m) height of tree, (2.57 to 7.13cm) DBH, (2.35 to 3.45m) canopy diameter, (3 to 11) branches for number of branches per tree and (60 to 150) number of fruits per tree.

## **2.2 Phytochemical traits**

Bhatia *et al.* (1977) studied the barks of *T. arjuna*, *T. alata*, *T. bellirica* and *T. chebula* and reported that tannin contents in the barks ranged from 7.20-20.85 per cent in *T. arjuna*, 9.06-16.55 per cent in *T. alata*, 4.45-16.30 per cent in *T. bellirica* and 9.25-25.30 per cent in *T. chebula*. In each species oxalic acid and tannin contents varied considerably in the bark samples from different locations with no obvious correlation with climate or soil.

Daniel and Sabnis (1978) worked on estimation of tannin in Gujarat, of 26 plant species. They collected inflorescences and young branches of *Tamarix ericoides* Rottl. in all season in view to find out seasonal variation of tannin content in various plant parts. The estimation of total tannin was done using standard methods. The tannin contents has expressed in terms of percentage dry weight. They reported that the inflorescences and young branches of *ericoides* were found to posses more than 10 percent tannin content. They recommended January-February and July-August were two peak periods at which plants be harvested for any commercial exploitation. Their results also showed that inflorescence of that plant was found to be even richer than younger branches in their tannin content.

Krishnamoorthy *et al.* (1992) studied variability and bark yield in *Cinnamomum verum* and reported that bark recovery had moderately good association with dry weight of bark.

Jamalludheen *et al.* (1995) examined in the species of *Lagerstroemia speciosa* considerable variation in vigour of trees expressed as various vegetative, flowering, fruit and seed characters. Height of tree showed comparatively less variation (CV = 14.13 per cent) than the girth (CV = 18.53 per cent). Height of tree varied from 460 to 725 cm with a mean of 625.80 cm. Height was strongly and positively correlated with girth ( $r=0.732$ ) and also with spread (0.692). A coefficient of variation for girth was 18.53 per cent and for spread was 14.29 per cent. The mean number of primary branches was found to be 14.9.

Lin and Hsu (1999) worked on tannin and related compounds from *Terminalia catappa* and *Terminalia parviflora* bark. Malan and Roux (1975) evaluated tannin content in *Acacia* species in the form of Catechin from South Africa. Similarly, Seigler *et al.* (1986) studied tannins from four common *Acacia* species (*Acacia berlandierii*, *Acacia farnesiana*, *Acacia greggii*, *Acacia rigidula*) of Texas and North Eastern Mexico. Total tannin content in leaves, bark, wood and immature fruits was determined by Folin Denis method. Bark and fruits had high tannin content (5-15%) and wood had much lower (less than 1%) and leaves has intermediate values.

Readel *et al.* (2001) studied the percentage of tannin in leaves, bark, wood, and immature fruits of several species of *Acacia* from series gummiferae, vulgares, and filicinae and related mimosoid legumes from the South Western United States and Mexico along with a few from Costa Rica and Argentina. The total amount of tannin present varied from almost none to about 15 per cent. Leaves and bark contained larger quantities of tannin than wood.

Trugilho *et al.* (2003) determine tannin from Eucalyptus species through two extraction methods, one using hot water and another sequence of toluene and ethanol. The result indicated that the method extract showed significant differences in level of tannins. The hot water method had higher

level of tannin in viz., *Eucalyptus cloeziana* (94.31%) followed by *Eucalyptus melanophoia* (20.49 %) and *Eucalypts paniculata* (16.03%).

Monterio *et al.* (2005) evaluated the tannin levels in samples of the stem bark and leaves of *Myracrodruon urundeuva* (Engl.), *Anadenanthera colubrina* (Vell.), Brenam and *Caesalpinia pyramidalis*. Observed no significant relationship between the tannin levels of these species with the diameter at breast height and the total height of the individual.

Kumar *et al.* (2005) noticed the significant variation in height, diameter, bark percentage, sapwood percentage, heartwood percentage, fibre length, specific gravity of *Dalbergia sissoo*.

Monteiro *et al.* (2006) studied effect of seasonal climatic changes in caatinga (semi arid plant species tannin levels in *Myracrodruon urundeuva* (Engl.) Fr. All. and *Anadenanthera colubrine* (Vell.) Brenan of Brazil. Tannin was quantified by using Casien precipitation method. Tannin was expressed in per milligram of dry materials. They reported that trunk and bark of two species contained more tannin during dry seasons (August - December) than rainy season (January – July).

Gujrathi and Babu (2007) worked on environment friendly products from Black wattle. They reported that mature black wattle (8-10 years growth) contains on average 35% tannin. Tannin occur in all plant parts but commercially they are derived only from bark. The tannin content of the bark varies within a single tree, being highest in the thick basal bark and gradually decreasing with increasing height. The bark of lowest tannin content can therefore, be found in the youngest portion of trunk and branches. Tannin content usually increases with increasing age and thickness of bark, but varying soil condition, rainfall and environmental factors also exercise a marked influence. A higher correlation exists between the DBH of tree and tannin content. They also reported that Black wattle trees after reaching maturity are felled and stripped of bark during the period October to June, when the soil moisture content is high. The trees strip easily and almost continuously in areas of rainfall, but with difficulty in dry areas after a sudden drop of temperature.

Chunlong *et al.* (2008) analyzed colorimetric methods, the concentration of total phenolics, flavonoids and condensed tannins in 9 categories of organs in *Populus euphratica*, including green branches (D<5 mm in diameter), branches (5-10 mm in diameter) and barks. They showed that phenolic compounds were present throughout the collected organs. The average condensed tannin contents in bark in two categories and branches in three classes were 8.41, 4.03 and 4.47 mg/g respectively. Phenolic compounds in branches decreased with the branches matured, resulting in the following orders: green branches > (D < 5 mm) > branches (5-10 mm). Condensed tannins in roots increased with the root diameter, decreasing and the highest condensed tannin contents were found in small roots (D < 2 mm) (25.95 mg/g).

Mishra *et al.* (2009) studied *Ichnocarpus frutescens* ash value, extractive value, total carbohydrate, protein, tannin and phenol contents. Protein, tannin and phenol content were found higher in stem portion (3.12%, 5.94%, 8.03%) in the plants.

Pandey and Kori (2009) studied variation in tannin. Tannin content was ranged from 6.75 to 14.82 gram per 100 gram. The variation was noticed in tannin content with season and age of the tree. The result showed that, variation in tannin and oxalic acid content may be due to variation in climatic conditions (rainfall, humidity and mean temperature). Bark collected in March contains higher amount of tannin (14.82%) followed by the bark collected in November.

Killedar and More (2010) estimated tannins in different parts of *Memecylon umbellatum* Burm by Folin-Denis method using simple spectrophotometric method. Tannin content was found highest in bark ( $2.4125 \pm 0.124$ ) followed by in leaves ( $1.7586 \pm 0.18$ ), roots ( $1.3318 \pm 0.16$ ) and stem bark ( $1.0538 \pm 0.16$ ). Samples were collected in the month of Feb-March for analysis. The estimation were also made repeatedly with fresh and stored sample (up to 3 year) and found no significant difference in tannin content. Maximum average variation was found in bark (0.0037%) and minimum (0.0011%) in stem wood compared to fresh sample.

Pandey *et al.* (2011) studied that the harvested bark sample of *Holarrhena antidysenterica* R.Br. Sans (Kutaj) and different plant parts like twig bark, wood, flowers and leaves were analysed for tannin, total phenols, total alkaloids and total flavonoids. Phytochemical analysis revealed that the active ingredients in trunk bark were comparatively higher, i.e. total phenols (7.51+0.12%), total flavonoids (0.19+0.09%), total alkaloids (2.25+0.06%), and tannins (8.61+0.10%) than other plant parts studied.

Patil and Gaikwad (2011) analysed the bark of *T. arjuna* and examined phytochemical presence of alkaloids, glycosides, flavonoids, flavanols, phenols, saponins and terpenoids. Further revealed the concentrations of secondary metabolites found higher in the apical stem bark followed by middle and mature stem bark.

Pandey *et al.* (2011) revealed that the optimum girth class to harvest barks of *B. uariiegata* was 36-55 cm, *S. asoka* 61-90 cm and *T. arjuna* 121-150 cm as these were found to contain maximum concentration of active ingredients and possess high radical scavenging activity.

Batubara *et al.* (2012) observed that tannin content in bark of *Terminalia catappa* 59.3% and in stem 11.5%.

Nama *et al.* (2012) studied that *Terminalia arjuna* It's stem, bark and leaves possess glycosides, large quantities of flavonoids, tannins and minerals. Flavonoids have been found to possess antioxidant, anti-inflammatory and lipid lowering effect whereas glycosides are cardiogenic, therefore making *Terminalia arjuna* distinctive among currently used medicinal plants.

Mandal *et al.* (2013) investigated phytochemical screening of *T. arjuna* bark extract and showed the active compounds presence in high concentration, such as phytosterol, lactones, flavonoids, phenolic compounds and tannins and glycosides.

Desai and Chanda (2014) reported the presence of alkaloids, flavonoids, tannins, triterpenes, cardiac glycosides and saponins and concluded that the microscopic and physiochemical analysis of the *T. arjuna* leaf is useful in standardization for quality, purity, and sample identification.

Tahira Parveen and Sharma (2014) noticed the presence of several secondary metabolites viz., alkaloids, steroids, volatile oil, fat, tannin, carbohydrate, saponin and flavonoids in various organic solvents of leaves and stem bark extracts of *T. arjuna* and *Tecomella undulata*.

Chaudhari and Mahajan (2015) assessed the detailed pharmacognostic study of *T. arjuna* stem bark (TASB) and Qualitative phytochemical analysis of the methanolic extract of TASB (MeOH-TASB) and confirmed the presence of alkaloids, glycosides, tannins, flavonoids, phenols, Saponins and steroids in the extract.

Tiwari *et al.* (2017) conducted studies on the detailed physicochemical, phytochemical and screening for antibacterial activity of stem bark of *Terminalia arjuna* and found that the bark of *T. arjuna* contains appreciable amount of secondary metabolite. They further ascertained phytoconstituents may acts as resource of pharmacologically active agents and natural antioxidants.

Chaudhary *et al.* (2018) studied transverse sections of Arjuna bark which shows the calcium oxalate crystal, starch grains and lignified cells respectively and reported that Xylem Vessels, Sclerenchymatous Fibers, Cork Cells, Tracheids, Sclereids, LOD value of the sample of Arjuna is 5.63%.

Uthirapathy and Ahamad (2019) studied phytochemical analysis of petroleum ether, ethyl acetate and methanolic fractions of *T. arjuna* bark by GC-MS analysis. The study revealed main identified compounds are 9-Octadecenoic acid (Z)-methyl ester (35.38%), Hexadeca-2,6,10,14-tetraen-1-ol (34.94%) and Furan carboxaldehyde, 5-(hydroxymethyl) (19.31%) from petroleum ether, ethyl acetate and methanolic fractions of bark of *T. arjuna*, respectively.

Mahmood *et al.* (2020) studied antioxidant potential of the drinks which indicated significant variations for TPC, flavonoids, DPPH, ABTS and FRAP with non-significant variations with storage and concluded that different extraction techniques significantly affected the antioxidant potential and sensorial attributes of TA bark based functional drink.

Kumari and Jain (2022) conducted studies on phytochemical screening, estimation of phenolic, flavonoid, ascorbic acid content and free radical scavenging assay of the aqueous bark extract of *Terminalia arjuna* and found that it contains 190 mg per gram of ascorbic acid in bark.

### **2.3 Correlation studies**

Townsend (1977) reported significant variation in height, diameter and phenology among different provenances of *Acre rubrum* at two year stage.

Khanvilkar *et al.* (1987) evaluated physical characters of Kokam (*Garcinia indica* choisy). The yield in terms of number of fruits/ plants on weight basis was recorded for the selected 25 Kokam types. There was positive correlation between fruit yield and number of fruits. Fruit length exhibited significant negative correlation with yield. The characters like fruit breadth, fresh weight of rind and number of seeds, weight of pulp exhibited very poor associated with yield.

Tewari *et al.* (1994) reported (*Populous deltoides*) tree volume had positive and significant correlation with height, diameter, clear bole strength, crown length and crown width. The characters studied also reported positive and significant correlation with each other.

Luna and Kumar (2008) studied seventeen fruit sources of Aonla (*Embllica officinalis* Gaertn.) in Shiwalik hills of Punjab and studied the fruit characters mainly fruit diameter, pulp weight, pulp stone ratio and number of fruits per kg and recorded the significant variation in fruit traits, Correlation coefficient gave highly significant results between tree girth, tree height and tree crown characters. Highly significant but negative relationship exists between diameter of fruit vs number of fruit per kg and stone weight vs pulp/stone ratio.

Pawar *et al.* (2017) revealed correlation studies between different physico-chemical characteristics like fresh weight, dry weight, length, moisture content, length of fruit, weight of fruit pulp, weight of seed, TSS, acidity, total sugar, reducing sugar, non-reducing sugar in fruit of *Terminalia bellirica* (Roxb.)

## CHAPTER III

### MATERIAL AND METHODS

The present investigation entitled "Evaluation of bark of *Terminalia arjuna* (Roxb.) for phytochemical traits" was carried out and the detail of material used and method adopted during the study was described in this chapter.

#### 3.1. Experimental details

##### 3.1.1. Experimental site

The survey was carried out where the population of *Terminalia arjuna* was occurred in the Akola and Amravati district of Maharashtra. The trees of *Terminalia arjuna* was identified on different locations of Akola and Amravati district. Total twenty-five trees were marked on different locations of Akola and Amravati district. The identified trees were marked with yellow paint. Latitude and longitude of each tree was recorded at site by using GPS Waypoint. The details of location, tree number, latitude and longitude is as given in Table 1. Mature tree species ranging girth size from 60 to 150 cm were selected for extraction of bark. The barks were stripped away by using chisel and hammer. Approximately 300 grams of bark was collected from each tree. The collected bark was analysed for different phytochemical traits. A photograph of extraction of bark on standing tree is shown in plate 1. and a photograph of collected bark sample is shown in plate 2. The Morphological characters of *Terminalia arjuna* were recorded at site and experimental work related to chemical analysis was undertaken in the laboratory of Nagarjuna Medicinal Plant Garden, Dr. PDKV, Akola.

#### 3.2. Observations recorded

The observations recorded for morphological and phytochemical parameters of *Terminalia arjuna* is given below.

##### 3.2.1 Morphological characters

###### 3.2.1.1. Height of tree (m)

The height of the tree was taken from where the top and base of the tree was visible with the help of Ravi altimeter and recorded in meters.



Plate 1 : Extraction of bark on standing tree of *Terminalia arjuna*



Plate 2 : Collected bark samples of *Terminalia arjuna*

**Table 1. Tree number and Location of *Terminalia arjuna* trees in different location of Akola and Amravati Districts.**

<b>Sr. No.</b>	<b>Location</b>	<b>Tree No.</b>	<b>Latitude (North)</b>	<b>Longitude (East)</b>
1	Nagarjun Medicinal Plant Garden	NAG-1	20° 69' 40"	77° 02' 85"
2	Nagarjun Medicinal Plant Garden	NAG-2	20° 69' 40"	77° 01' 89"
3	Malkapur Block	MB-1	20° 88' 64"	76° 21' 62"
4	Malkapur Block	MB-2	20° 88' 64"	76° 23' 65"
5	Patur Ghat	PTG-1	20° 19' 32"	76° 53' 00"
6	Patur Ghat	PTG-2	20° 19' 41"	76° 53' 04 "
7	Shirla	SRL-1	20° 50' 86"	76° 95' 07"
8	Shirla	SRL-2	20° 50' 86"	76° 94' 08"
9	Gondhalwadi	GDW-1	20° 37' 06"	76° 95' 57"
10	Gondhalwadi	GDW-2	20° 37' 06"	76° 96' 59"
11	Dudhani	DDN-1	20° 46' 28"	76° 93' 84"
12	Dudhani	DDN-2	20° 46' 28"	76° 94' 05"
13	Dharani	DRN-1	21°35' 01"	76° 59' 47"
14	Dharani	DRN-2	21° 31' 54"	77° 04' 28"
15	Anjangaon	ANG-1	21° 09' 36"	77° 18' 36"
16	Anjangaon	ANG-2	21° 09' 36"	77° 15' 39"
17	Shahanur	SHN-1	21° 22' 79"	77° 03' 92"
18	Shahanur	SHN-2	21° 22' 79"	77°04' 95"
19	Popatkhed	PPK-1	21° 14' 57"	77° 04' 11"
20	Popatkhed	PPK-2	21° 15' 07"	77° 04' 13"
21	Khatakali	KTK-1	21° 14' 58"	77° 03' 49"
22	Khatakali	KTK-2	21° 15' 07"	77° 04' 13"
23	Malkapur Beat	MBT-1	21° 14' 58"	77° 03' 49"
24	Malkapur Beat	MBT-2	21° 14' 58"	77° 04' 06"
25	Malkapur Beat	MBT-3	21° 14' 47"	77° 04' 09"

A photograph of measurement of height of tree *Terminalia arjuna* is shown in plate 3.

### **3.2.1.2. Diameter at Breast Height (cm)**

Diameter of trees was measured at breast height (1.37 m above from ground level) with the help of tree calliper. It was measured at two points which were at right angle to each other and mean value of two observations were recorded as diameter at breast height in cm. A photograph of measurement of diameter at breast height of *Terminalia arjuna* is shown in plate 4.

### **3.2.1.3. Number of Primary Branches**

Number of primary branches of each tree were counted at site.

### **3.2.1.4. Thickness of bark (mm)**

The bark thickness of tree was measured in millimeter at breast height with the help of Swedish Bark Guage. It was measured at four locations perpendicular to each other and the average of these were taken as bark thickness. A photograph of measurement of thickness of bark is shown in plate 5.

### **3.2.1.5. Moisture content of bark (%)**

The percentage of moisture of bark was estimated by oven drying a known weight of samples of bark at 55°C-60°C till to get constant weight. Moisture content of bark was recorded in percentage by subtracting the final weight of sample from the initial fresh weight of sample (A.O.A.C.1975).

$$\text{Moisture \%} = \frac{\text{Weight of fresh sample} - \text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100$$

### **3.2.2 Phytochemical characters of bark**

The collected bark were dried and powdered for estimating the phytochemical characters viz., tannin content, total phenol, antioxidant activity, ascorbic acid. The data of twenty five samples for phytochemical characters were recorded. A photograph of grinded sample of bark of *Terminalia arjuna* is shown in plate 6.



**Plate 3 : Measurement of height of tree *Terminalia arjuna***



**Plate 4 : Measurement of DBH of *Terminalia arjuna***



**Plate 5: Measurement of thickness of bark of *Terminalia arjuna***



**Plate 6: Grinded sample of bark**

### 3.2.2.1. Tannins in bark (%)

Tannins were estimated by Folin-Denis Method (Thimmaiah,1999).

Reagents:

- a) **Folin-Denis reagent:** Sodium tungstate (100 g) and phosphomolybdic acid (20 g) were dissolved in 750 ml distilled water in a suitable flask containing 50 ml phosphoric acid. The mixture was refluxed for 2 hours and final volume was made to one litre with distilled water.
- b) **Sodium carbonate solution:** 350 g of sodium carbonate was dissolved in distilled water at 70-80°C. After cooling, the volume was made to one litre with distilled water. It was then filtered through glass wool after allowing it to stand overnight.
- c) **Standard tannic acid solution:** 100 mg of tannic acid was dissolved in 100 ml of distilled water. This was labelled as stock solution.
- d) **Working standard solution:** 5 ml of the above tannic acid stock solution was diluted to 100 ml with distilled water.

#### Procedure

200 mg of the powdered material was boiled (30 minutes) with 50 ml of distilled water in a 250 ml flask. The contents were then centrifuged for 20 minutes and the supernatant was made to 100 ml with distilled water. 1 ml of the above sample extract was taken in a 100 ml volumetric flask containing 75 ml distilled water and to it 5 ml of Folin-Denis reagent and 10 ml of sodium carbonate solution were added. The total volume was then made to 100 ml with distilled water. After shaking and allowing it to stand for 30 minutes, absorbance was recorded at 700 nm. Standard graph was prepared by taking 0, 1, 2, 3, 4 and 5 ml of working standard solution of tannic acid and using the other reagents as mentioned above. Blank was prepared by taking distilled water. Tannins content was calculated as tannic acid equivalent from standard graph. A photograph of estimation of tannin content is shown in plate 7.



Prepared samples for estimation of tannin



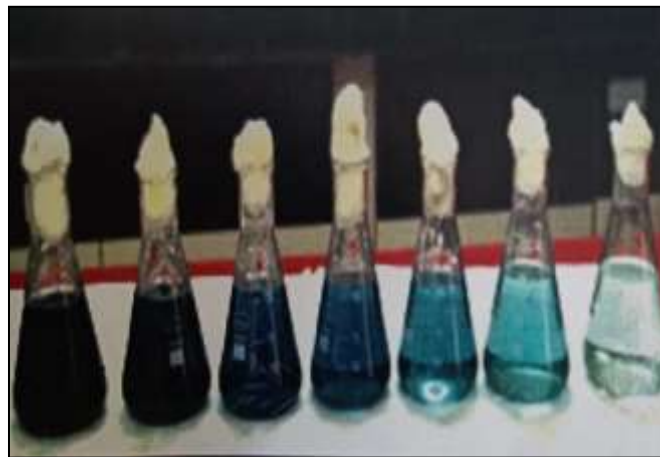
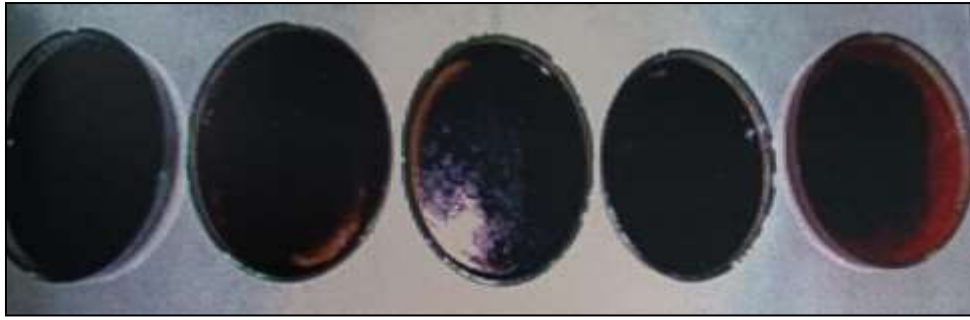
Spectrophotometer for estimation of tannin

Plate 7 : Estimation of tannin content in *Terminalia arjuna*

### 3.2.2.2. Total phenol in bark (%)

Total phenols content was determined by Folin-Ciocalteu procedure given by Singleton and Rossi (1965), in which absorbance was measured at 765 nm in a colourimeter against water blank. One gram of sample was taken and grinded with 10 ml of 80 per cent ethanol in pestle and mortar and centrifuged for 20 minutes at 10000 rpm and filtered. Filtrate was evaporated in oven up to the dryness and dried extract was dissolved in 5 ml distilled water. 2 ml aliquot was taken in separate test tubes and volume was made upto 3 ml. Then 0.5 ml Folin-Ciocalteu reagent was added. Phenols with phosphomolybdic acid in FolinCiocalteu reagent and in alkaline medium produce a highly dark blue coloured complex (molybdenum blue). After 3 minutes 2 ml of  $\text{Na}_2\text{CO}_3$  (20 %) was added and mixed. Test tubes were placed in boiling water bath for one minute and then cooled. Optical density of these prepared sample solutions were recorded at 765 nm. The concentration was determined as per the standard procedure from the standard curve.

A standard calibration curve of gallic acid using its different concentrations was prepared. Stock solution was prepared by dissolving 0.5 g of dry gallic acid in water to make the final volume 100 ml in a volumetric flask. Aliquot 0, 1, 2, 3, 5 and 10 ml of gallic acid were taken in separate volumetric flasks and then final volume was raised upto 100 ml with distilled water. Pipette 1 ml of each from these in separate 100 ml volumetric flask. Water 60 ml and FolinCiocalteu 5 ml reagent were added to the respective flasks and mixed well. Then, 15 ml  $\text{Na}_2\text{CO}_3$  (20%) solution was added. The contents were mixed properly and final volume was made to 100 ml with distilled water. After 2 hr, absorbance was recorded at 765 nm. Absorbance was then plotted against concentration and concentration of total phenols in the given sample was calculated and expressed as mg/100 g of sample. A photograph of estimation of total phenol content is shown in plate 8.



**Plate 8 : Estimation of total phenol content in *Terminalia arjuna***

### 3.2.2.3. Antioxidant activity ( $\mu\text{g/ml}$ )

#### 3.2.2.3.1 DPPH Radical Scavenging Activity Assay

##### Experimental details

DPPH scavenging activity tests were carried out according to the method of Brand Williams *et al.*, 1995 for which 100 mg of sample was dissolved in 10 ml ethanol and concentration (10mg/ml) was prepared. 2ml DPPH solution was added into 10  $\mu\text{l}$  of sample solutions. The mixture was shaken vigorously and incubated 30 minute in 30°C water bath. Absorbance of the resulting solution was measured at 517 nm UV visible spectrophotometer. All the assays were carried out in triplicates with ethanol as a control and with Gallic acid which was used as the standard antioxidant.

- **Percentage of inhibition (DPPH scavenging activity) determined as follows.**

$$\% \text{DPPH radical-scavenging} = \frac{(\text{Absorbance of DPPH} - \text{Absorbance of sample})}{\text{Absorbance of DPPH}}$$

(Burcin *et al.*, 2010)

Decreased absorbance of the reaction mixture indicates stronger DPPH radical scavenging activity (Plate 9).

#### 3.2.2.4. Ascorbic acid in bark (mg /100 ml)

The ascorbic acid content was estimated by using the method described by Ranganna (2001). A known volume of sample was taken and transferred to 100 ml volumetric flask and volume was made up with 3 percent metaphosphoric acid. From this, 10 ml aliquot was taken into 100 ml beaker and titrated against 2,6-dichlorophenol-indophenol dye solution until the stable faint pink colour was appeared. The result was expressed as mg of ascorbic acid 100 ml<sup>-1</sup> edible portion.

**Standardization of dye:** Standardization of 2,6-dichlorophenol-indophenols dye was done by titrating it against standard ascorbic acid solution. The standard was prepared by dissolving 100 mg of pure L-ascorbic acid in 100 ml of 3 per cent metaphosphoric acid. Then 1 ml of ascorbic acid solution (aliquot) was used for titration (Plate 10).



**Plate 9 : Spectrophotometer for estimating antioxidant activity**



**Plate 10 : Estimation of ascorbic acid content in *Terminalia arjuna***

### **3.2.2.5 Extraction of secondary metabolites from bark of *Terminalia arjuna***

#### **3.2.2.5.1 Preparation of samples for extraction**

For extraction purpose bark of *Terminalia arjuna* was used. Bark was dried in hot air oven at 40 °C till it completely dried. Dried bark was powdered using mixer grinder. Ultimately the dried powdered was used for further extraction by solvent.

#### **3.2.2.5.2 Cold extraction of secondary metabolites from *Terminalia arjuna***

About 200 mg of dried powder of bark was taken in a separate test tube with paraffin paper and then 5ml of each solvent (methanol, petroleum ether, and Chloroform) was added into the test tube. The test tubes were kept at room temperature in dark with intermittent shaking after each 24 hrs for three days. Then the extracts were filtered by intermittent shaking after each 24 hrs for three days. Then the extracts were filtered by using Whatman filter paper and dried at room temperature in beaker. Weight of beaker was noted prior to drying of the extracts. The weight of each beaker after drying of extracts was also noted. The weight of the extract was then calculated from the difference finally all the dried extracts were kept in desiccators. They were stored in a refrigerator for future use (Harborne, 1973).

#### **3.2.2.5.3 Phytoconstituents Analysis**

Preliminary analysis of extracts was carried out to identify the presence of various phytoconstituents by employing standard protocols. Chemical tests were carried out using the extracts of bark of *Terminalia arjuna* plants, using standard procedures of phytochemical screening to identify the constituents as described by Harborne and Williams (1998). The tests for the presence or absence of various secondary metabolites were summarized below:

##### **3.2.2.5.3.1 Test for tannins**

###### **Ferric chloride test**

Presence of tannins in various plant extracts was determined with the protocol reported by Sofowara (1993). 50 mg of crude extract was

boiled in 20 ml of water in test tubes then filtered. Addition of few drops of 0.1% ferric chloride was mixed and observed for colour change, the presence of brownish green coloration or blue-black coloration indicated presence of tannins (Harborne and Williams, 1998).

#### **3.2.2.5.3.2 Test for phenols**

##### **Gelatine test (Evans, 1997)**

The extract (50mg) was dissolved in 5ml of distilled water and 2ml of 1% solution of gelatine containing 10% sodium chloride was added to it. White precipitate indicated the presence of phenols.

#### **3.2.2.5.3.3 Test for Saponins**

##### **Frothing test**

Determination of saponins in various plant extracts was carried out according to Harborne (1973). The extracts were diluted with distilled water and volume made up to 20 ml. The suspension was shaken in a graduated cylinder for 15 min. The layer of foam indicated the presence of saponins (Kokate,1999).

#### **3.2.2.5.3.4 Test for flavonoids**

##### **Shinoda test**

Presence of flavonoids in various plant extracts was determined with the protocol reported by Mace (1963). In this method an aqueous solution of the extracts was treated with 10% ammonium hydroxide solution. Yellow fluorescence indicated the presence of flavonoids.

#### **3.2.2.5.3.5 Test for Terpenoids**

##### **Salkowski test**

Presence of terpenoids in various plant extracts was determined according to Harborne (1973). 5 ml (1mg/ml) of the extract was mixed with 2 ml of chloroform and then 3 ml of concentrated H<sub>2</sub>SO<sub>4</sub>. Change of reddish-brown coloration of the interface showed the presence of terpenoids.

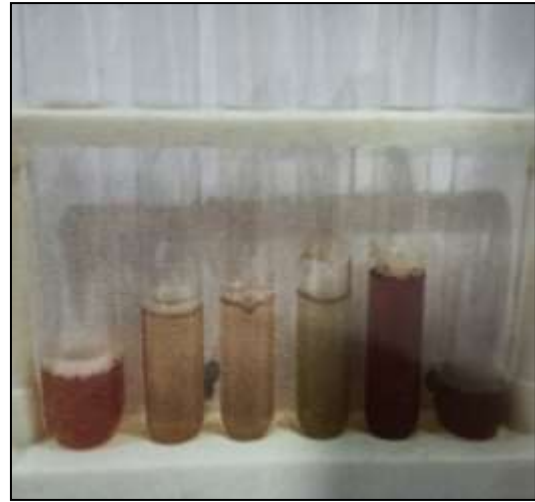
#### **3.2.2.5.3.6 Test for alkaloids**

##### **Dragendorff 's test**

By adding 1 ml of Dragendorff's reagent to 2 ml of extract, an orange red precipitate was formed, indicating the presence of alkaloids (Plate 11).



**Test of Tannins**



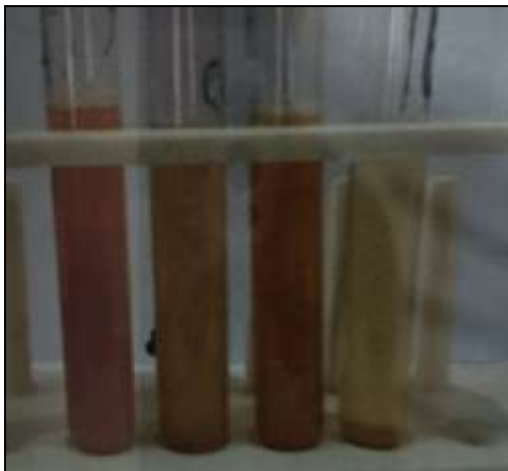
**Test of Saponins**



**Test of Phenols**



**Test of Flavonoids**



**Test of Alkaloids**



**Test of Terpenoids**

**Plate 11: Phytochemical screening of bark extract of *Terminalia arjuna***

### 3.3 Statistical analysis

Tabular form was used for all morphological characters. Correlation studies (Karl Pearson's) between morphological and phytochemical characters was worked out as per the method suggested by Panse and Sukhatme, 1978.

#### 3.3.1 Simple correlation

Simple correlation coefficient (Karl Pearson's) between two characters was worked out by using the following formula (Panse and Sukhatme, 1978).

$$r(xy) = \frac{Cov(x,y)}{\sqrt{V(x)} \cdot \sqrt{V(y)}}$$

Where,

$r(xy)$  - simple correlation between x and y

$Cov(x,y)$  - covariance of x and y character

$V(x)$  - Variance of x character

$V(y)$  - Variance of y character

For testing of simple correlation the 't' value was calculated by the following formula given by Gosset (1908) also known as student's t-test.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \sim t_{n-2}(5\%)$$

Where,

t - t-test value

r - Simple correlation

n - Sample size

This value was compared with the tabulated 't' value at (n-2) as the degree of freedom.

## CHAPTER IV

### RESULTS AND DISCUSSION

The results obtained during the present studies on “Evaluation of bark of *Terminalia arjuna* (Roxb.) for phytochemical traits” are presented in this chapter under the following headings.

4.1 Morphological characteristics of *Terminalia arjuna*.

4.2 Phytochemical traits of bark of *Terminalia arjuna*.

4.3 Correlation between morphological and phytochemical characters of bark of *Terminalia arjuna*.

#### **4.1. Morphological characteristics of trees**

Mean performance and range of twenty five trees of *Terminalia arjuna* for five morphological characters are presented in Table 2 and Table 3.

##### **4.1.1. Height of tree**

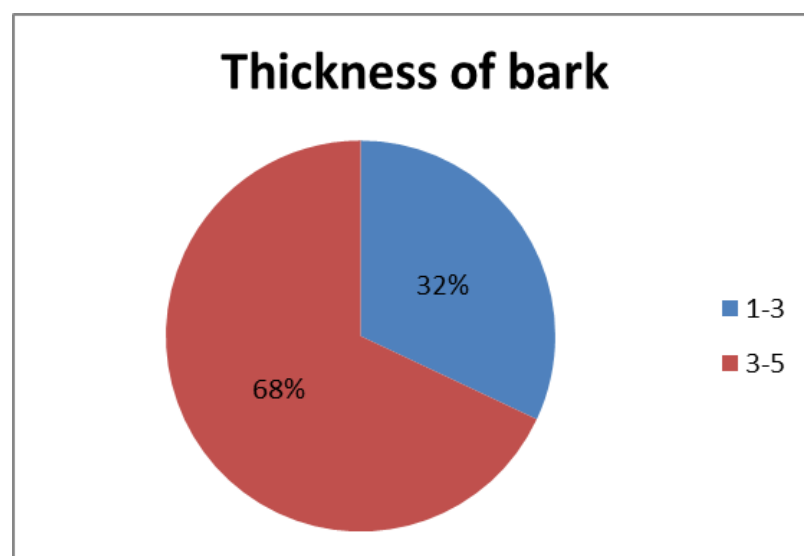
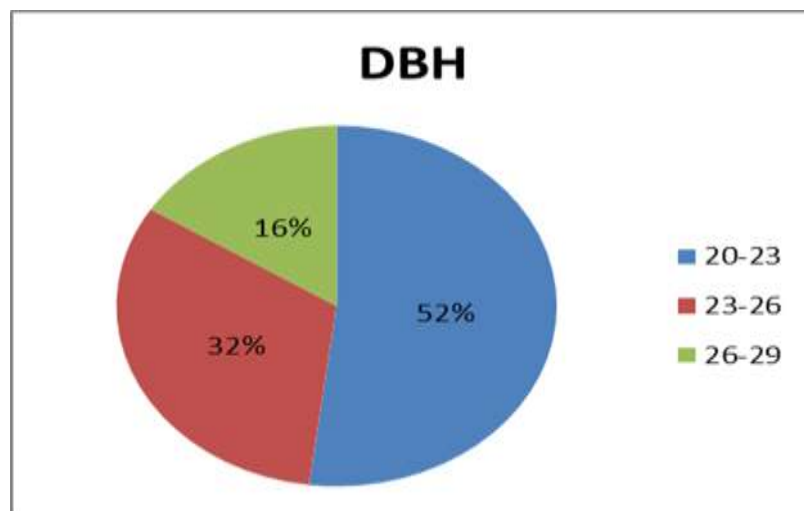
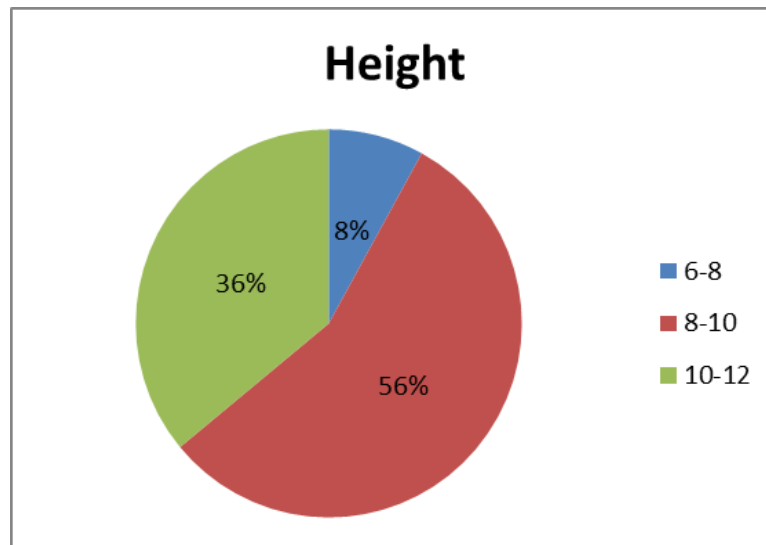
The data with respect to height of tree is appended in Table 2. The maximum height of tree was 11.37 m observed in MB-2 and minimum was 06.47m recorded in SRL-2. The mean value for height of tree was obtained to be 09.48m. Among twenty five trees of *Terminalia arjuna*, 11 trees had taller and 14 trees had smaller than mean height of trees (Fig.1). The survey result shown that majority of the trees has found to have less than the average height of trees. Variations in respect to height of trees has been reported by Jamalludheen *et al.* (1995) reported in *Lagerstroemia speciosa*, Navhale *et al.* (2011) has noticed in Hirda (*Terminalia chebula*) and Pawar *et al.* (2017) reported in *Terminalia bellirica* and Rajput (2018) reported in *Helicteres isora* L.

##### **4.1.2. Diameter at breast height**

The data recorded for diameter at breast height presented in Table 2. The highest DBH of tree was 27.22 cm (GDW-2) and lowest was observed as 20.17 cm (DRN-1). The mean value for diameter at breast height of tree was obtained to be 23.09 cm. Numbers of trees at the higher side of mean were found to be 12 tree and the numbers of trees at the lower side were found to be 13 trees (Fig.1).

**Table 2. Morphological characters in respect of height, DBH, and number of Primary branches of *Terminalia arjuna* in different location of Akola and Amravati Districts.**

Sr. No.	Location	Tree No.	Height (m)	DBH (cm)	No. of Primary Branches
1	Nagarjun Medicinal Plant Garden	NAG-1	09.47	25.23	3
2	Nagarjun Medicinal Plant Garden	NAG-2	10.43	21.24	3
3	Malkapur Block	MB-1	09.03	20.32	3
4	Malkapur Block	MB-2	11.37	23.23	4
5	Patur Ghat	PTG-1	10.00	22.10	3
6	Patur Ghat	PTG-2	09.47	21.03	3
7	Shirla	SRL-1	07.97	21.22	3
8	Shirla	SRL-2	06.47	20.35	3
9	Gondhalwadi	GDW-1	08.47	26.80	4
10	Gondhalwadi	GDW-2	08.27	27.22	3
11	Dudhani	DDN-1	09.07	25.13	3
12	Dudhani	DDN-2	10.03	21.10	3
13	Dharani	DRN-1	09.77	20.17	4
14	Dharani	DRN-2	08.87	21.22	4
15	Anjangaon	ANG-1	09.57	20.19	4
16	Anjangaon	ANG-2	11.10	26.39	4
17	Shahanur	SHN-1	09.33	22.52	3
18	Shahanur	SHN-2	10.17	26.75	3
19	Popatkhed	PPK-1	10.97	23.33	3
20	Popatkhed	PPK-2	09.47	25.50	4
21	Khatakali	KTK-1	09.15	22.25	4
22	Khatakali	KTK-2	10.23	24.16	3
23	Malkapur Beat	MBT-1	08.56	20.56	3
24	Malkapur Beat	MBT-2	09.45	23.52	4
25	Malkapur Beat	MBT-3	10.47	25.75	3
Mean			09.48	23.09	3.36
Range			06.47-11.37	20.17-27.22	3-4



**Fig.1: Variation in height, DBH and thickness of bark of *Terminalia arjuna***

The survey result shown that majority of the trees has found to have less than the average diameter at breast height of tree. The work on the same aspect has been reported by Jindal *et al.* (1987) in *Tecomella undulate*, Jamalludheen *et al.* (1995) in *Lagerstroemia speciosa*, Luna and Kumar (2008) revealed in *Emblica officinalis*, Navhale *et al.* (2011) noticed in Hirda (*Terminalia chebula*), Pawar *et al.* (2017) revealed in *Terminalia bellirica* and Rajput (2018) noticed in *Helicteres isora*.

#### **4.1.3. Number of primary branches**

The data on number of primary branches are appended in Table 2. The number of primary branches range varied from 3 to 4. The highest number of primary branches were observed 4 in MB-2, GDW-1, DRN-1, DRN-2, ANG-1, ANG-2, PPK-2, KTK-1 and MBT-2 and minimum was recorded as 3 in majority of trees. The mean value for number of primary branches were obtained to be 3.36. 9 trees had more number of primary branches, while 16 had less number of primary branches than general mean. The survey result shown that majority of the trees were found to have less than the average number of primary branches of trees.

#### **4.1.4. Thickness of bark**

The perusal of data, depicted in Table 3 revealed the data on thickness of bark range varied from 2.27 mm to 4.22 mm. The maximum thickness of bark was 4.22 mm recorded in ANG-1 while minimum was 2.27 mm observed in SHN-1. The mean value for thickness of bark was obtained to be 3.42. Number of trees at the higher side of mean were found to be 15 trees, while the numbers of trees at the lower side were found to be 10 trees. The survey result shown that majority of the trees has observed to have more than the average thickness of bark of trees (Fig.1).

#### **4.1.5. Moisture content of bark**

The scrutiny of Table 3 illustrated for moisture content of bark ranged from 51.59% to 56.39%. The maximum moisture content of bark was 56.39% noticed in DDN-2 and minimum was recorded as 51.59% in MBT-1. The mean value for moisture content of bark was obtained to be 52.99%.

**Table 3. Thickness and moisture content of bark of *Terminalia arjuna* in different location of Akola and Amravati Districts.**

<b>Sr. No.</b>	<b>Location</b>	<b>Tree No.</b>	<b>Thickness of Bark (mm)</b>	<b>Moisture content of bark (%)</b>
1	Nagarjun Medicinal Plant Garden	NAG-1	3.44	52.74
2	Nagarjun Medicinal Plant Garden	NAG-2	4.10	52.32
3	Malkapur Block	MB-1	4.12	53.16
4	Malkapur Block	MB-2	3.36	53.88
5	Patur Ghat	PTG-1	4.13	53.83
6	Patur Ghat	PTG-2	4.16	51.96
7	Shirla	SRL-1	2.47	52.26
8	Shirla	SRL-2	3.03	52.29
9	Gondhalwadi	GDW-1	2.49	51.65
10	Gondhalwadi	GDW-2	3.64	52.01
11	Dudhani	DDN-1	2.36	52.53
12	Dudhani	DDN-2	3.48	56.39
13	Dharani	DRN-1	3.48	52.87
14	Dharani	DRN-2	4.14	53.49
15	Anjangaon	ANG-1	4.22	52.61
16	Anjangaon	ANG-2	3.75	52.78
17	Shahanur	SHN-1	2.27	53.40
18	Shahanur	SHN-2	2.95	53.06
19	Popatkhed	PPK-1	4.18	52.93
20	Popatkhed	PPK-2	2.31	52.54
21	Khatakali	KTK-1	3.18	53.48
22	Khatakali	KTK-2	4.11	52.36
23	Malkapur Beat	MBT-1	3.65	51.59
24	Malkapur Beat	MBT-2	4.19	54.56
25	Malkapur Beat	MBT-3	2.45	54.28
Mean			3.42	52.99
Range			2.27-4.22	51.59-56.39

Number of trees at the higher side of mean were found to be 10 trees and the numbers of trees at the lower side were found to be 15 trees. The survey result shown that majority of the trees has observed to have less than the average moisture content of bark of trees. The said work are in accordance with Suryawanshi (2006) in birch bark, Singh *et al.* (2010) noticed moisture content (loss on drying) for standardization of Ajunarishtha formulation.

## **4.2. Phytochemical traits of bark of *Terminalia arjuna***

### **4.2.1. Tannin and ascorbic acid in bark**

#### **4.2.1.1. Tannin content (%)**

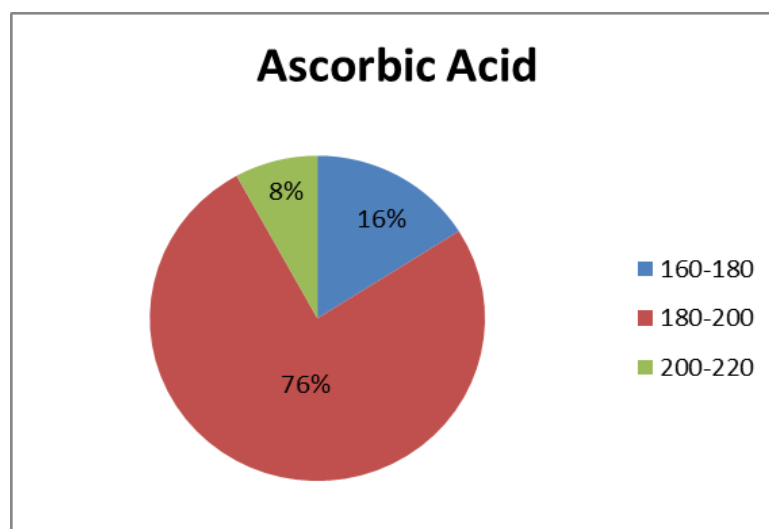
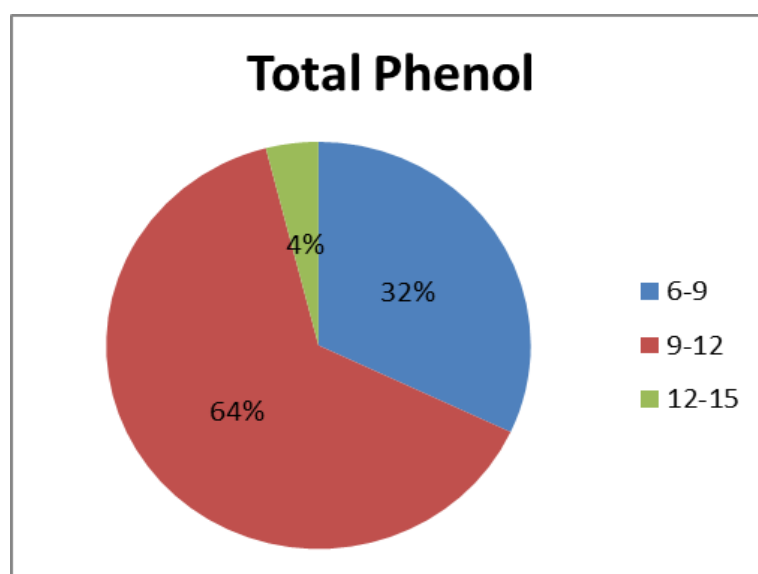
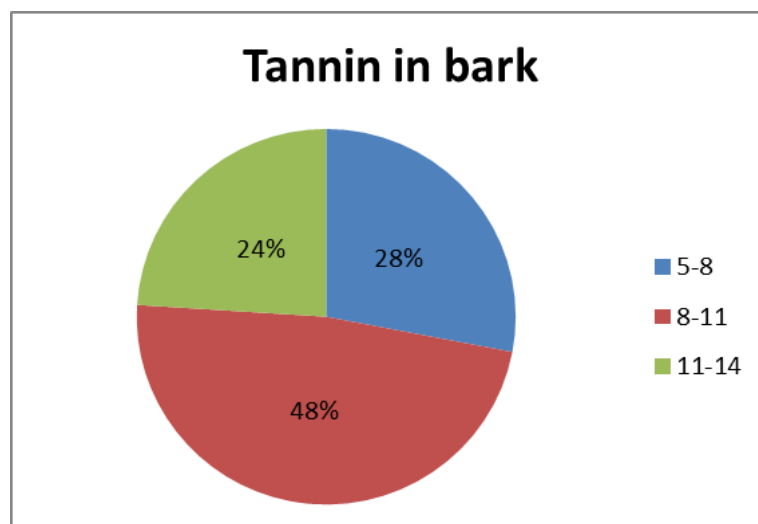
The data pertaining to the tannin in bark is presented in Table 4. The maximum tannin content of bark was observed 12.89% in ANG-1. The minimum was recorded as 6.88% in GDW-1. The mean value for tannin content of bark was obtained to be 9.35%. Number of trees at the higher side of mean were found to be 12 trees and the number of trees at the lower side were found to be 13 trees (Fig.2). The survey result shown that majority of the trees has found to have less than the average tannin content in trees. The result of this investigation are in agreement with the result obtained by Mishra *et al.* (2009) in *Ichnocarpus frutescens*, Pandey and Kori (2009) noticed in *Terminalia arjuna* bark and Bhatia *et al.* (1977) noticed in *Terminalia arjuna*, *Terminalia alata*, *Terminalia bellirica* and *Terminalia chebula*.

#### **4.2.1.2. Ascorbic acid (mg /100 ml)**

The data pertaining to the ascorbic acid in bark is presented in Table 4. The maximum ascorbic acid content of bark was observed 210 mg/100 ml in ANG-1. The minimum was recorded as 170 mg/100 ml in NAG-1. The mean value for ascorbic acid content of bark was obtained to be 187.76 mg /100 ml. Number of trees at the higher side of mean were found to be 12 trees and the number of trees at the lower side were found to be 13 trees (Fig.2). The survey result shown that majority of the trees has found to have less than the average ascorbic acid content in bark of trees. The result of this investigation are in agreement with the result obtained by Kumari and Jain (2022) in *Terminalia arjuna* bark.

**Table 4. Phytochemical characters with respect to tannin and ascorbic acid in bark of *Terminalia arjuna*.**

Sr. No.	Location	Tree No.	Tannin in bark (%)	Ascorbic Acid (mg /100 ml)
1	Nagarjun Medicinal Plant Garden	NAG-1	07.74	170
2	Nagarjun Medicinal Plant Garden	NAG-2	08.17	184
3	Malkapur Block	MB-1	11.87	174
4	Malkapur Block	MB-2	10.06	182
5	Patur Ghat	PTG-1	10.25	184
6	Patur Ghat	PTG-2	07.49	186
7	Shirla	SRL-1	07.41	181
8	Shirla	SRL-2	07.19	188
9	Gondhalwadi	GDW-1	06.88	186
10	Gondhalwadi	GDW-2	07.02	179
11	Dudhani	DDN-1	09.76	184
12	Dudhani	DDN-2	11.19	181
13	Dharani	DRN-1	08.32	196
14	Dharani	DRN-2	08.09	206
15	Anjangaon	ANG-1	12.89	210
16	Anjangaon	ANG-2	12.71	200
17	Shahanur	SHN-1	11.72	198
18	Shahanur	SHN-2	11.42	191
19	Popatkhed	PPK-1	08.47	190
20	Popatkhed	PPK-2	09.56	185
21	Khatakali	KTK-1	08.26	199
22	Khatakali	KTK-2	10.68	188
23	Malkapur Beat	MBT-1	09.54	172
24	Malkapur Beat	MBT-2	08.70	189
25	Malkapur Beat	MBT-3	08.56	191
Mean			9.35	187.76
Range			06.88- 12.89	170-210



**Fig. 2: Variation in tannin, total phenol and ascorbic acid content of bark of *Terminalia arjuna***

## **4.2.2. Antioxidant activity and total phenol content in bark**

### **4.2.2.1. Antioxidant activity ( $\mu\text{g/ml}$ )**

The scrutiny of Table 5 illustrated for antioxidant activity in bark ranges from 24.59 to 38.36  $\mu\text{g}/100\text{ml}$ . The maximum antioxidant activity in bark was 38.36  $\mu\text{g}/100\text{ml}$  in DRN-1 and minimum was recorded as 24.59  $\mu\text{g}/100\text{ml}$  in ANG-1. The mean value for antioxidant activity in bark was obtained to be 33.03  $\mu\text{g}/100\text{ml}$ . Number of trees at the higher side of mean were found to be 15 trees and the number of trees at the lower side were found to be 10 trees. The survey result shown that majority of trees were found to have more than the observed average antioxidant activity in bark of trees.

### **4.2.2.2. Total phenol (%)**

The scrutiny of Table 5 illustrated for total phenol per cent in bark ranges from 08.34% to 12.89%. The maximum phenol content in bark was 12.89 per cent in ANG-1 and minimum was recorded as 08.34 per cent in GDW- 2. The mean value for phenol content in bark was obtained to be 10.27%. Number of trees at the higher side of mean were found to be 13 trees and the number of trees at the lower side were found to be 12 trees (Fig.2). The survey result shown that majority of the trees were found to have more than the observed average phenol content in bark of trees. Similar result has been noticed by Mishra *et al.* (2009) in *Ichnocarpus frutescens* in bark and Pandey *et al.* (2010) revealed in *Holarrhena antidysentrica* bark.

**Table 5. Phytochemical characters with respect to antioxidant activity and total phenol in bark of *Terminalia arjuna***

Sr. No.	Location	Tree No.	Antioxidant activity ( $\mu\text{g/ml}$ )	Total Phenol (%)
1	Nagarjun Medicinal Plant Garden	NAG-1	35.02	08.40
2	Nagarjun Medicinal Plant Garden	NAG-2	37.02	08.96
3	Malkapur Block	MB-1	26.21	11.92
4	Malkapur Block	MB-2	31.21	11.43
5	Patur Ghat	PTG-1	30.31	11.45
6	Patur Ghat	PTG-2	34.42	08.38
7	Shirla	SRL-1	35.11	08.37
8	Shirla	SRL-2	36.01	08.36
9	Gondhalwadi	GDW-1	37.21	08.35
10	Gondhalwadi	GDW-2	38.00	08.34
11	Dudhani	DDN-1	32.02	11.41
12	Dudhani	DDN-2	29.12	11.46
13	Dharani	DRN-1	38.36	09.53
14	Dharani	DRN-2	36.22	08.52
15	Anjangaon	ANG-1	24.59	12.89
16	Anjangaon	ANG-2	25.01	11.99
17	Shahanur	SHN-1	27.05	11.76
18	Shahanur	SHN-2	28.69	11.72
19	Popatkhed	PPK-1	37.22	09.99
20	Popatkhed	PPK-2	33.11	10.91
21	Khatakali	KTK-1	38.00	09.50
22	Khatakali	KTK-2	30.00	11.45
23	Malkapur Beat	MBT-1	34.22	10.85
24	Malkapur Beat	MBT-2	35.15	10.81
25	Malkapur Beat	MBT-3	36.56	10.12
Mean			33.03	10.27
Range			24.59-38.36	08.34-12.89

#### 4.2.3 Phytochemical Screening of bark extract of *Terminalia arjuna*

Extracts were prepared based on their polarity like methanol, petroleum ether, chloroform extracts of *Terminalia arjuna*. Secondary metabolites like tannins, phenols, alkaloids, terpenoids, saponin and flavonoids were tested in all extracts.

The observation for qualitative phytochemical screening of crude extracts of bark of *Terminalia arjuna* were shown in Table 6. Phytochemical studies of solvent extracts revealed that tannins, phenols, alkaloids, terpenoids, saponin and flavonoids were present in methanol extract of all the bark samples. Tannins were absent in petroleum ether extract of all the samples except ANG-1, SHN-1, SHN-2, GDW-1, GDW-2, PTG-2, MB-1, MB-2. Tannins were present in chloroform extract of all the samples except PPK-1. Phenols were absent in petroleum ether extract of all the samples except in ANG-1, SHN-1, SHN-2, GDW-1, GDW-2, PTG-2, MB-1, MB-2. Phenols were present in chloroform extract of all the samples except PPK-1. Alkaloids were absent in petroleum ether of all the samples except ANG-1, SHN-1, SHN-2, GDW-1, GDW-2, PTG-2, MB-1, MB-2. Alkaloids were present in all the samples of chloroform extract except PPK-1. Terpenoids were present in petroleum ether and chloroform extract of all the samples. Saponin were absent in petroleum ether extract of all the samples except ANG-1, SHN-1, SHN-2, GDW-1, GDW-2, PTG-2, MB-1, MB-2. Saponin was only absent in chloroform extract of PPK-1 whereas present in all other samples. Flavonoids were present in petroleum ether and chloroform extract of all the samples.

The qualitative phytochemical screening of *Terminalia arjuna* bark in methanol extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids. However, qualitative phytochemical screening of bark in petroleum ether extract showed active compound namely, tannins, phenol, alkaloids, and saponin presence in low concentration whereas, terpenoids and flavonoids presence in high concentration. While qualitative phytochemical screening of bark in chloroform extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids.

**Table 6: Phytochemical screening of bark extract of *Terminalia arjuna***

Sr.No.	Location	Tree No.	Fraction	Tannin	Phenol	Alkaloids	Terpenoids	Saponin	Flavonoids
1	Nagarjun Medicinal Plant Garden	NAG-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
2	Nagarjun Medicinal Plant Garden	NAG-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
3	Malkapur Block	MB-1	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
4	Malkapur Block	MB-2	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
5	Patur Ghat	PTG-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
6	Patur Ghat	PTG-2	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
7	Shirla	SRL-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
8	Shirla	SRL-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+

Sr.No.	Location	Tree No.	Fraction	Tannin	Phenol	Alkaloids	Terpenoids	Saponin	Flavonoids
9	Gondhalwadi	GDW-1	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
10	Gondhalwadi	GDW-2	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
11	Dudhani	DDN-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
12	Dudhani	DDN-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
13	Dharani	DRN-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
14	Dharani	DRN-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
15	Anjangaon	ANG-1	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
16	Anjangaon	ANG-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+

Sr.No.	Location	Tree No.	Fraction	Tannin	Phenol	Alkaloids	Terpenoids	Saponin	Flavonoids
17	Shahanur	SHN-1	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
18	Shahanur	SHN-2	Methanol	+	+	+	+	+	+
			PE	+	+	+	+	+	+
			Chloroform	+	+	+	+	+	+
19	Popatkhed	PPK-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	-	-	-	+	-	+
20	Popatkhed	PPK-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
21	Khatakali	KTK-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
22	Khatakali	KTK-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
23	Malkapur Beat	MBT-1	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
24	Malkapur Beat	MBT-2	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+
25	Malkapur Beat	MBT-3	Methanol	+	+	+	+	+	+
			PE	-	-	-	+	-	+
			Chloroform	+	+	+	+	+	+

(+) Presence, (-) Absence

Similar type of work has also been reported by Shreya Mandal *et al.*, (2013); Parsodkar and kalkar, (2020) while studying phytochemical constituents of *Terminalia arjuna*.

### 4.3 Simple correlation coefficients

#### 4.3.1 Correlation between morphological and phytochemical characters

The values for simple correlation coefficient between morphological and phytochemical characters of bark of *Terminalia arjuna* are presented in Table 7. As regards to simple correlation coefficients the morphological characteristics such as tree height showed significant correlation with phytochemical characteristics of tannin (0.461\*) and total phenol content (0.489\*) at 5% level of probability. Notably, a very high and positively significant correlation of 0.547 was identified between number of primary branches and ascorbic acid. Whereas, the remaining correlations were determined to be non-significant.

Townsend (1977) in *Acer rubrum* have also reported significant variation in the height and diameter growth of different provenances. Kumar *et al.* (2005) reported significant variation in height and diameter of *Dalbergia sissoo*.

**Table 7. Correlation between morphological and phytochemical characters**

	<b>Tannin content</b>	<b>Total phenol</b>	<b>Antioxidant activity</b>	<b>Ascorbic acid</b>
<b>Height</b>	0.461*	0.489*	-0.303	0.162
<b>DBH</b>	-0.048	0.001	0.041	-0.095
<b>No. of primary branches</b>	0.058	0.083	0.030	0.547**
<b>Thickness of bark</b>	0.135	0.084	-0.103	0.072
<b>Moisture content of bark</b>	0.314	0.359	-0.214	0.117
<b>*Significant at 5% level (r = 0.396)</b>				
<b>**Significant at 1% level (r = 0.505)</b>				

## CHAPTER V

### SUMMARY AND CONCLUSIONS

The present studies were carried out on “Evaluation of bark of *Terminalia arjuna* (Roxb.) for phytochemical traits” in the year 2022-23 at Department of Forestry, PGI, Dr.P.D.K.V, Akola. The study was carried out with objective to survey and select *Terminalia arjuna* trees in Akola and Amravati district of Maharashtra, to study the morphological characters of selected trees of *Terminalia arjuna* and to examine the bark of *Terminalia arjuna* for phytochemical traits. Accordingly, the trees of *Terminalia arjuna* were selected in Akola and Amravati district and the bark of selected trees were collected for evaluation of phytochemical traits.

The trees were studied for their five morphological characters viz. height of tree, diameter at breast height, number of primary branches, thickness of bark and moisture content. Four phytochemical characters viz. tannin content, total phenol, antioxidant activity and ascorbic acid in bark were studied.

In the present study, morphological characters of trees of *Terminalia arjuna* (Roxb.) ranged from 06.47 to 11.37 m for height of tree, 20.17 to 27.22 cm for DBH, 3 to 4 for number of primary branches, 2.27 to 4.22 mm for thickness of bark and 51.59 to 56.39 per cent for moisture content of bark. Phytochemical characteristics of bark ranged from 06.88 to 12.89 per cent for tannin, 08.34 to 12.89 per cent for phenol content, 24.59 to 38.36 µg/ml for antioxidant activity and 170 to 210 mg/100 ml for ascorbic acid.

The qualitative phytochemical screening of *Terminalia arjuna* bark in methanol extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids. However, qualitative phytochemical screening of bark in petroleum ether extract showed active compound namely, tannins, phenol, alkaloids, and saponin presence in low concentration whereas, terpenoids and flavonoids presence in high concentration. While qualitative phytochemical screening of bark in chloroform extract showed active compound presence in

high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids.

Correlation studies between morphological and phytochemical characters of bark of *Terminalia arjuna* showed significant correlation of tree height with phytochemical characteristics such as tannin (0.461\*) and total phenol content (0.489\*) at 5% level of probability. Notably, a very high and positively significant correlation of 0.547 was identified between number of primary branches and ascorbic acid. Whereas, the remaining correlations were determined to be non-significant.

### **Conclusions:**

1. Among twenty five trees of *Terminalia arjuna*, height of 56 per cent trees were found between 8 to 10 m, height of 36 per cent trees were recorded between 10 to 12 m while, height of 8 per cent trees were observed between 6 to 8 m.
2. 52 per cent, 32 per cent and 16 per cent of the trees in respect of diameter at breast height, were found between the range of 20 to 23 cm, 23 to 26 cm and 26 to 29 cm., respectively.
3. 9 trees had more number of primary branches, while 16 trees had less number of primary branches than general mean. The survey result shown that majority of the trees were found to have less than the average number of primary branches of trees.
4. 68 per cent of trees in respect of thickness of bark were found between 3 to 5 mm thickness whereas, 32 per cent trees were observed in between 1 to 3 mm thickness.
5. Number of trees in respect of moisture content of bark, 10 trees were at higher side of mean and 15 trees at the lower side of mean. The survey result shown that majority of the trees observed less than the average moisture content of bark.
6. Highest tannin per cent of bark was noticed in ANG-1 (12.89%). Tannin content in bark of 48 per cent of trees were recorded between range of 8 to 11 per cent, 28 per cent of trees were observed between range of 5 to 8

per cent, and 24 per cent trees were observed between range of 11 to 14 per cent of tannin.

7. Maximum ascorbic acid per cent of bark was recorded in ANG-1 (210 mg/100ml). Ascorbic acid in bark of 76 per cent, 16 per cent and 8 per cent of trees were observed between 180 to 200 mg/100ml, 160 to 180 mg/100ml and 200 to 220 mg/100ml., respectively.
8. DRN-1 (38.36  $\mu\text{g/ml}$ ) recorded highest antioxidant activity of bark while ANG-1 (24.59  $\mu\text{g/ml}$ ) observed lowest value. Number of trees in respect of antioxidant activity, 15 trees were at higher side of mean and 10 trees at the lower side of mean. The survey result shown that majority of trees were found to have more than observed average antioxidant activity in bark of trees.
9. ANG-1 (12.89%) recorded maximum per cent of phenol whereas, GDW-2 (08.34%) recorded minimum. 64 per cent of tree among twenty five trees of *Terminalia arjuna*, phenol per cent in bark were found between range of 9 to 12 per cent, 32 per cent of trees were found between range of 6 to 9 per cent and 4 per cent of trees were found between range of 12 to 15 per cent of phenol.
10. The qualitative phytochemical screening of *Terminalia arjuna* bark in methanol extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids.
11. The qualitative phytochemical screening of *Terminalia arjuna* bark in petroleum ether extract showed active compound namely, terpenoids and flavonoids presence in high concentration.
12. The qualitative phytochemical screening of *Terminalia arjuna* bark in chloroform extract showed active compound presence in high concentration such as tannins, phenol, alkaloids, terpenoids, saponin and flavonoids.
13. Correlation studies between morphological and phytochemical characters of bark of *Terminalia arjuna* showed significant correlation of tree height with phytochemical characteristics such as tannin (0.461\*) and total phenol content (0.489\*) at 5% level of probability. Notably, a very high and

positively significant correlation of 0.547 was identified between number of primary branches and ascorbic acid. Whereas, the remaining correlations were determined to be non-significant.

14. Among twenty five *Terminalia arjuna* trees selected from Akola and Amravati district, Tree No. ANG-1 and ANG-2 was found superior in respect of phytochemical traits.

## CHAPTER VI

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