"Quality evaluation and Value addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)"

by

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(2013-17-111)

THESIS

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DECLARATION

I hereby declare that this thesis entitled "Quality evaluation and Value addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)" is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Dedicated to

Sai

Mummy, Akka and Papa...

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

1. Introduction

Forests are important to the food security, because they are one of the accessible productive resources available to them. The vast potential of forest and forest land which is a repository of variety nutritious foods is not yet fully realised. It offers a potential for providing many more, yet unknown benefits to future generations. Forest fills the gap in 'hungry season' by supplying food during seasonal shortage period and act as emergency food in times of drought or other crisis. Thus in times of scarcity or when the staple food is in short supply, people are dependent upon various species of forest plants for food.

Various nutrients are essential in human diet for healthy and active life. Alarming situation of malnutrition is existing in the country particularly in arid, hilly and tribal areas. Fruits are considered as a protective food being rich in vitamins and minerals. Non – traditional fruits which generally grow in the hilly and tribal areas can provide a solution to the problem of malnutrition. These fruits are wild, hardy in nature, producing a crop even under adverse soil and climatic conditions and rich in nutrients.

India being rich in biodiversity has a very large number of wild fruits but the information on the nutritive value is not available for all of them (Rathore, 2001) Western Ghats region is very rich in diversified edible fruit yielding plant species. The forests generally occur throughout the tropical parts of Southern India and Andaman. The region has several mountain peaks which intercept monsoon winds which result in heavy rainfall in the region. The heavy rainfall and different type of temperature condition makes it a home for several plant species. Many of them yield edible fruits and vegetables.

As per one estimate, there are more than 3000 wild edible fruit and nut species. Many have unique taste and are good sources of minerals and vitamins. Only about 25 per cent of them are being utilised on commercial scale, to enter the diet. Several other fruits hold great promise and are yet to be recognised and exploited for their potential importance (Jallikop, 2006).

Fruits are generally acceptable as good source of nutrients such as vitamins and minerals. Fruits composition database attains prime attention while addressing various health and nutrition issues. It is essential for planning food, nutrition and health related policy tools (Shajib *et al.*, 2013). Lack of data on chemical composition of fruits limits their use. Therefore knowledge on the biochemical composition of such underutilised fruits enhances their utilization and consumption by the rural poor. With the hike in population, exploration of nutritional potential of these fruits will help in curbing food insecurity.

Studies on fruit characterization can be helpful in selecting better quality fruits. Physical characters like size, shape, weight volume etc. act as an important tool to properly design machines for harvesting, handling and storage processes. Information on physical characters of fruit forms the basis for studying growth and developmental changes occurring in fruits. The physical and chemical properties of fruits are important indicators of their external and internal quality and decisive factors for accomplishment of market demands (Cavalcante *et al.*, 2012).

Value addition of the fruits and development of popular products from them would therefore be an ideal way to take them into the consumption successfully. Production of value-added preparations has been identified as a key aspect of domestication, improvement, development, and utilization of underutilized fruit tree. There is a huge gap between potential and actual performance of the fruit sector. Product development would help to overcome this gap. Value-added wild fruits are limited in markets. Unavailability of fresh fruits and non- preferences for the product were factors that did not allow products to come to markets and spread. Traditional food preparations of underutilized fruits are available in specific traditional markets. These practises must be identified and scientific approach paves the way for the development of the processed wild fruits which is a very rich source of minerals and vitamins. In spite of their role in nutritional, economical and ecological security, less attention has been paid for their crop improvement and production or commercialization.

Accordingly, development of newer products from these under-exploited fruits by the application of modern technology is essential to boost the morale of our processing sector and these products can attract wider spectrum of the consumer market. Therefore value added products prepared from underutilised fruits would play a significant role not only for their domestic market but also for their export (Srivastava and Sanjeev, 2002).

A study on quality evaluation of the *Elaeocarpus serratus* L. fruits will be helpful in assessing the nutritional potentiality of the fruit. Developing the value added products from the fruit paves way for commercialisation of the fruit and developing the standard processing procedure.

With this background, the present study has been carried out to ascertain the physico-chemical and sensory characters of the *Elaeocarpus serratus* fruits, develop value added products such as Ceylon olive Pickle and Candy and also to study the organoleptic and chemical qualities of the product developed.

Review of Literature

2. REVIEW OF LITERATURE

The relevant literature on the study entitled "Quality evaluation and value addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)" have been briefly reviewed here. Wherever sufficient literature is not available on the fruit or the product tried in this experiment, results of experiments conducted on related fruits or the products are also cited.

2.1. Introduction : *Elaeocarpus*

The genus *Elaeocarpus* derived from the greek word *elaia* meaning "olive" and *karpos* meaning "fruit". Elaeocarpaceae the family to which the genus belongs has about 360 species distributed in temperate, sub-tropical and tropical zones throughout South-East Asia, Australia, Chile, New Zealand and the West Indies. Out of about 120 species of *Elaeocarpus* reported from Asia. *Elaeocarpus* tree has a remarkable range of habitation, from Himalayan foothills, to Southeast Asia, Indonesia and New Guinea, to Austrailia, Guam and Hawaii (Mabberley, 2008 and Khan *et al.*, 2005). Thirty three species occur in India of which 10 are endemic (Murthi, 1993). Eighty percent of the endemic *Elaeocarpus* species are confined to the Western Ghats including four steno endemics namely, *E. blascoi* Weibel, *E. gaussenii* Weibel, *E. recurvatus* Corner and *E. venustus* Bedd. According to a latest revision of section elaeocarpus in Southern India and Sri Lanka nine species were recognized, including three new species (*E. hedyosmus, E. variablis* and *E. taprobanicus*) with one new variety *E. serratus* L. var. weibelii Zmarzty (Zmarzty, 2001).

2.2. *Elaeocarpus serratus* : An overview

2.2.1. Distribution

Elaeocarpus serratus, commonly called as Ceylon Olive and is locally known as Karamavu, Nalla Kara, Valiya karai. *E. serratus* is indigenous to Sri Lanka (Jayasuriaya and Rajapakse, 2004) and distributed wild in the Indo-Malaysian region. A fossil fruit stone discovered in Australia has confirmed that Elaeocarpus was represented in the eastern Australian flora as early as the early Oligocene period (Dettmann and Trevor, 2001). This tree is cultivated in homegardens as the fruit tree. It is also cultivated as an ornamental fruit tree or medicinal plant in Australia, Brazil, China, Ghana, Indonesia, Malaysia, Bangladesh, Taiwan and Thailand. (Dahanayake, 2015).

Elaeocarpus serratus has a very broad distribution extending from southern India to as far as north as Sikkim and Nepal and as far east as Java (Hooker, 1874). *Elaeocarpus serratus* is found in evergreen and semi evergreen forests almost throughout India (Mohanan and Sabu, 2002) and sometimes cultivated in Kerala, Bengal and Assam.

2.2.2. Botanical description

Elaeocarpus serratus is an evergreen small to medium sized tree growing to a height of about 10-12 m with a spreading canopy and a bole of about 30 cm in diameter. The leaves petiole 1-1.5 cm; leaf blade 5-10 cm long, obovate oval acute at base obtuse rounded apex, margin shallowly crenate serrate with dents in the incisions; pale olive green or drying brown at lower face; lateral veins about 4-5 with glandular thickenings in axils connected by marginal network of veins. Leaves turn red before senescence.

Flowers are numerous 4-8 cm long, racemes from axils of past and present leaves and rather shorter than them, pedicels long as sepals, sepals 4-6 mm, lanceolate, acute, fine-pilose or glabrous, petals white about 5-6 mm with a broad cuneate base, cut more than halfway down into numerous filiform lacunae stamens, 25-35 filaments, short, anthers linear, black, one valve tipped with a brush of hair half as long; disk hairy orange ovary hairy and 3 celled.

Fruit is a drupe, about 3-4 cm long, ovoid bluntly pointed, smooth, dull, greenish yellow, pulp light to dark green, copious acid, edible; stone ovoid oblong, thick bony, strongly tubercled, 1 celled, 1 seeded. The fruits of *Elaeocarpus* species are endowed with a hard and highly ornamental stony endocarp.

Elaeocarpus serratus wood is light yellowish white and wood density is low. It is used for match sticks (Peiris, 2007). The wood of Elaeocarpus is underappreciated. It bears a nice straight grain without significant figure, light but strong, takes a good finish, although it is thought to be only moderately durable out of doors (Coode, 1983)

2.2.3. Propagation

In nature, the germination of most of the *Elaeocarpus* species nuts is very low and erratic, since nuts are unable to imbibe water (Bhuyan *et al.,* 2002). Poor or no germination coupled with prolonged dormancy owing to the hardness of the endocarp cause significant reduction in the regeneration of several *Elaeocarpus* species Therefore, in order to improve regeneration of rudraksh, it is recommended that mechanical cracking of the nut coat by vise that is simple, convenient and cheap method requiring little skill, may be employed in the nurseries. Further, seedlings emerging from the single nut should be thinned out at the early age (Khan *et al.,* 2005). In spite of its vulnerability and poor seed germination, other methods of propagation have not been studied so far.

Elaeocarpus is found to have coppicing behaviour. Propagation of plants via stem cuttings and pre existing meristems such as terminal or lateral buds are widely used. Stem cuttings of small shoot portions of pencil thickness were used and treated with IBA (1200 ppm) and NAA (400 ppm) for two hours (Eganathan *et al.*, 2000 and Suresh *et al.*, 2007).

2.2.4. Utilization

Most of the Elaeocarpaceae family members have indolizidine alkaloid compounds, which have attracted a great deal of interest on account of their ability to inhibit the enzymatic activity of glucosidases. Hence there is some potential to explore it further in the treatment of AIDS, diabetes and cancer (Dahanayake, 2015).

It is used as diuretic and cardiovascular stimulant. The leaves are used in the treatment of rheumatism and as antidote to poison, while fruits are locally prescribed for treatment of diarrhoea and dysentery. The fruit juice of *Elaeocarpus serratus* is given for stimulating secretion from taste buds thus increasing appetite in patients. (Sriti *et al.*, 2011) Fruits contain tannin and large amount of plant acids. Bark is used in hemorrhages, biliousness and ulcers (Pullaiah, 2006).

Various Elaeocarpus species have also been widely studied for their various pharmacological activities like analgesic, antifungal, antiinflammatory, antimicrobial, antidiabetic, antioxidative, antiviral, antitumor, antihypertensive, antianxiety and antidepressant activities (Dahanayake, 2015).

2.3. Phenology

The term phenology was first introduced in 1853 by the Belgian botanist Charles Morren and it has been derived from the Greek words; *phaino*, meaning "to appear, to come into view" and *logos*, meaning "to study." Phenology is the science that measures the timing of life cycle events for plants, animals, and microbes, and detects how environment influences the timing of these events. In case of flowering plants, these life cycle events include leaf budburst, first flower, last flower, first ripe fruit, and leaf shedding (Haggerty and Mazer, 2008).

2.3.1. Flowering phenology

In tropical forests, association of intensified flowering activity with hot, dry season is a commonly observed phenomenon. Reasons being that tree are leafless and flowers are more visible and accessible to pollinators. Furthermore, it is essential if fruits are to ripen and seeds are to be dispersed in time for the following rainy season, when conditions for germination are optimal (Elliott *et al.*, 1994).

Elaeocarpus serratus flowers during Febraury – April and flowers are 1.5 cm across. Sepals ovate, acute, glabrous, green. Petals lanciniate, white. Anthers with 4 -5 bristles at apex (Sasidharan and Sivarajan, 2002). *Elaeocarpus glandulosus* flowers during March - April and the sepals ovate-acute, reddish. Petals are lanciniate. *Elaeocarpus tuberculatus* also flowers during March – April and flowers are 2.5 cm across. Sepals ovate lanceolate, densely tomentose outside. *Elaeocarpus ganitrus* flowers during May to June and fruits ripen during November to December. The flowers were born as the racemes inflorescence of 10-14 flowers in a branch and only one or two will attain the fruit shape. More flowers were early dispersed at the time of pollination and opening. It takes 3-4 months to mature the seeds (Khan *et al.*, 2005).

2.3.2. Fruiting phenology

Fruiting shows a strong seasonal pattern in a tropical forest and occurs throughout the year. Fruiting in April – June is commonly observed in Elaeocarpaceae family (Kimkim and Yadav, 2001). Fruiting trees of *E. ganitrus* with greater girth and height produced more flowers and fruits. It is generally accepted that tall, dominant trees with large crowns, which receive a lot of light, produce maximum flowers (Elliott *et al.*, 1994). Mishra *et al.* (2006) also noted that the peak fruiting period of both overstorey and understorey species in Similipal Biosphere Reserve, Orissa; were same i.e. from May to June. The fruiting phenology followed closely the flowering phenology.

Duration of fruit maturation was longest in deciduous forest from monsoon to pre-monsoon period with a peak in November to January. While in evergreen forest, the fruit maturation was more in pre-monsoon period with a peak in the month of April (Nanda *et al.*, 2011).

Kimkim and Yadav (2001) classified two categories of fruiting activity i.e. rapid and lengthy. "Rapid" can be characterised as fruit maturation periods of 4 months or less following fertilization and those more than 4 months are termed as "lengthy". *Elaeocarpus serratus* was categorized as lengthy maturation i. e. it takes more than 4 months for maturation of fruits.

2.4. Physical Characters

Fruits have several unique characteristics that differentiate them from other engineering materials. These physical characters determine the quality of the fruit. Information regarding dimensional attributes such as length, diameter, weight etc. is used in describing fruit shape, designing of various machines and evaluation of consumer preference (Beyer *et al.*, 2002 and Naderiboldaji *et al.*, 2008).

2.4.1. Fruit Length

The fruit length is an important physical parameter which may signify the different varieties within the species, help in designing the harvesting machine and also packaging (Sethi, 1993). Fruit length may vary according to the genetic and environmental conditions in which the species is prevailing.

Kumar *et al,* (2014) studied the physical fruit characteristic of *Elaeocarpus serratus* at different land managements and found that the highest fruit length

25.37±1.42 mm was recorded in natural forest and the value decreased further in orchards and home gardens.

It is important to start monitoring fruit length over a number of seasons in order to build up a better picture of how the fruits are growing (Dash *et al.*, 2008).Various studies have been conducted on physical characteristics of tropical fruits. In *Spondias mombin, Garcinia indica* and *Simarouba glauca,* almost similar fruit length has been reported (Bora *et al.*, 1991; Patil *et al.*, 2009; and Dash *et al.*, 2008).

2.4.2. Fruit Width and Diameter

Fruit width and diameter help in deciding the maturation stage of the species. Hence these parameters may help in reducing the pre harvest loss of the species.

Kumar *et al.* (2014) studied the fruit width characteristic of *Elaeocarpus serratus* at different land managements and found that the maximum width (12.31± 1.05 mm) was recorded in natural forest and the value decreased further in orchards and home gardens. Similar studies in other tree species like *Tectona grandis* (Jijeesh and Sudhakara, 2007, 2013), *Pongamia pinnata* (Hooda *et al.*, 2009), *Azadirachta indica* (Kaushik *et al.*, 2012), *Aegle marmelos* (Venudevan *et al.*, 2013) and *Calophyllum inophyllum* (Ajeesh *et al.*, 2014). Fruit width and diameter helps in grading the fruit according to the size classes which help in designing the harvesting and grading machinery paving way for modern processing technologies (Bora *et al.*, 1991).

2.4.3. Fruit Weight

Fruit mass or weight indicates the quantity of solid or tissue content in the fruit and can potentially determines the yield per plant or unit area, packaging and transportation requirements and expected income generation from the market.

The fruit weight in *Elaeocarpus serratus* varied from weight 1.96 g, 1.38 g and 0.87 g among the different landuse patterns of natural forest, orchard and home gardens respectively (Kumar *et al.*, 2014). In *Garcinia indica*, fruit weight varied from 14.15 to 34.54 g (Patil *et al.*, 2009) and from 52.36 g to 60.38 g in carambola fruit (Narain *et al.*, 2001). Maiti (2010) conducted a study to assess the correlation between fruit weight and its components to provide an idea on effect of various characters on fruit weight of jackfruit. They observed a positive correlation between fruit weight of edible part, fruit and rind weight, and number of stones and flakes.

The fruit weight parameter is tool to measure the external quality of fruit, yield, to predict optimal harvest time and consumer preferences (Patil *et al.*, 2009).

2.4.4. Fruit Volume

The volume and surface area of the fruit have special significance not only due to being components of yield but they also determine the time of harvesting and acceptance of fruit by the stakeholders in the field and the market.

Volume of medlar (*Mespilus germanica*) fruit was found to be 13.68 cm^3 (Haciseferogullari *et al.*, 2005). In *Punica granatum* cultivars fruit volume varied from 99.41 to 547.88 cm^3 (Akbarpour *et al.*, 2009). The fruit volume in *Elaeocarpus serratus* varied from weight 7.50 ml, 5.16 ml and 3.15 ml among the different landuse patterns of natural forest, orchard and home gardens respectively (Kumar *et al.*, 2014). Fruit volume may be used to calculate the density of fruits and to assess the maturity in some fruits. Fruit volume may be used to build the model to predict the yield of fruit (Pathak and Chakraborty, 2006).

2.4.5. Weight of pulp and seeds

Weight of pulp and seed is to provide information useful to food processors and agriculturist in optimizing the economic and nutritional potentials of the fruit.

The Pulp : Seed ratio of *Elaeocarpus serratus* as reported by Kumar *et al.* (2014) is 4.75, 3.44 and 3.43 for natural forest, orchard and home gardens respectively. Pulp weight of 100 fruits were 83.00 g, 63.33 g, and 50.33 g for natural forest, orchard and home gardens. Nour *et al.* (1980) reported that in baobab fruit, weight of pulp and seeds per fruit were 28 g and 63.7 g respectively. Edible portion and individual seed of carambola fruit weigh about 55.62 g and 0.70 g respectively (Narain *et al.*, 2001). It will also provide information necessary in the classification of the fruit (Khoshnam *et al.*, 2007).

2.4.6. Other fruit characters

Irudhayaraj and Ramasubbu (2014) reported *Elaeocarpus blascoi* which has fruits that are drupes, 1.5cm long, ellipsoid, round at base and apex, laterally scarcely compressed, one-seeded. It flowers in the month of January and sets fruits in September. But we found some oscillation in the flowering and fruiting period from January to May.

Elaeocarpus sphaericus fruit pulp are sour to taste, fruit shape is round and ovate; size - length: 5-6 inch, diameter: 11/2 inch. The fruits are used to make prayer beads the stones of this plant are cleaned, polished, sometimes stained and used for making bracelets and other ornamental objects (Anon, 1952).

According to Sharma *et al.* (2006), there existed a significant association between fruit yield per tree and average fruit weight, which is further associated with fruit length, weight of bulbs (with seed) per fruit and weight of bulbs (without seed) per fruit. Study revealed that number of fruits per tree and average fruit weight, exhibit direct effect on fruit yield per tree.

2.5. Variability studies on morphological and physical characters

Variation in fruit characteristics is an important aspect of germplasm evaluation of the species whose fruits have multipurpose uses. Further, it can be concluded that this variability among different characters can be utilized for selection of best genotypes for plantation and utilization in making different value added products.

Thakur *et al.* (2011) also concluded that variability existed for physical parameters (fruit size and weight) of wild pomegranate fruit collected from different districts. Cosmulescu *et al.* (2010) observed that the difference in physical characteristics of *Juglans regia* was caused probably by different agro-climatic conditions and genetic characteristics. According to Okello (2010), morphological characteristics of *Tamarindus indica* pods (pod length, pod breadth, pod mass etc.) showed variations in different agro-ecological zones. From the findings, he opined that these morphological differences expressed in genetic variations can be useful for promoting domestication and commercialization of *Tamarindus indica.*

Studies on fruit characteristic variation in the species of *Terminalia bellirica* with respect to geographic source was done by Sood *et al.* (2009). Average fruit weight (fresh and dry), average pulp weight (fresh and dry), and average fruit length and diameter varied significantly possibly due to genetic and environmental factors. Similar findings were reported in walnut from different agro-climatic regions (Cosmulescu *et al.*, 2010). Yadav *et al.* (2006) opined that a large variability exists in *Hippophae salicifolia* populations particularly for fruit length, 100 fruit weight, number of fruits per unit length of fruiting branch and fruit yield.

2.6. Biochemical and Nutritional Composition

Major constituents of fruit include sugars, polysaccharides and organic acids whereas minor constituents include pigments, aroma substances, vitamins and minerals of nutritional importance. Investigations on biochemical composition of fruits form the basis for establishing the nutritional value and overall acceptance by the consumers. Study on nutritional components of tropical fruits revealed that different fruit varieties may deliver healthful benefits by supplying natural antioxidants, dietary fibre, vitamins and carotenoids (Baldwin *et al.*, 2008).

2.6.1. Moisture

Moisture content analysis is a critical component of material quality and essentially a function of quality control. Moisture content control greatly influences the physical properties and product quality at all stages of processing and final product existence.

Moisture content in *Elaeocarpus serratus* ranges from 60 to 65 per cent (Mohanan and Sabu, 2002). Similar values were reported by Thisajeni and Liyanage, (2006) while working on the chemical composition of off-season *Elaeocarpus ganitrus*. In Sri Lanka the moisture content of the *Elaeocarpus serratus* fruit was reported to be 63 g/100 g by a study conducted by Department of Agriculture, Sri Lanka (2004). Moisture content of fruit samples *Zizyphus mauritiana, Docynia indica, Elaeagnus pyriformis, Phyllanthus emblica, Prunus armeniaca, Elaeocarpus floribundus* and *Calamus latifolius* range from 80.31 per cent to 85.14 per cent (Shodhganga, 2006).

Water has been called the universal solvent as it is a requirement for growth, metabolism, and support of many chemical reactions occurring in food products. Water in fruit or vegetables is the water available for chemical reactions, to support microbial growth, and to act as a transporting medium for compounds.

2.6.2. Total Soluble Solids

The TSS or 'sugar content' measures and includes the carbohydrates, organic acids, proteins, fat and minerals of the fruit. It represents from 10 - 20 per cent of the fruit's fresh weight and increases as fruit matures to produce a less acidic, sweeter fruit.

For various tropical fruits like bael, custard apple, carambola, jackfruit etc., total soluble solids ranged from a lowest value of 6.25 to a highest value of 32.20 ^{0}Brix (Pathak and Chakraborty, 2006). Among different selections of *Garcinia indica* values for TSS ranged from 8.46 to 17.70 ^{0}Brix (Patil *et al.*, 2009).

The total soluble solids is a key characteristic determining taste, texture and feel of fruit segments. It contributes towards giving many fruit their characteristic flavor. It is also an indicator of commercial and sensory ripeness (Sood *et al.*, 2010).

2.6.3. Titrable acidity

Titrable acidity is the sugar/acid ratio which contributes towards giving many fruits their characteristic flavour and so is an indicator of commercial and organoleptic ripeness. Acidity in fruit is an important factor in determining maturity.

Goswami *et al.* (2011), Pathak and Chakraborthy (2006) opined that most of the tropical fruits studied were low in acidity. Higher titrable acidity (5.31 to 17.91 per cent) was reported among different kokum selections (Patil *et al.*, 2009). Nour *et al.* (1980) concluded that pulp of baobab tree, *Adansonia digitata* L. was acidic, and rich in ascorbic acid.

2.6.4. Sugars

Sugar is an important contributor to flavour. Depending on the food application, sugar has the unique ability to heighten flavour or depress the perception of other flavours.

According to Nour *et al.* (1980) pulp of baobab tree, *Adansonia digitata,* contains total sugar and reducing sugar content of 23.2 per cent and 18.9 per cent respectively. Nazarudeen (2010) investigated the nutritive value of wild fruits of Kerala. Total sugars for these wild fruits varied from 5.98 to 16.2 per cent and reducing sugars from 4.91 to 1.79 per cent respectively. A study conducted in Nepal by Shodhganga (2006) showed the Low amount of total sugar were observed in *Elaeocarpus floribundus* (13.35 mg/100 g), Citrus species (phouheiri) (11.27 mg/100 g), *Prunus triflora* var. mangomix (8.73 mg/100 g), *Averrhoa carambola* (7.86 mg/100 g). *Elaeocarpus floribundus, Spondias pinnata, Calamus latifolius, Prunus triflora* var. kalenheikha range from 1.05 to 4.31 mg/100 g.

Sugar makes an important contribution to the way we perceive the texture of food. Sugars function as flavor producing agents, texturizing agents and sweeteners (Manay and Shadaksharaswamy, 2001).

2.6.5. Starch

Starch is a type of carbohydrate made from long chains of glucose attached to one another. Fruits high in starch are mostly bland and have a mealy texture. Such fruits generally contain significant amounts of fiber, which is indigestible, but aids the process of digestion and movement of chyme through the intestines (Manay and Shadaksharaswamy, 2001).

Starch quantities in various chestnut cultivars ranged from 54.45 to 69.70 g/100 g (Erturk *et al.*, 2006). Biological studies that are undertaken show that *Elaeocarpus ganitrus* fruits contain glycosides, carbohydrates and flavonoids. Apart from this, it has been found that the exocarp of the fruit supplies a nutritious reward, because it is particularly rich in carbohydrates (0.58 g per fruit) and proteins (0.12 g per fruit), but lacking lipids (Anusha and Janarthan, 2014).

Starch gets hydrolysed during the ripening process of fruit. The form in which the carbohydrates exists in the food is of significance in any attempt to develop satisfactory method of value addition (Bean, 2000)

2.6.6. Carotene

β carotene is the most prevalent carotenoid in the plant sources of food chain and is also known as pro-vitamin A. Being an important flavonoid compound, β carotene has powerful antioxidant functions that help the body scavenge free radicals, and thereby limiting damage to cell membranes, DNA and protein structures in the tissues.

An analysis on nutrient composition of some wild edible fruits of Andaman and Nicobar Islands was done by Singh *et al.* (2001). Among the fruits studied, *Artocarpus heterophyllus* and *A. lakoocha* were found to be exceptionally rich in carotenoid content. Compared to the *Phyllanthus emblica* and *Spondias pinnata, Antidesma velutinosum* Blume contained higher levels of most nutrients as well as carotenoids (335 g/100 g).

Beta-carotene is the most widely studied carotenoid. They are found in many yellow fruits and vegetables. Value added products rich in beta carotene are associated with reduced risk of cardiovascular diseases and cancers and are appreciated in large (Baldwin *et al.*, 2008).

2.6.7. Ascorbic acid

Vitamin C is one of the most important water-soluble vitamins, naturally present in foods, especially in fruits and vegetables, and is widely used as a food additive and as an antioxidant. Antioxidants are substances that can prevent or delay oxidative damage of lipids, proteins and nucleic acids by reactive oxygen species. Vitamin C is a dietary antioxidant required as a co-factor for many enzymes (Benzie, 1999; Davey *et al.*, 2000).

Fruits of *Garcinia indica* have been reported to be rich in ascorbic acid with the values varying from 13.59 to 64.70 mg/100 g (Patil *et al.*, 2009). Pulp of *Balanites aegytiaca* was found to be rich in Vitamin C content with the value 1.26 g/100 g (Sadiq *et al.*, 2012). Judprasong *et al.* (2013) compared the nutritional potential of various indigenous fruits (*Phyllanthus emblica, Antidesma velutinosum* and *Spondias pinnata*). They observed that *Phyllanthus emblica* L. exhibited the highest levels of vitamin C (575 mg/100 g).

Vitamin C is required for the prevention of scurvy and maintenance of healthy skin, gums and blood vessels. The consumption of fruit juices is beneficial and the health effects of fruits are ascribed, in part to ascorbic acid, a natural antioxidant which may inhibit the development of major clinical disorders (Sarkar *et al.*, 2009).

2.6.8. Fibre

Dietary fibers are found naturally in the fruits, vegetables, nuts, and grains that we eat. Fruits containing fiber can provide health benefits such as helping to maintain a healthy weight and lowering your risk of diabetes and heart disease (Baldwin *et al.*, 2008).

Adepoju (2009) analysed pulp of wild fruits like *Spondias mombin, Dialium guineense* and *Mordii whytii* for their nutrition potential in meeting needs of consumers. Crude fibre content in these fruits ranged from 0.6 to 11.8 mg/100g. Investigations on chemical composition of *Annona muricata* revealed that fruits possess high fibre content of 6.26 per cent (Onyechi *et al.*, 2012). A comparison was made between the biochemical composition of *Tamarindus indica* and *Ziziphus spina christi* seed and fruit. Highest crude fibre content (18.83 per cent) was observed in *Tamarindus indica* pulp (Adekunle and Adenike, 2012).

2.6.9. Nutritional Significance of wild edible fruits

Wild edible fruits play an important role in the dietary requirements of the tribal as well as local communities. A comparison was attempted relating to nutritional status of 15 most popular and commonly consumed wild fruits. It revealed that most of the wild fruits qualify as high nutrient and mineral content comparable to popular cultivated counterparts as Banana and Guava (Rathore, 2009).

Nazarudeen (2010) and Mahapatra *et al.* (2012) compared the nutritive values of wild fruits collected from forests with those of commonly cultivated fruits. It was concluded that some of the wild fruits are more nutritional than commonly cultivated fruits. An analysis of the nutritional content of Saba fruit (*Saba senegalensis*) revealed that the fruit recorded Vitamin C content of 16.41 mg/100g, brix level of 14.1 per cent, crude fibre 13.52 per cent and 74.23 per cent available carbohydrates. Results suggested that the nutritional composition of this fruit was even higher than commercially available fruits (Boamponsem *et al.*, 2013).

2.7. Mineral Composition

2.7.1. Potassium

Potassium maintains the ionic balance and water status within the plant. It is involved in the production & transport of sugars in the plant; enzyme activation; and synthesis of proteins. High levels of available K improve the physical quality, disease resistance, and shelf life of fruits.

Wild fruits *Elaeocarpus floribundus, Punica granatum, Prunus armeniaca, Phyllathus emblica, Prunus triflora* var. mangomix, *Prunus triflora* var. applemix and *Elaeagnus pyriformis* have 400 mg/100 g, 390 mg/100 g, 380 mg/100 g, 310 mg/100 g, 290 mg/100 g, 280 mg/100 g and 240 mg/100 g respectively of K content (Shodhganga, 2006). Highest potassium content was reported in *Ficus racemosa* (1922 mg/100 g) by Valvi and Rathod (2011) and in *Zizyphus mauritiana* (1865 to 2441 mg/100 g) by Nyanga *et al.* (2013). According to Arukwe *et al.* (2012), *Persea americana* also showed potassium content falling in the nearby range (385.14 mg/100 g). Potassium is also very important mineral for the body. It controls the functioning of the nerves and the muscles. Fruits generally contain high Potassium levels.

2.7.2. Phosphorous

Phosphorus is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next (Kader, 2008).

Narain *et al.* (2001) observed a large variation in mineral composition of carambola fruit during maturation from green mature to ripe stage. Phosphorous content decreased from 20.50 to 19.24 mg/100 g. Arukwe *et al.* (2012) analysed mineral composition of *Persea americana.* They concluded that the fruit contained 51 mg/100 g of phosphorous. Erturk *et al.* (2006) opined that phosphorous content in various domestic and foreign hybrid cultivars of chestnut varied greatly. Values were found to be varying from 107 mg/100 g to 185 mg/100 g. Different cultivars of *Zizyphus jujuba* as well as *Zizyphus mauritiana* showed almost similar values (Li *et al.*, 2007 and Nyanga *et al.*, 2013).

Phosphorous improves the quality of fruits and vegetables and also vital to seed formation. A series of phosphorous compounds are formed in the utilization of carbohydrates in the body. It is vital to the fundamental process of metabolism in the body (Saunders, 2007).

2.7.3. Calcium

Calcium plays a special role in maintaining the cell wall structure in fruits by interacting with the pectic acid in the cell wall and help in maintaining the firm fruit structure. In the tissue of many fruits, calcium is one of the mineral believed to be an important factor governing fruit storage quality (Lechaudel *et al.*, 2005).

Fruits of *Antidesma velutinosum* possess high calcium content varying as 325 mg/100 g (Judprasong *et al.*, 2013). Even higher values have been reported by Adekunle and Adenike (2012) in the pulp of *Tamarindus indica* and *Ziziphus spina christi* in the range of 450 mg/100 g. After investigating the mineral content of various wild edible fruits, Valvi and Rathod (2011) came to the conclusion that fruits of *Ficus racemosa* were richest in calcium content as 928.4 mg/100 g.

Value added products rich in calcium is recommended for the children and women for the greater health benefits they provide. Recently efforts are being made by food industry to develop fruit products rich in calcium (Boamponsem *et al.*, 2013).

2.7.4. Iron

Iron is a component of many enzymes associated with energy transfer, nitrogen reduction and fixation, and lignin formation. Iron is included in the synthesis of chloroplastic protein and it may impair the machinery for chlorophyll synthesis (Gauch, 1957 and Alabi and Alausa, 2006). Iron is also an important dietary mineral which carries oxygen around the body.

Narain *et al.* (2001) studied the range of iron content in *Averrhoa carambola* from green to ripe stage. Data were found to be in the range of 0.55 to 0.49 mg/100 g. These values were in agreement with those reported in the fruits of *Persea americana* by Arukwe *et al.* (2012). Even higher values varying from 35 to 39 mg/100 g have been noted in wild edible fruits of *Meyna laxiflora* and *Ziziphus spina christi* (Valvi and Rathod, 2011 and Adekunle and Adenike, 2012).

Nazarudeen (2010) opined that iron content of underutilized fruits from the wild was higher compared to other popular fruits like pineapple, pomegranate, sapota, apple etc.

2.8. Organoleptic and sensory evaluation of fruit

Sensory quality attributes and nutritive value of fruit play an important role in consumer satisfaction and they influence further consumption. Sensory ratings of fruit by panelists and physical measurements of fruit properties are useful methods in the evaluation of fruit quality (Colaric *et al.*, 2005). Sensory quality is a difficult concept to define, it should be comprehended as interaction between the product and the consumer. It is necessary to establish a relationship between the physical and chemical composition of the product and its sensory attributes such as color, texture, aroma (volatile compounds) and taste (sweet, sour, salty and bitter sensations), as well as between the sensory perceptions and the acceptability for the consumer (Escribano *et al.*, 2010).

Taste, aroma, texture and appearance are generally considered to be among the most important sensory attributes. Taste is related to water-soluble compounds. Sweetness is mostly attributable to mono and disaccharides rather than to other compounds. Sour tastes are reliably linked up with organic acids and pH.

2.9. Value addition of fruits

2.9.1. Processing

Processing of fruits can be defined as adding value to conventional and innovative fruit items, through various permutations and combinations providing protection, preservation, packaging, convenience carriage and disposability (Rao, 1989). Development of fruit preservation industries in rural areas can help generate employment, support growers, upgrade local nutrition and increase the gross national production (Maini and Anand, 1985).

Fruit processing helps to mitigate the problems of unemployment during off season in agricultural sector (Poornia *et al.*, 1994). The food industry can provide processed fruit products at reasonable and steady prices throughout the year, meeting the requirement of defense forces in broader area and earning foreign exchange for the country by development of exports (Shaw *et al.*, 1993).

India a diversified country with a wide range of fruits, can play an important role by providing exotically flavored processed products (Tandon and Kumar, 2006). In addition to major fruits, a large number of minor fruits, accounting for about 5.53 million tonnes are also produced in the country but utilization of fruits by the processing industry is only one per cent (Sethi, 1999).

2.9.2. Scope of processing

India is enriched with a variety of delicious indigenous fruits, which have great potential for processing into nutritious, delicately flavored products. The processing of indigenous fruits like the bael, kiwi, amla, jamun, karonda etc could help the even distribution of fruits from places of abundance to the places of scarcity, the availability of fruit products even during off season and at reasonable price thereby improving the per capita availability as well as consumption (Roy and Pal, 2000).

The annual fruit production in India is estimated to be 45.5 million tonnes (Negi, 2001). Inspite of high fruit production the Indians do not get basic daily requirement of fruits due to wastage and value destruction. If the fruits are processed then they are evenly marketed from places of abundance to the place of scarcity, not only will the consumers get the produce at a reasonable price but also the producer will not be forced to sell at throw away prices (Roy, 2001).

2.9.3. Processing of under exploited fruits

India is the center of origin for many tropical fruit tree species, most of which are not commercially cultivated but provide a significant source of livelihood support for many rural communities. Besides their importance for their nutritional value and as a source of household income, this fruit diversity also has a cultural and social value and contributes to the stability of ecosystems (Arora, 1998). Many tropical fruits are labelled as "underutilized species", which are characterized by the fact that they are i) locally abundant, but restricted in their geographical dispersion and have a high use value, ii) there is a lack of scientific knowledge about them, and iii) that their current use is limited relative to their economic potential (Hiremath *et al.*, 2006).

Value addition to the underutilized fruits and development of popular products from them would therefore be an ideal way to take them into the consumption successfully (Gunasena *et al.*, 2004). Production of value-added preparations has been identified as a key aspect of domestication, improvement, development, and utilization of underutilized fruit trees (Abeyrathne and Jaenicke, 2006; Pushpakumara *et al.*, 2006). There is a huge gap between potential and actual performance of the fruit sector. Product development would help to overcome this gap (Ravichandran, 2004). Underutilized fruits have tremendous potential for introducing a variety of new products of commercial and nutritional importance and in turn finding their use in human diet, sheerly for high nutritive value (Hiremath *et al.*, 2006).

The underutilized fruits like amla, karonda, bael etc. have the ability to grow under adverse conditions and known for their therapeutic and nutritive value. However some of these fruits are not acceptable in the market in fresh form due to their acidic nature and for their stringent taste. There is a need to create demand for such fruits crop in domestic and international markets. This is to some extent, can be achieved through processing (Gajanana, 2006).

2.10. Product development from underexploited fruits

Highly nutritious product could be prepared from the underexploited fruits. Maikhuri *et al.* (1994) have made an attempt to utilize the wild fruits as a source of income, particularly for poor rural inhabitants and unemployed youth of the region, through making a variety of edible products such as Jam, Jelly, Squash and Sauce.

Veralu / Ceylon olive (*Elaeocarpus serratus*) is one of the underutilized fruit species found in the wet zone and the intermediate zone of Sri Lanka. Few value added products of this fruit (Veralu pickles and cordial) are available in the market. But still there is a need of development of more value added products using Veralu to enhance utilization and availability in off season (Priyanthi *et al.*, 2009). Edirisinghe *et al.* (2013) developed Ceylon olive ripple ice cream and found to be organoleptically acceptable.

Muthukrishnan and Palaniswamy (1974) revealed the suitability of West Indian cherry for the preparation of clarified juice and squash. According to Parvathy *et al.* (2006) in their studies, products such as squash, cordial, RTS and milkshake were prepared from West Indian Cherry. Roy and Singh (2007) noticed by adjusting the amount of pulp, brix and acidity, good quality nectar and squash could be prepared from bael fruit.

Tripati *et al.* (2001) developed a recipe for amla juice, which was found organoleptically acceptable. Indigenous fruits like phalsa, jamun and kokum can be exploited for beverages and concentrates can serve as good items for export (Chadha, 1994). According to Khurdiya and Singh (2001) ber fruits can be used for the preparation of murabba, candy, pickle, chutney etc. Similar products were prepared by Srivastava and Kumar (1994) from ber fruits. Karonda are used for making pickles, chutney, pudding and candy (Misra and Jaiswal, 2004).

Materials and Methods

3. Materials and Methods

The present study entitled "Quality evaluation and value addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)" was carried out to evaluate the fruit characteristics of *Elaeocarpus serratus* and also to analyse the biochemical and mineral composition of the fruit. The production of two value added products from the fruit was also attempted. The materials and methods adopted for the study are presented in this section.

3.1. Study site:

3.1.1. Location

The fruits were collected from Vazhachal forest division in Thrissur district of Kerala state (Fig. 1). Vazhachal forest division supports extensive tracts of natural forest. They include Southern Tropical Wet Evergreen forests ($1AC_3$), Southern Tropical Semi Wet Evergreen Forests ($2AC_3$), Southern and Tropical Moist Deciduous Forests ($3BC_2$). The *Elaeocarpus serratus* trees were distributed in wet evergreen and semi evergreen forests. Fruits were collected during the month of May and June.

3.1.2. Climate

Temperatures range from a minimum of 30^0 C and the temperatures can rise up to a maximum of 36^0 C. May is the hottest month of the year. The place gets a substantial rainfall from the South West Monsoon. The months of October and November also get certain amount of rainfall from the North East Monsoon. The average rainfall in a year ranged from 3000-3500 mm.

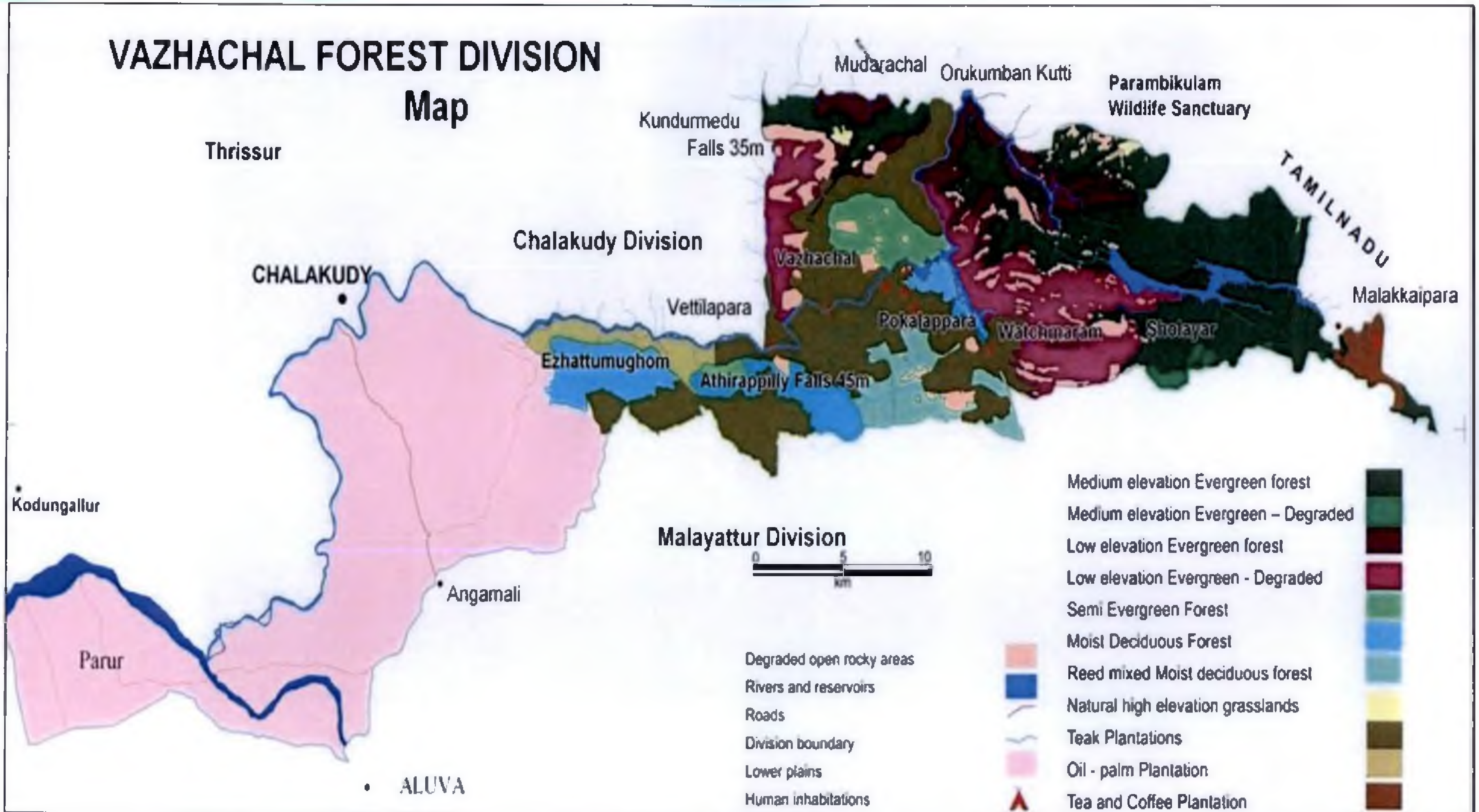

Fig. 3: Vegetation map of Vazhachal forest division of Thrissur district, Kerala. (Source- Kerala Forest Department)

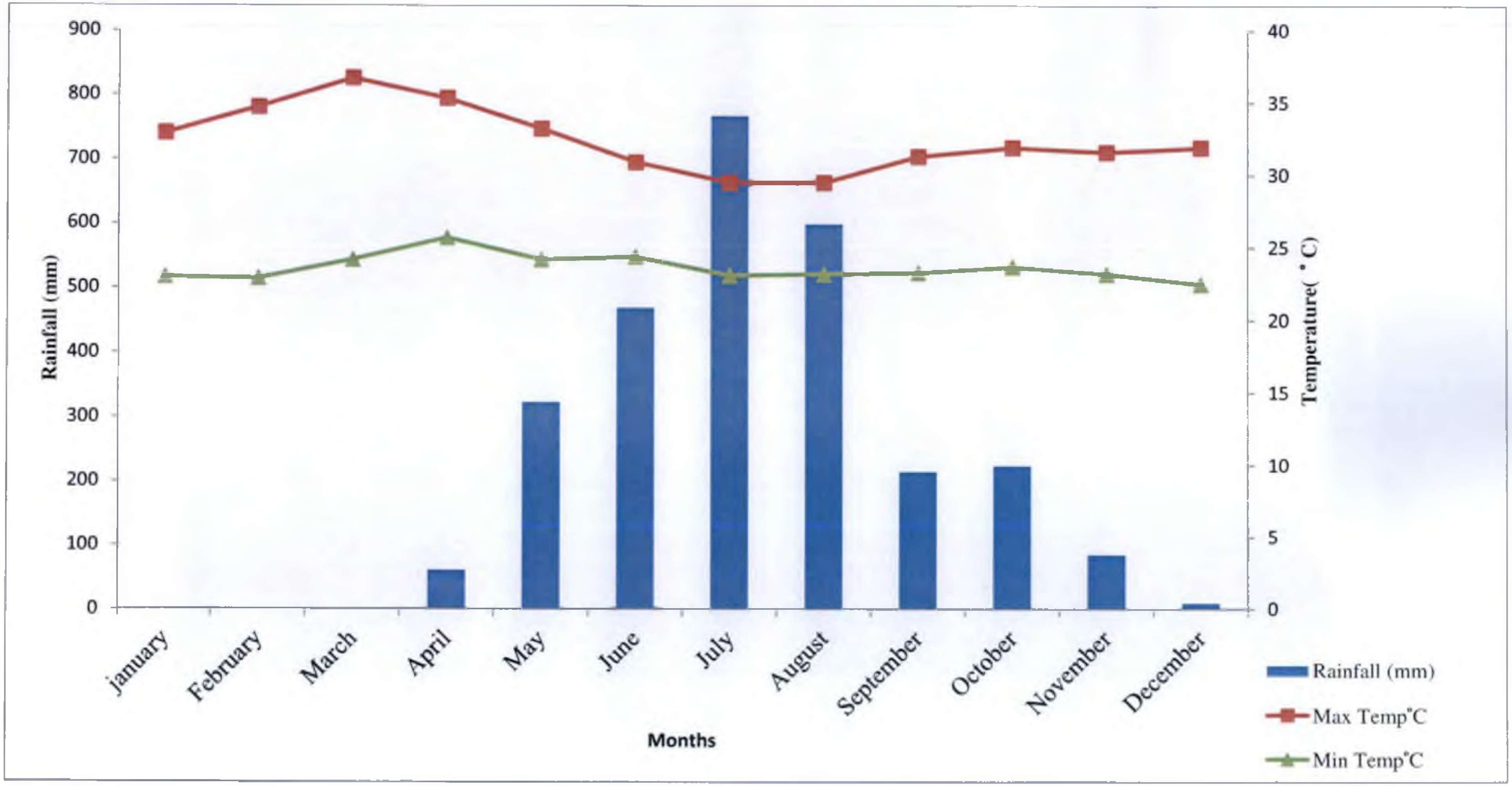

Fig. 2: Ombrothermic diagram showing temperature and rainfall during the period January 2014 to December 2014 in Thrissur district, Kerala.

(Source: Dept. of Agro meteorology, KAU, Vellanikkara)

3.2. Quality evaluation of fruits

Quality evaluation of Ceylon Olive was carried out using standard procedure.

3.2.1. Physical characters

Various physical characters were recorded which included fruit size (mm), weight (g) and volume (cm^3).

3.2.1.1. Fruit size

Length (mm) and diameter (mm) of 50 fruits was determined with the help of digital vernier calliper and mean weight was recorded.

3.2.1.2. Fruit weight

Weights (g) of 50 fruits were determined and mean weight was recorded.

3.2.1.3. Fruit Volume

Volume (cm^3) of 50 fruits was measured by water displacement method and the mean value was recorded.

3.2.2. Physical composition

Proportion of the pulp and seed in a single fruit was evaluated by weighing each component separately and then calculating the per cent proportion of that component of the whole fruit.

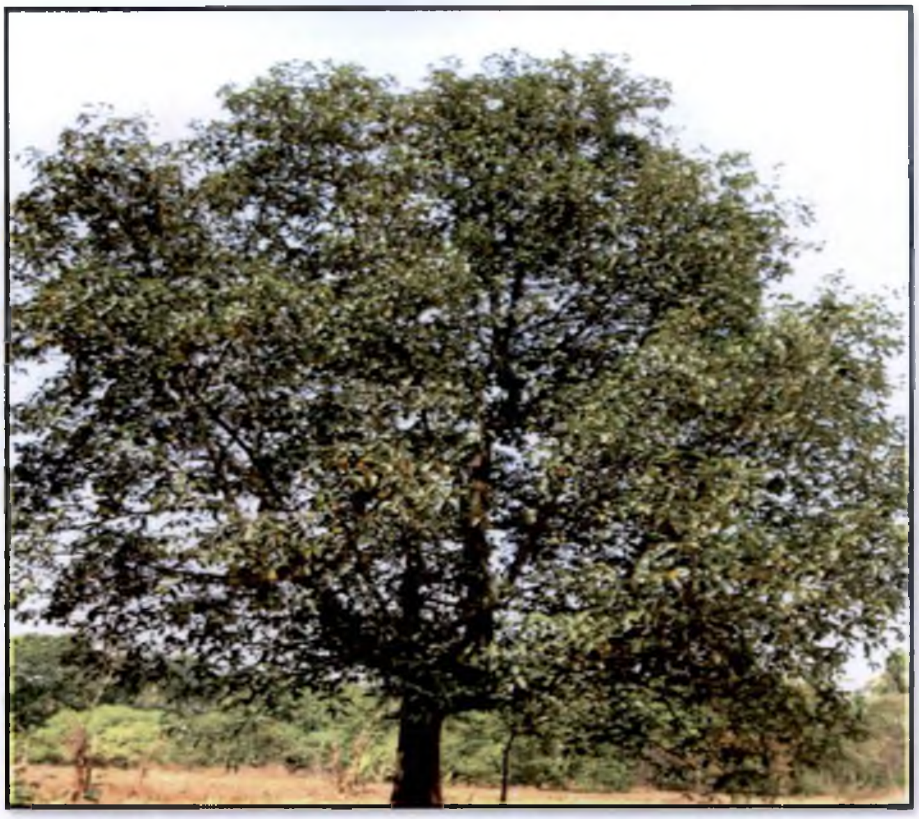

Plate.1.a. *Elaeocarpus serratus* habit

Plate 1.*b. Elaeocarpus serratus* fruits borne on tree

Plate 2.a. *Elaeocarpus serratus* fruits in Vazhachal Forest of Thrissur

Plate 2.b. *Elaeocarpus serratus* fruits collected.

Plate 3: *Elaeocarpus serratus* graded as big and small sized fruits

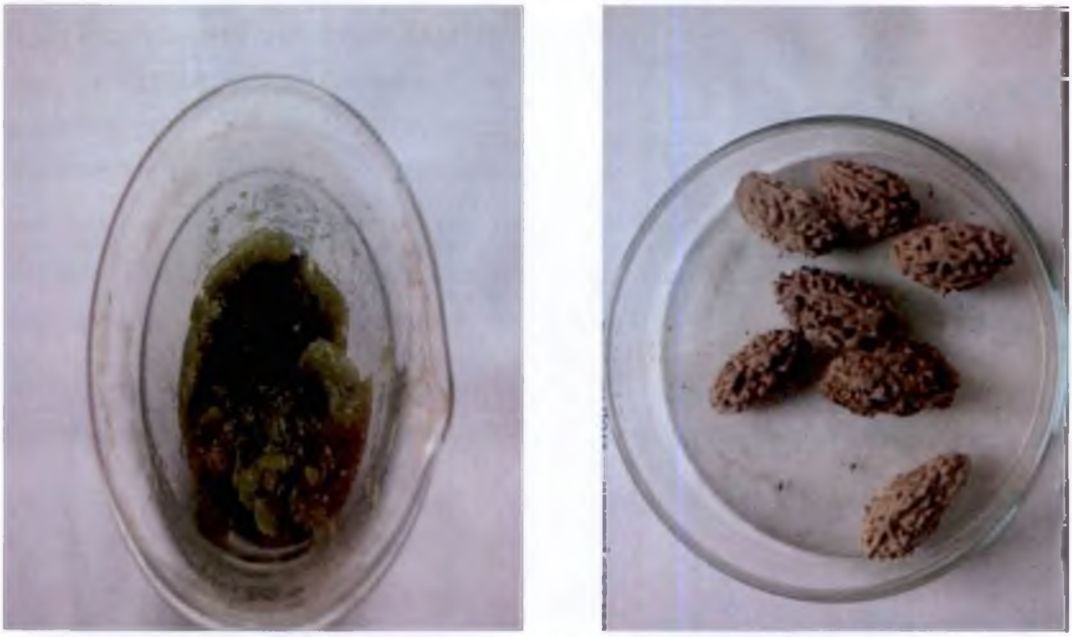

Plate 4: *Elaeocarpus serratus* fruit pulp and seeds

3.2.3. Biochemical and Nutritional constituents

Biochemical and nutritional qualities of the fruits were assessed using standard procedure. Analysis was carried out for the following constituents.

3.2.3.1. Moisture

To determine the moisture content of the fruit, 5g of the fruit pulp was taken in a petridish and dried in a hot air oven at 60 ^{0}- 70 ^{0}C, cooled in a desiccator and weighed. The process of heating and cooling was repeated until a constant weight was achieved. The moisture content was calculated from the loss in weight during drying and expressed in percentage (A.O.A.C., 1980).

3.2.3.2. Starch

The starch content was estimated colorimetrically using anthrone reagent as suggested by Sadasivam and Manikam (1992). The sample (0.1 g) was extracted with 80 per cent ethanol to remove sugars completely. The residue was dried over a water bath and added 5 ml water 6.5 ml of 52 per cent perchloric acid and extracted in the cold for 20 minutes. The supernatant was pooled and made up to 100 ml. From this, 0.2 ml of the supernatant was pipetted out and made up to 1 ml with water and 4 ml of anthrone reagent was added, heated for eight minutes, cooled and optical density value read at 630 nm.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was obtained and the value was multiplied by the factor of 0.9 to arrive at the starch content.

3.2.3.3. Total soluble Solids

Total soluble solids were recorded using a hand refractometer (Erma, Japan) of brix ranging from 0 to 32^0 at room temperature and the values were expressed in degree brix (Ranganna, 1986).

3.2.3.4. Titrable acidity

Titrable acidity was described by Hooi *et al.* (2004). Ten grams of sample was placed in a beaker and titrated with 0.1 N sodium hydroxide solution using phenolphathalien as an indicator. End point of the titration was the transition from colourless to pink. Acidity was expressed as percentage.

3.2.3.5. Reducing sugar

Reducing sugar was estimated by the method given by Lane and Eyon (Ranganna, 1986). To 10 g of sample, 100 ml of distilled water was added and then clarified with neutral lead acetate. Excess lead was removed by adding potassium oxalate. The volume was then made up to 250 ml. An aliquot of this solution was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage.

3.2.3.6. Total sugar

The total sugar was determined by the method given by Lane and Eyon (Ranganna, 1986). From the clarified solution used for the estimation of the reducing sugar, 50 ml was taken and boiled gently after adding citric acid and water. It was later neutralised with NaOH and the volume was made up to 250 ml. An aliquot of this solution was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator. The total sugar was expressed as percentage.

3.2.3.7. Fibre

The fibre content was estimated by acid alkali digestion method as suggested by Chopra and Kanwar (1978). The 2 g of dried sample was boiled with 200 ml of 1.25 per cent sulphuric acid for 30 minutes. It was filtered through a muslin cloth and washed with boiled water and boiled again with 200 ml of 1.25 per cent sulphuric acid for 30 minutes. Filteration through muslin cloth was repeated and the residue was washed with sulphuric acid, water and alcohol in a sequential manner. Residue was transferred to a pre weighed ashing dish and was ignited for 30 minutes in a muffle furnace at 250^0 C, cooled in a dessicator and weighed. The fibre content of the sample was calculated from the loss in weight on ignition.

3.2.3.8. β carotene

Beta carotene was estimated by the method suggested by Srivastava and Kumar (1994). Five gram of sample was extracted adding 10 to 15 ml Acetone and few crystals of anhydrous sodium sulphate. The supernatant was decanted and 10 to 15 ml petroleum ether was added and mixed thoroughly and kept outside for layer separation. The supernatant was collected in a 100 ml volumetric flask and the volume was made up to 100 ml with petroleum ether and intensity of color was read at 452 nm in a spectrophotometer. The β carotene content was expressed as μ g per 100 g.

3.2.3.9. Vitamin C

The vitamin c content was estimated by the method suggested by Sadasivam and Manikam (1992). An exact amount of three grams of fresh sample was extracted with 4 per cent oxalic acid, made up to 100 ml with oxalic acid and supernatant was titrated against the dye solution 2, 6-dichlorophenol indophenol until the appearance of pink colour which persisted for a few seconds. Vitamin C content was expressed in mg per 100 g of the sample.

3.2.4. Minerals

Minerals Content (Calcium, Phosphorous, Potassium and Iron) was estimated using the following procedures

3.2.4.1. Calcium

The calcium content was estimated by atomic absorption spectrophotometric method using diacid extract prepared from the sample (Perkin-Elmer, 1982). One gram of the sample was pre digested with 15 ml of 9:4

mixture nitric acid and perchloric acid and made up to 50 ml and used directly in atomic absorption spectrophotometer for the estimation of calcium and expressed in mg per 100 g of sample.

3.2.4.2. Iron

Iron content was estimated by atomic absorption spectrometric method using the diacid extract prepared from the sample (Perkin-Elmer, 1982). One gram of the sample was pre-digested with 15 ml of 9:4 mixture nitric acid and perchloric acid. This solution was read directly in atomic absorption spectrophotometer and iron content was expressed in mg per 100 g.

3.2.4.3. Phosphorous

The phosphorous content was analysed colorimetrically as suggested by Jackson (1973), which gives yellow colour with nitric acid vanaomolybdate reagent. To 5 ml of predigested aliquot, 10 ml of nitric acid vanaomolybdate reagent was added and made up to 50 ml with distilled water. After 10 minutes, the OD was read at 420 nm.

A standard graph was prepared using serial dilution of phosphorous solution. The phosphorous content of the sample was estimated from the standard graph and expressed in mg per 100 g of sample.

3.2.4.4.Potassium

Potassium content was determined by flame photometric method (Jackson, 1973). One gram of sample was digested with 9:4 mixture nitric acid and perchloric acid and made up to 50 ml. this solution was directly read in Flame Photometer and Potassium content was expressed in mg per 100 g of sample.

3.2.5. Organoleptic evaluation of the fruit

Organoleptic evaluation of the fruit was conducted using score cards by selecting a panel of ten judges

3.2.5.1. Selection of judges

A series of acceptability trails were carried out using simple triangle test at laboratory level to select a panel of ten judges between the age group of 18 to 35 years as suggested by Jellinek (1985).

3.2.5.2. Preparation of score card

Score card containing the eight quality attributes like appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability was prepared for the assessment of fruit. Each of the above mentioned qualities were assessed by a nine point hedonic scale.

3.2.6. Preparation of *Elaeocarpus serratus* pickle

The steps followed in the preparation of Ceylon olive pickle is as follows.

3.2.6.1. Selection of fruit

Fully matured *Elaeocarpus serratus* fruits without blemishes and injury were selected. The selected fruits are washed thoroughly in running cold water to remove the adhering dirt and other extraneous matter.

3.2.6.2. Blanching

The fruits were blanched for 2 minutes in water at 80 C.

3.2.6.3. Cooking

Heated gingelly oil, seasoned split green chillies and added ginger, garlic pastes and stirred till oil separated from the mixture. To this added chilli powder, salt, vinegar, fenugreek powder, asafoetida powder and mustard powder.

3.2.6.4. Mixing

Blanched fruits were then added to this paste and mixed thoroughly.

3.2.6.5. Preservative

Sodium benzoate was added at the rate of 250 mg/kg of the finished product.

3.2.6.6. Bottling

The prepared Ceylon olive pickle was filled in sterilised glass bottles and stored in cool, dry place at ambient temperatures.

Fig. 3: Flow chart for the preparation of Ceylon Olive Pickle

Fully mature *Elaeocarpus serratus* fruits

↓

Washing

↓

Blanching

↓

Heating gingelly oil, seasoned split green chillies and added ginger, garlic pastes

↓

Add chilli powder, salt, vinegar, fenugreek powder, asafoetida powder and mustard powder

↓

Mixing

↓

Bottling

3.2.7. Preparation of *Elaeocarpus serratus* Candy

The steps followed in the preparation of Ceylon Olive candy is as follows.

3.2.7.1. Selection of fruits

Fully mature and firm fruits were washed with ample quantity of fresh water.

3.2.7.2. Processing of the fruits

The washed fruits were cut longitudinally and pricked with stainless steel fork. After pricking the fruits were immersed in 4 per cent lime solution for one hour before further processing. After washing in water the fruits were blanched for five minutes in boiling water and drained. Sugar solution of 40^0 brix was prepared. Fruits were added to this solution in air tight container. This was allowed to stand for 24 hours. Next day, the syrup was drained and sugar solution was heated to raise the thickness of syrup (60^0 brix). A small quantity of citric acid (62-125 g/100kg of sugar initially taken) is also added to invert a portion of the cane sugar. The syrup with the fruits was boiled and kept for 24 hours. On the next day the syrup strength was raised to 68^0 brix by boiling the sugar solution. Sodium benzoate was added at the rate of 200 mg/kg of the final product. Fruits were kept in the syrup for 2 - 3 days period. The strength of the syrup was raised to 70^0 brix and the fruits were kept for a week. Finally the fruits were removed from the syrup and washed with lukewarm water and kept in oven for drying at 60^0 C.

3.2.7.3. Packaging

The candy is packed in clean aluminium pouches and sealed.

Fig. 4: Flow chart for the preparation of Ceylon Olive Candy

Fully matured Ceylon olive fruits

↓

Washing

↓

Cutting and Pricking of fruits

↓

Immersion in 4 per cent lime solution

↓

Blanching

↓

Preparation of sugar syrup of 40^0 brix and adding to fruits and Preservative

↓

Raising the syrup strength daily un till it reaches 70^0 brix

↓

Keep the fruits for a week undisturbed

↓

Washing and oven drying

↓

Packaging

3.2.8. Organoleptic evaluation of the products

Organoleptic evaluation of the fruit was conducted using score cards by selecting a panel of ten judges

3.2.8.1. Selection of judges

A series of acceptability trails were carried out using simple triangle test at laboratory level to select a panel of ten judges between the age group of 18 to 35 years as suggested by Jellinek (1985).

3.2.8.2. Preparation of score card

Score card containing the eight quality attributes like appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability was prepared for the assessment of pickle and candy. Each of the above mentioned qualities were assessed by a nine point hedonic scale.

3.2.9. Chemical composition of products

The products stored were analysed to find out the constituents such as Total soluble solids, Vitamin C, Acidity, Total Sugar and Reducing Sugar.

Plate 5: Pickle prepared from *Elaeocarpus serratus*

Plate 6: Candy prepared from *Elaeocarpus serratus*

Results

4. RESULTS

The results pertaining to the study entitled "Quality evaluation and value addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)" are presented in this chapter.

4.1. Physical characteristics of *Elaeocarpus serratus* fruits

Fruits of *Elaeocarpus serratus* were analysed for physical characteristics from Vazhachal forest of Thrissur District. The mean values of fruit weight, volume, length, diameter, pulp weight and seed weight were 3.55 g, 5.97 cm^3, 23.07 mm, 15.58 mm, 2.03 g and 1.52 g respectively (Table 1).

Table 1: Physical characteristics of *Elaeocarpus serratus* fruits

Sl No.	Physical characters	Mean
1	Fruit weight (g)	3.55 ± 0.10
2	Fruit volume (cm^3)	5.97 ± 0.21
3	Fruit diameter (mm)	15.58 ± 0.19
4	Fruit length (mm)	23.07 ± 1.82
5	Pulp weight (g)	2.03 ± 0.06
6	Seed weight (g)	1.52 ± 0.05

4.2. Correlation and regression equations

A correlation matrix computed for physical parameters of Ceylon olive fruits showed a significant and positive relation between all parameters (Table 2). From the result it is clear that as the weight of the fruit increases there is a significant increase in the volume, diameter, pulp weight and seed weight of the fruit. But the length of the fruit showed a negative correlation with the weight and volume parameter of the fruit. Diameter of the fruit also showed a positive correlation with pulp weight and seed weight. Table 2. also indicates that as the pulp weight increases the seed weight also increased significantly.

Regression equations were prepared by taking fruit weight, fruit diameter, fruit volume and pulp weight as an independent variable and pulp weight, fruit volume, fruit diameter and seed weight as dependent variable separately. Linear regressions were obtained for these parameters (Fig. 5, 6, 7, 8, 9, 10, 11 and 12). The regression equation obtained for fruit weight and pulp weight showed a R^2 value of 0.80 which reflects the high predictability between the two parameters. Similarly strong predictability was obtained in the regression equations for fruit volume, diameter and fruit weight and seed weight showed R^2 values of 0.77 and 0.75 respectively. But the regression equations obtained for parameters like fruit weight versus fruit volume, fruit weight versus fruit diameter, fruit diameter versus seed weight, fruit diameter versus pulp weight and pulp weight versus seed weight showed a weak predictability with R^2 values of 0.68, 0.68, 0.65, 0.64 and 0.51 respectively.

4.3. Proportion of fruit pulp and seed

The mean pulp and seed weight was obtained as 2.03 g and 1.52 g respectively for the fruits (Table 1). The proportion was estimated to be 57.50 per cent and 42.60 per cent of the total *Elaeocarpus serratus* fruit content. (Fig.13)

Table 2: Correlation of Physical characteristicsof *Elaeocarpus serratus* fruits

Parameters	Weight (g)	Volume (cm^3)	Diameter (mm)	Length (mm)	Pulp weight (g)	Seed weight (g)
Weight (g)	1	0.827**	0.826**	-0.075	0.898**	0.864**
Volume (cm^3)		1	0.877**	-0.072	0.676**	0.799
Diameter (mm)			1	0.044	0.664**	0.806**
Length (mm)				1	-0.075	0.039
Pulp weight (g)					1	0.560**
Seed weight (g)						1

**. Correlation is significant at the 0.01 level (2-tailed).

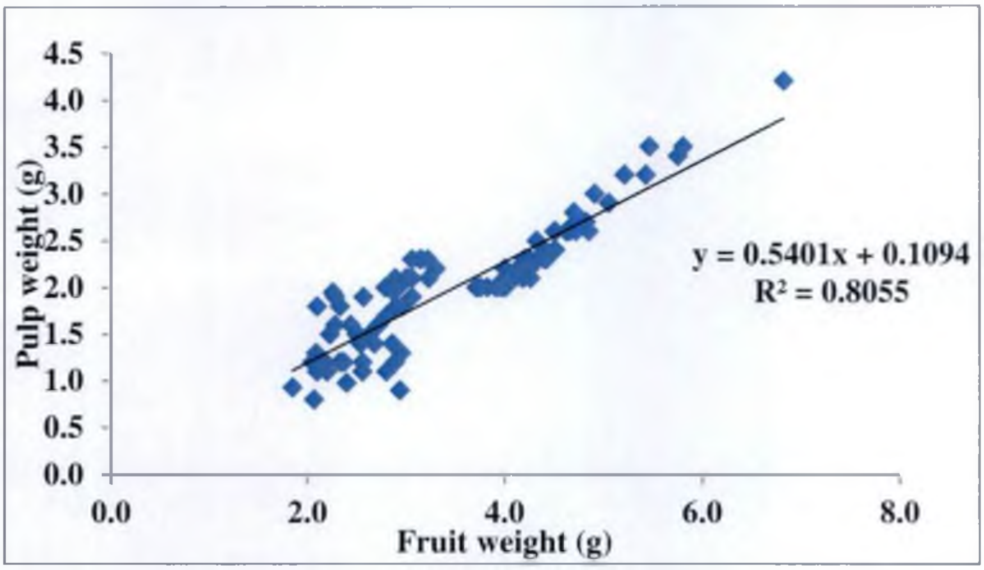

Fig. 5: Co-efficient of determination predicting relation between fruit weight and pulp weight in *Elaeocarpus serratus* fruits

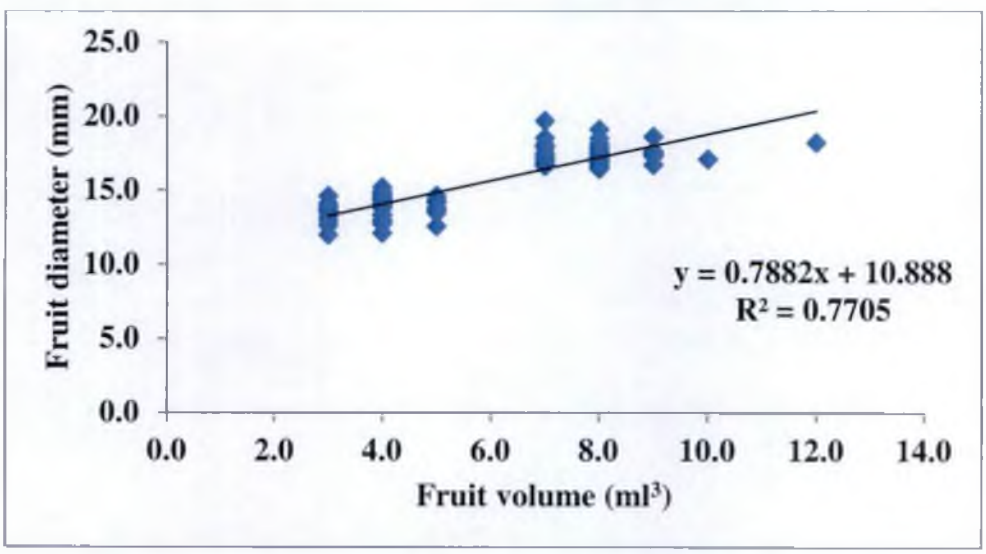

Fig. 6: Co-efficient of determination predicting relation between fruit volume and fruit diameter in *Elaeocarpus serratus* fruits

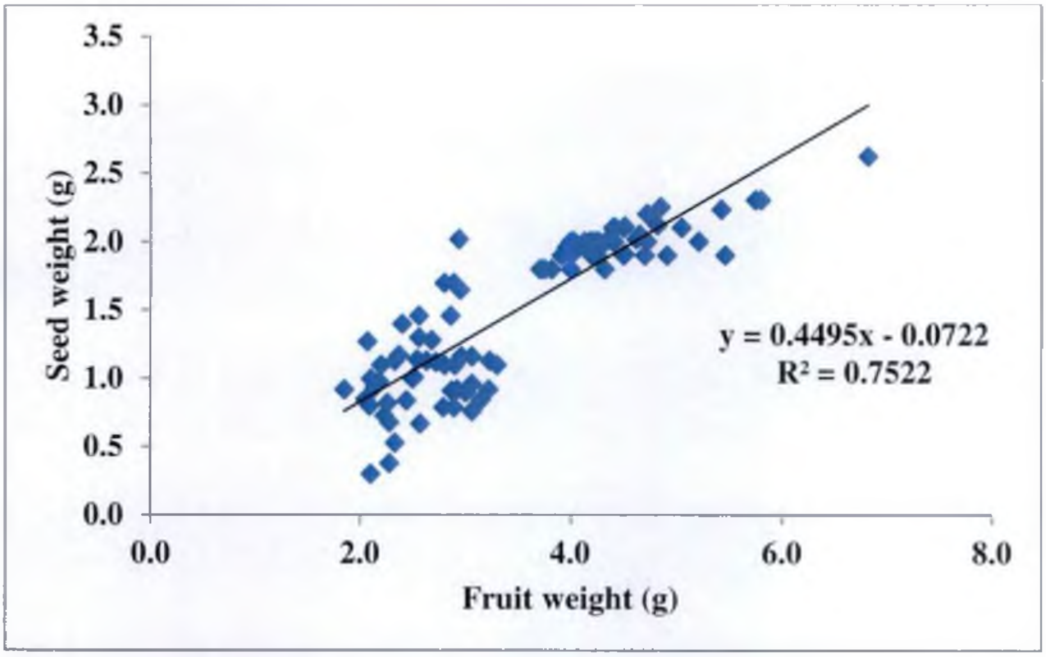

Fig. 7: Co-efficient of determination predicting relation between fruit weight and seed weight in *Elaeocarpus serratus* fruits

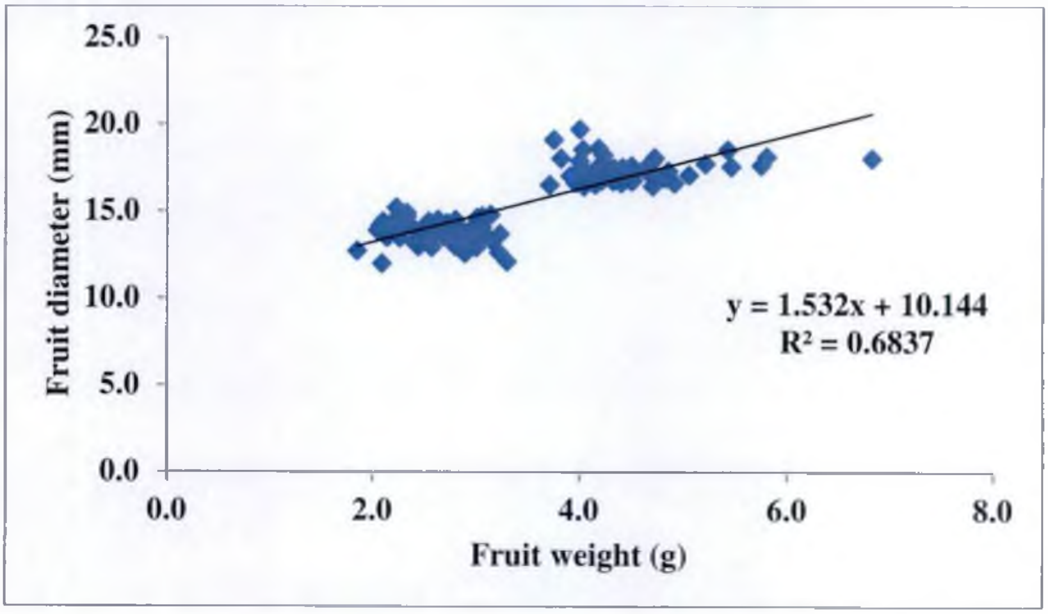

Fig. 8: Co-efficient of determination predicting relation between fruit weight and fruit diameter in *Elaeocarpus serratus* fruits

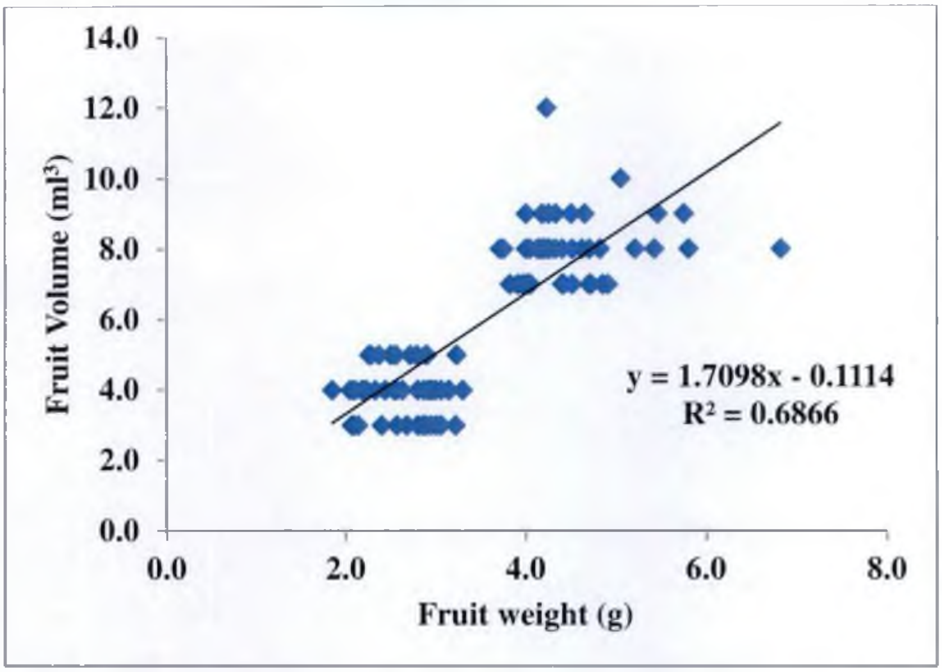

Fig. 9: Co-efficient of determination predicting relation between fruit weight and fruit volume in *Elaeocarpus serratus* fruits

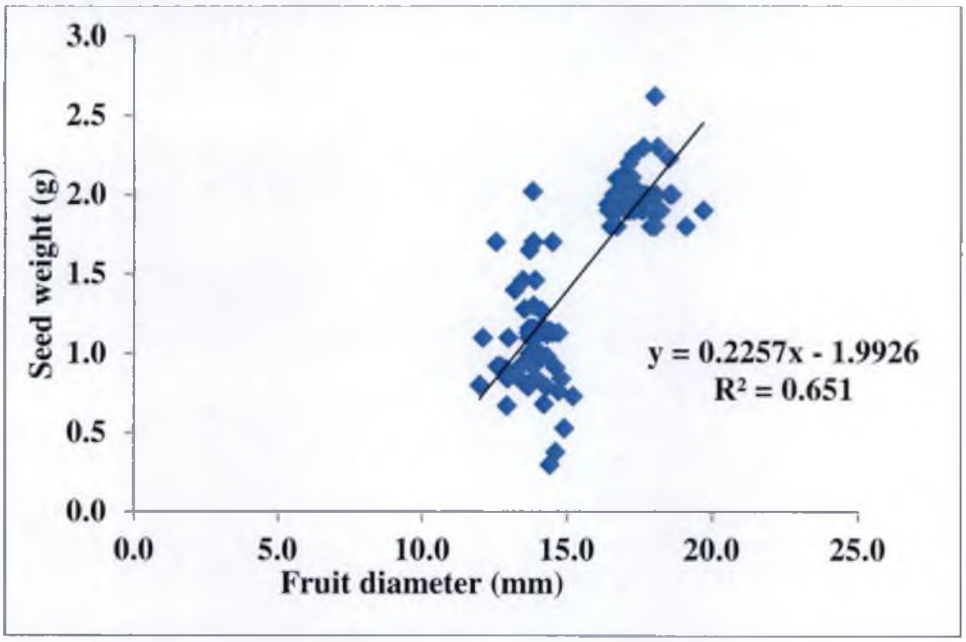

Fig. 10: Co-efficient of determination predicting relation between fruit diameter and seed weight in *Elaeocarpus serratus* fruits

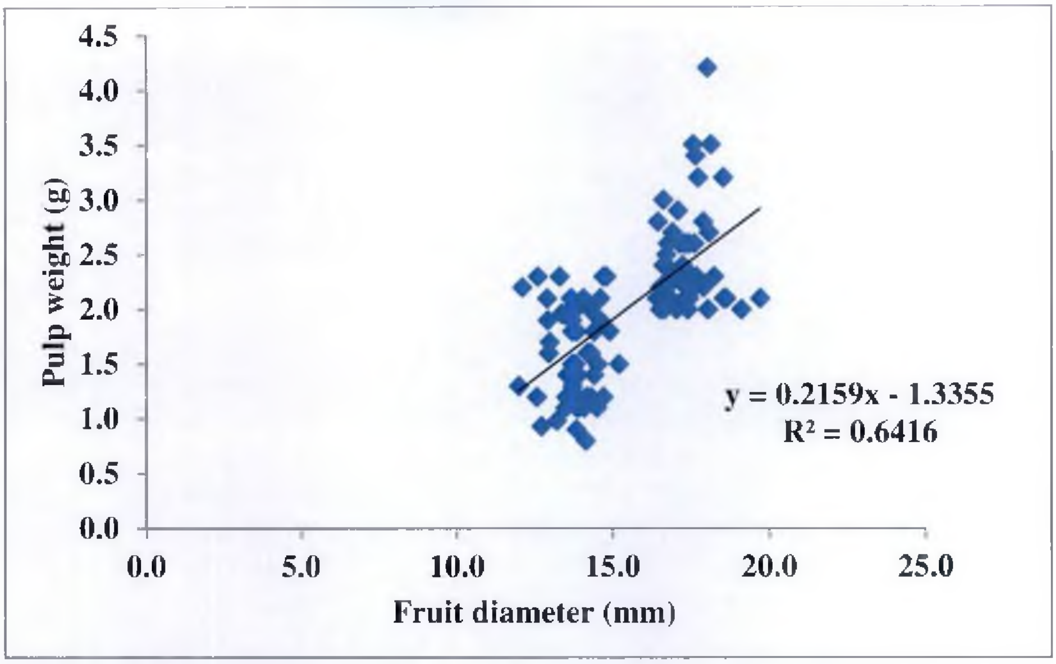

Fig. 11: Co-efficient of determination predicting relation between fruit diameter and pulp weight in *Elaeocarpus serratus* fruits

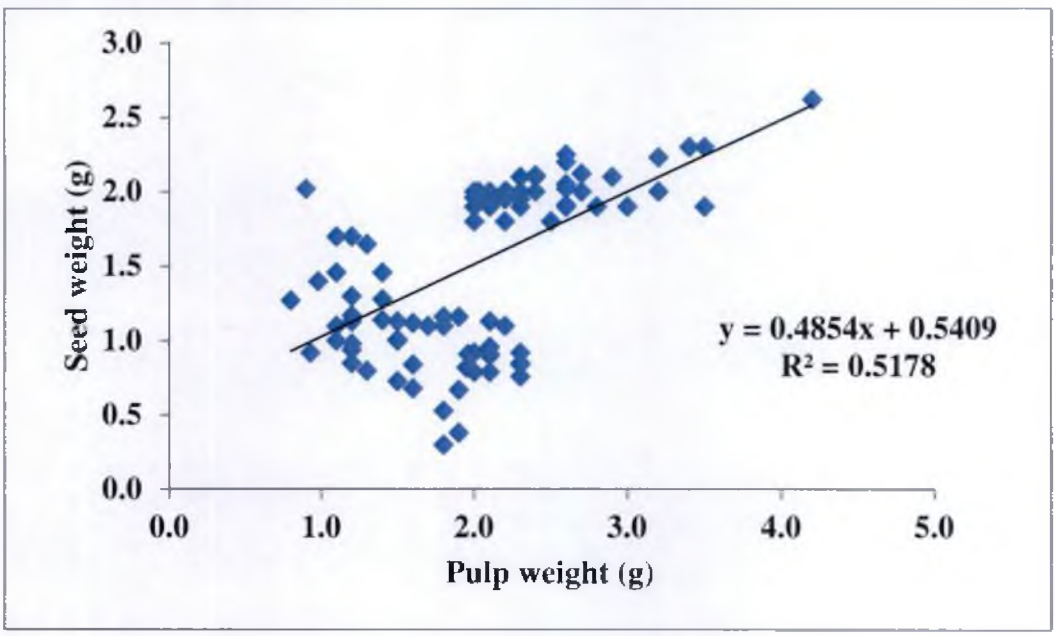

Fig. 12: Co-efficient of determination predicting relation between pulp weight and seed weight in *Elaeocarpus serratus* fruits

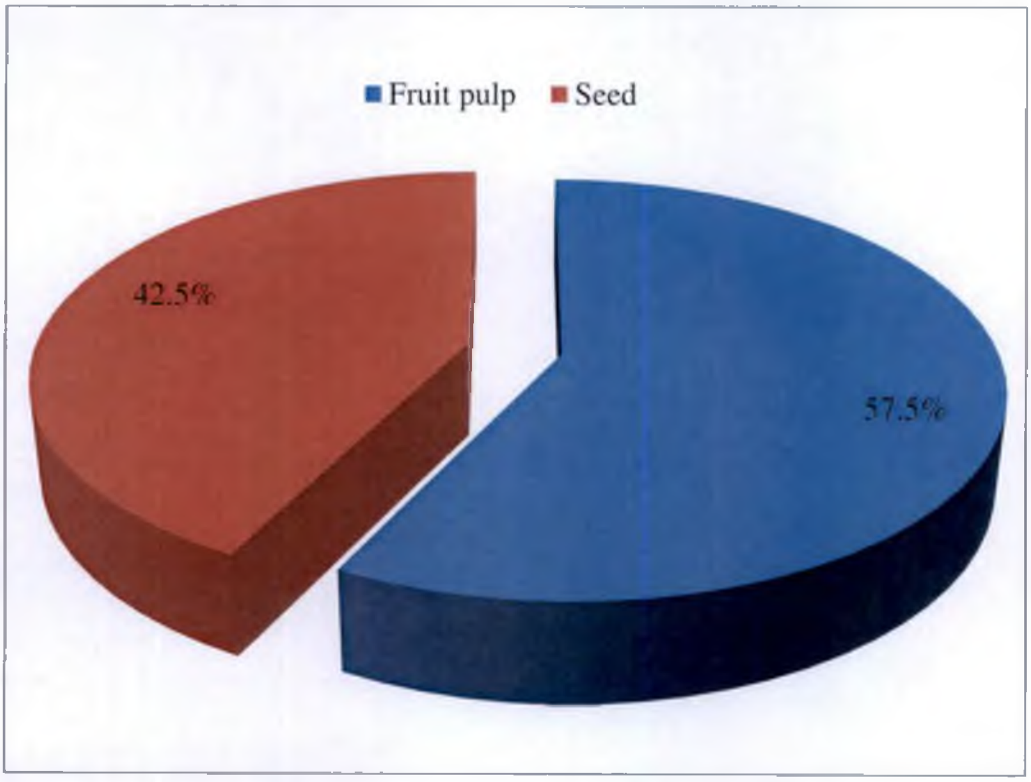

Fig. 13: Percentage composition of pulp and seed content in *Elaeocarpus serratus* fruits

4.4. Bio chemical composition of fruits

Biochemical composition of fruits collected were analysed and the values were recorded.

The mean Moisture content and Total soluble solids in the fruit was found to be 62.45 per cent and 5.99^0 brix respectively (Table 3 and Fig. 14).

4.4.1. Sugar content of fruits

The mean total sugar and reducing sugar were obtained as 12.05 per cent and 8.26 per cent respectively (Table 3 and Fig. 15).

4.4.2. Starch and fibre content of fruits

The mean starch and fibre content of the fruits were reported as 18.78 μg/100 g, 1.73 per cent respectively (Table 3 and Fig. 16).

4.4.3. Titrable acidity, β carotene and Vitamin C content

The mean titrable acidity, β carotene and Vitamin C content of the fruits constituted the values 1.36 per cent, 1.04 μg /100 g, 2.9 mg /100 g respectively (Table 3 and Fig. 17).

4.5. Correlation for bio chemical composition

A correlation matrix computed for biochemical parameters of Ceylon olive fruits. All parameters showed a significant and positive relation between all parameters. Table 4 reveals that as the moisture content of the fruit increases there is a significant increase in the titrable acidity and total sugar content in the fruit. Titrable acidity has a positive and significant correlation with other biochemical parameters like total sugar, reducing sugar, starch and fibre. Percentage of total sugar showed a significant correlation with reducing sugar, starch, fibre and total soluble solids. The starch content of the fruit showed a positive correlation with TSS of the fruit. Fibre content of the fruit showed a positive correlation with total soluble solids.

Table 3: Biochemical composition of *Elaeocarpus serratus* fruits

Sl. No.	**Biochemical composition**	**Mean**
1	Moisture (%)	62.45 ± 0.48
2	TSS (^{0}Brix)	5.99 ± 0.07
3	Total sugar (%)	12.05 ± 0.20
4	Reducing sugar (%)	8.26 ± 0.12
5	Starch (μg /100gm)	18.78 ± 0.20
6	Fibre (%)	1.73 ± 0.07
7	Titrable acidity (%)	1.36 ± 0.04
8	β carotene (μg /100gm)	1.04 ± 0.08
9	Vitamin C (mg /100gm)	2.9 ± 0.07

Table 4: Correlation between biochemical composition of *Elaeocarpus serratus* fruits

Biochemical composition	Titrable acidity	Total sugar	Reducing sugar	Starch	β Carotene	Vitamin C	Fibre	Total soluble solids
Moisture (%)	-0.501**	0.576**	0.462*	0.556*	0.370	0.278	0.272	0.406
Titrable acidity (g/100g)	1	-0.588**	-0.714**	-0.601**	-0.441	-0.233	0.666**	-0.782**
Total sugar(%)		1	0.690**	0.776**	0.436	0.338	0.789**	0.693**
Reducing sugar (%)			1	0.426	0.411	0.076	0.670**	0.564**
Starch (g/100g)				1	0.538*	0.481*	0.516*	0.564**
β Carotene (µg /100gm)					1	0.285	0.272	0.302
Vitamin C (µg /100gm)						1	0.252	0.345
Fibre (%)							1	0.647**

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

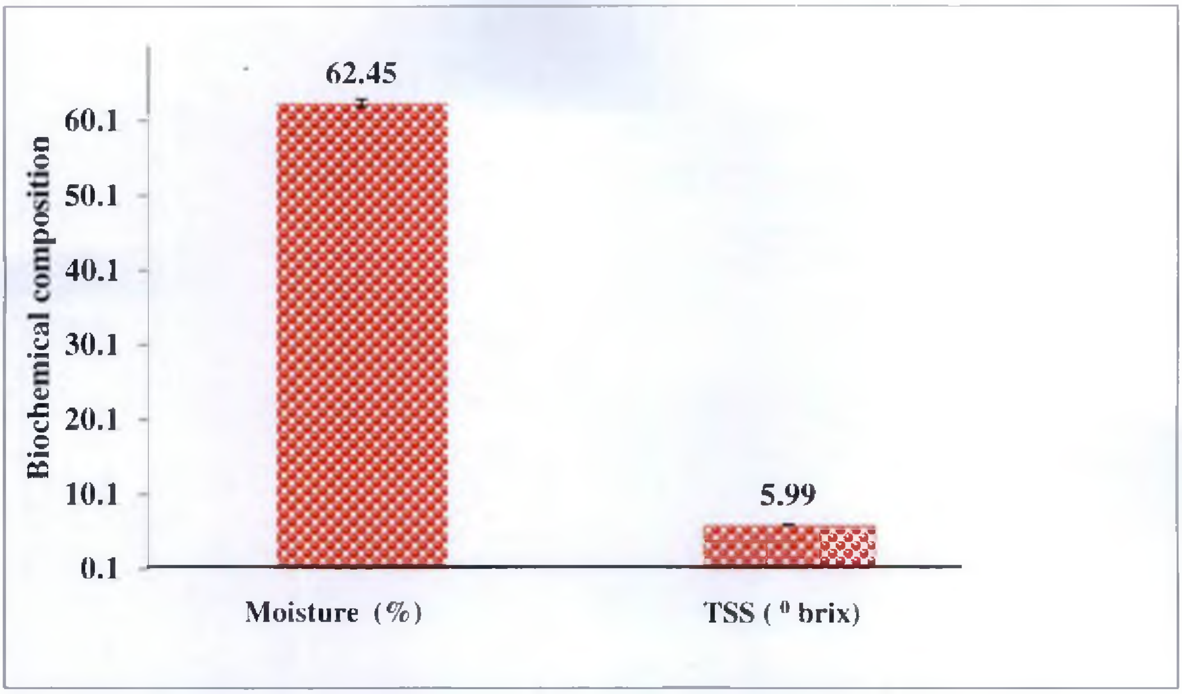

Fig. 14: Moisture content and Total soluble solids in fruits of *Elaeocarpus serratus*

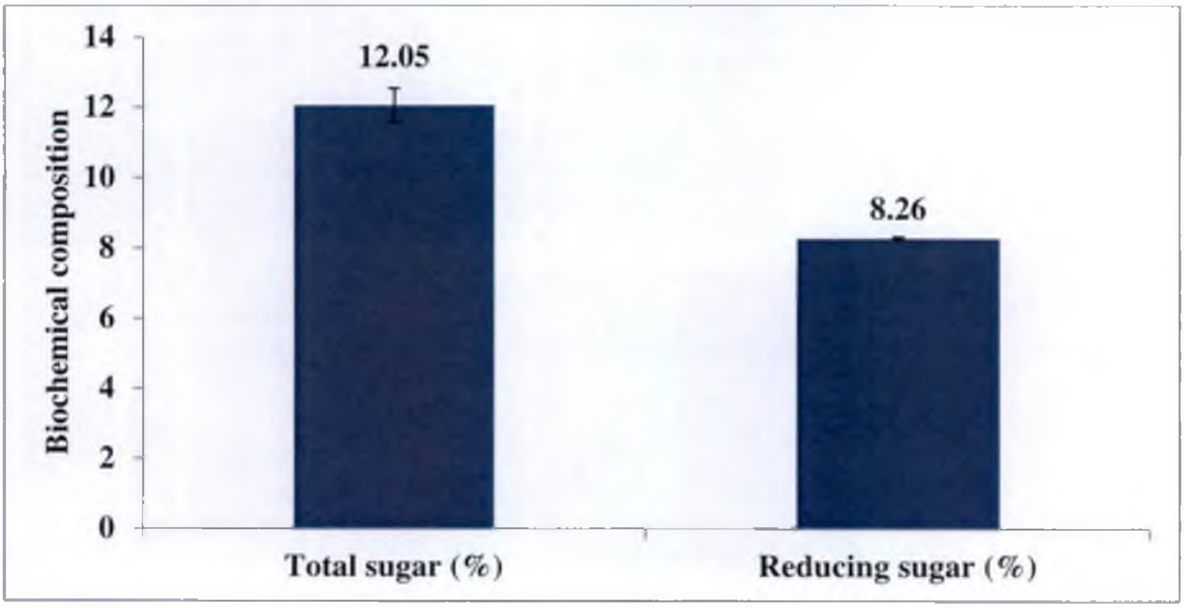

Fig.15: Sugar content in fruits of *Elaeocarpus serratus*

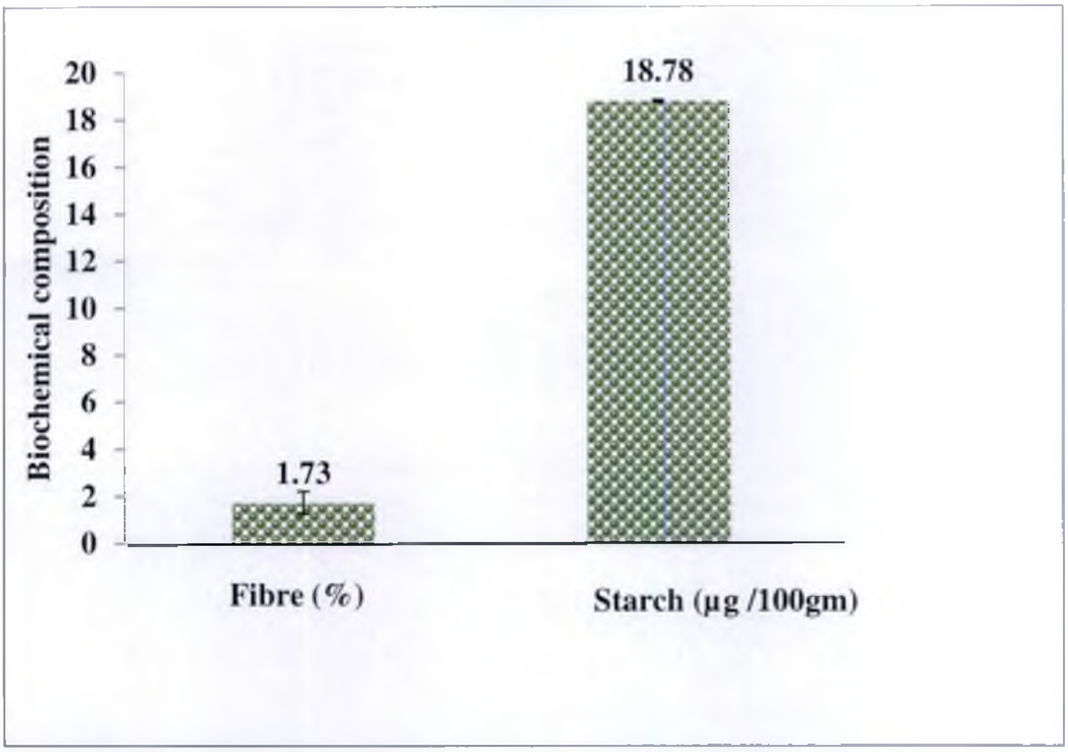

Fig. 16: Fibre and Starch content in *Elaeocarpus serratus* fruits

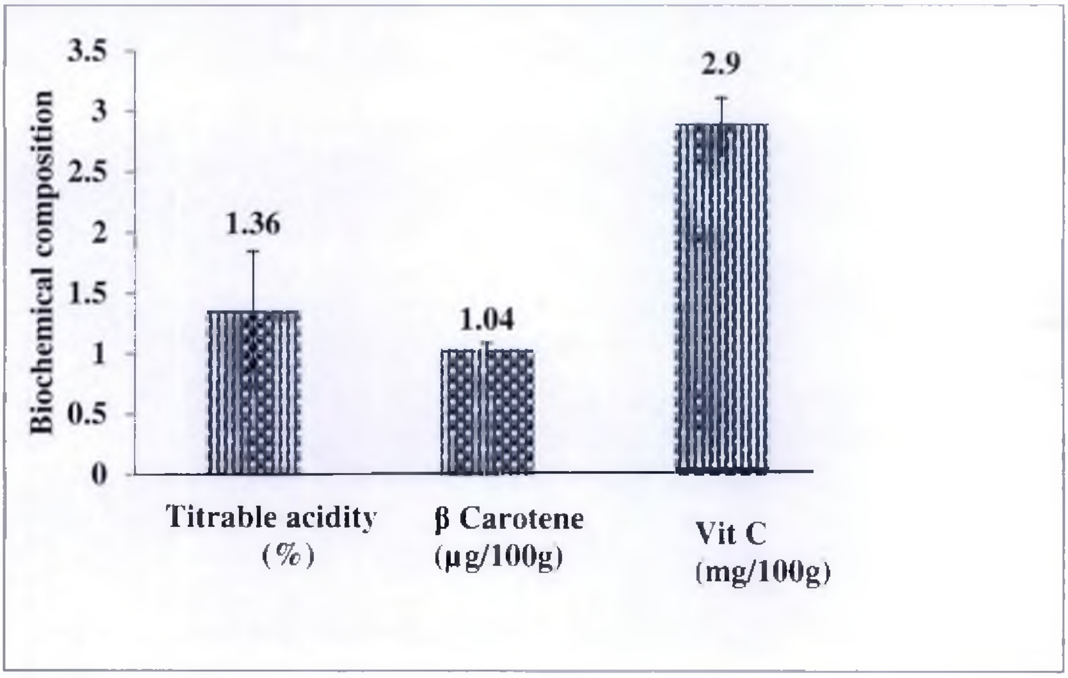

Fig. 17: Titrable acidity, β carotene and Vitamin C in *Elaeocarpus serratus* fruits

4.6. Mineral composition of fruits

Mineral content of the fruits collected was analysed and the mean values are depicted in Table 5. Mean values of phosphorous, potassium, iron and calcium content of *Elaeocarpus serratus* fruits recorded were 62.80 mg/100 g, 331.48 mg/100 g, 2.14 mg/100 g and 10.94 mg/100 g respectively (Fig. 18).

Table 5: Mineral composition of *Elaeocarpus serratus* fruits

Serial No.	**Mineral composition (mg/100 g)**	**Mean**
1	Phosphorous	62.80±0.14
2	Potassium	331.48±0.08
3	Iron	2.14±0.03
4	Calcium	10.94±0.04

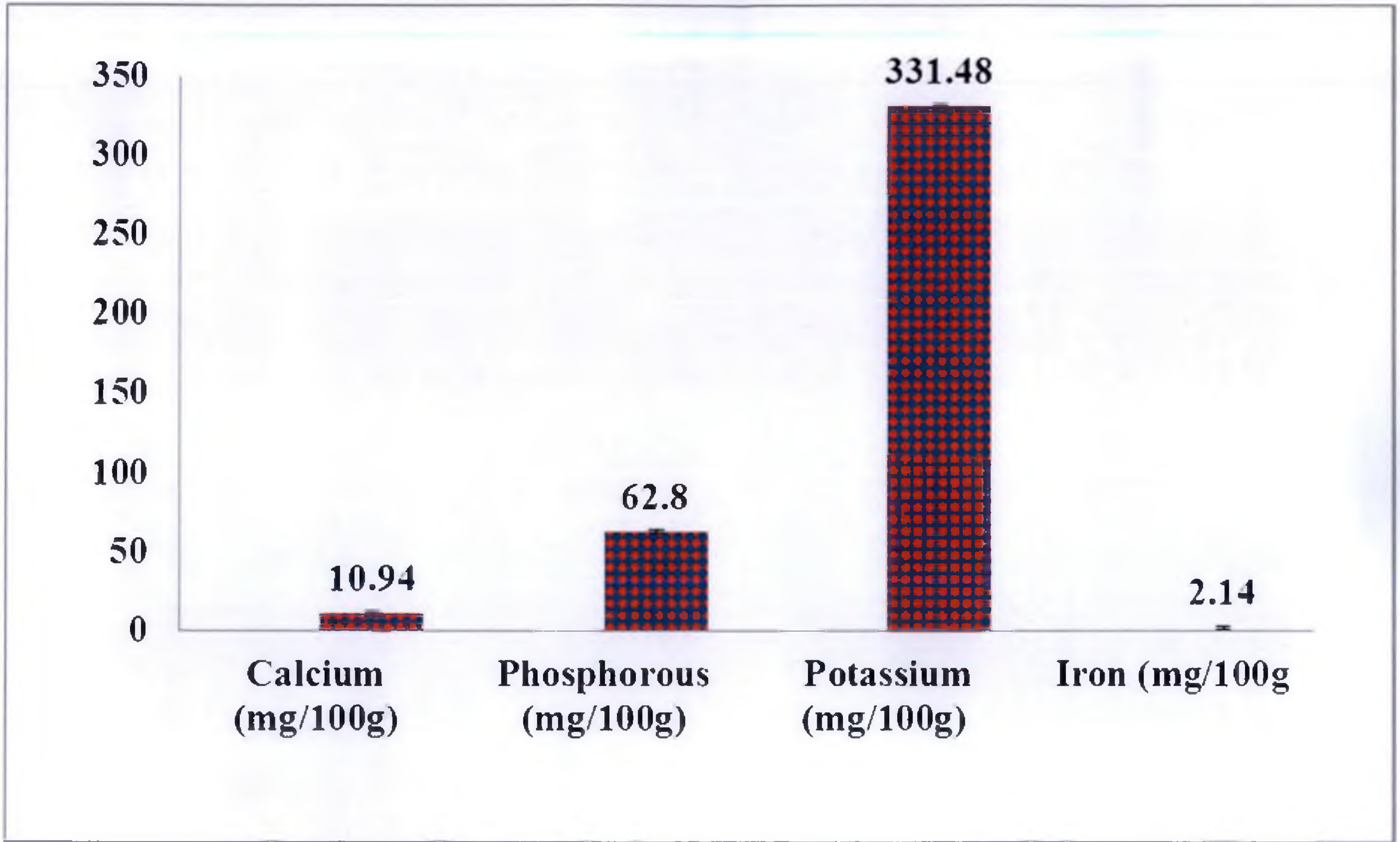

Fig. 18: Mineral composition in *Elaeocarpus serratus* fruits

4.7. Organoleptic evaluation of fruit

Organoleptic evaluation of the fruit was done by a selected panel of ten judges. Table 6 and Fig. 19 depicts the mean scores of organoleptic evaluation of fruits. Mean score for appearance, colour, flavour, texture 6.7, 6.8, 5, 5 respectively. For fruit characteristtics like odour, taste, after taste and overall acceptability low mean scores of 4.9, 4, 4.1 and 4.1 was obtained respectively.

Table 6: Mean scores for organoleptic evaluation of *Elaeocarpus serratus* fruits

	Appearance	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
Mean score	6.7	6.8	5	5	4.9	4	4.1	4.1

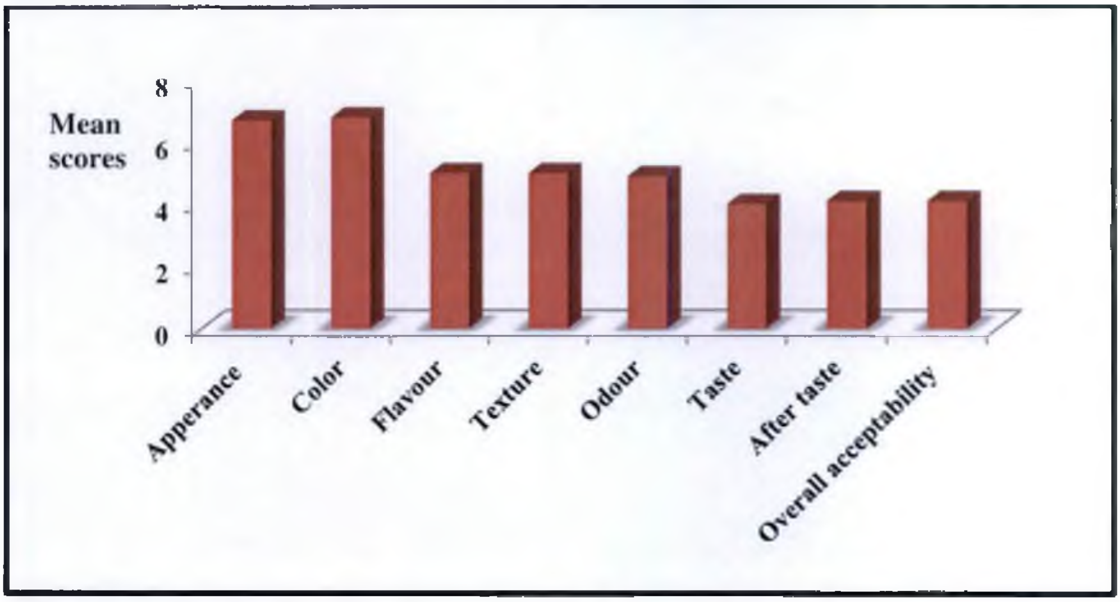

Fig. 19: Mean scores for evaluation of *Elaeocarpus serratus* fruits.

4.7. Organoleptic evaluation of Ceylon Olive Pickle

Organoleptic evaluation of the Ceylon olive pickle was done by a selected panel of ten judges. Table 7 and Fig. 20 depict the mean scores of organoleptic evaluation of pickle. For the pickle, mean score for appearance, colour, flavour, texture, odour, taste and after taste was 8.4, 8.8, 7.8, 7.8, 7.3, 8 and 8.2 respectively. The overall acceptability of the pickle showed the high mean score of 8.4 indicating high likeability among the judges.

Table 7: Mean scores for organoleptic evaluation of *Elaeocarpus serratus* fruit Pickle

	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
Mean scores	8.4	8.8	7.8	7.8	7.3	8	8.2	8.4

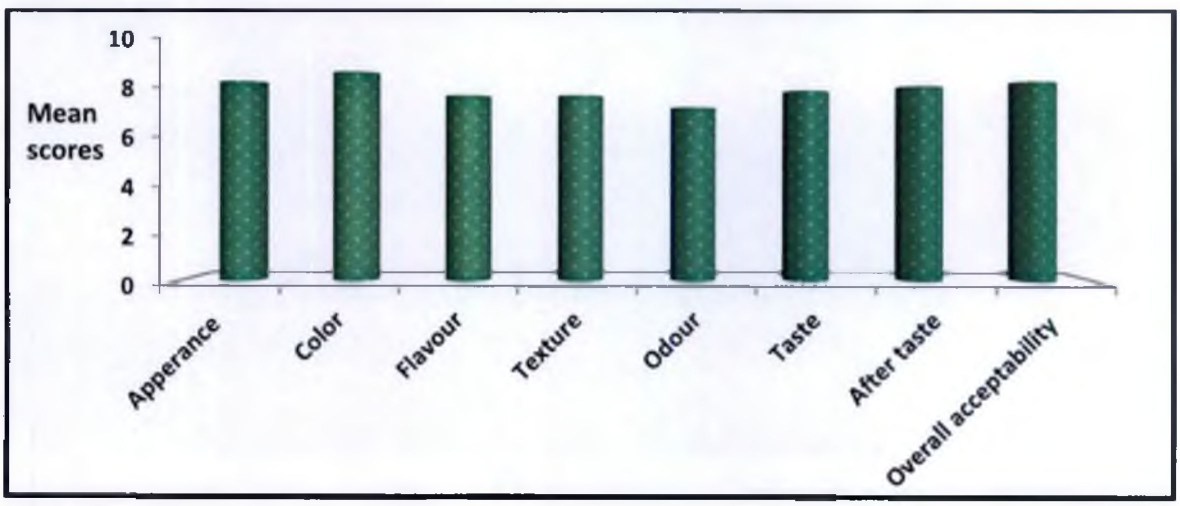

Fig. 20. Mean scores for evaluation of *Elaeocarpus serratus* Pickle.

4.8. Organoleptic evaluation of Ceylon Olive Candy

Organoleptic evaluation of the Ceylon olive candy was done by a selected panel of ten judges. Table 8 and Fig.21 depict the mean scores of organoleptic evaluation of candy. For the candy, mean score for appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability was 7.5, 7.7, 7, 7.4, 5.8, 7.4, 7.5 and 7.7 respectively.

Table 8: Mean scores for organoleptic evaluation of *Elaeocarpus serratus* fruit candy

	Appearance	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
Mean scores	7.5	7.7	7	7.4	5.8	7.4	7.5	7.7

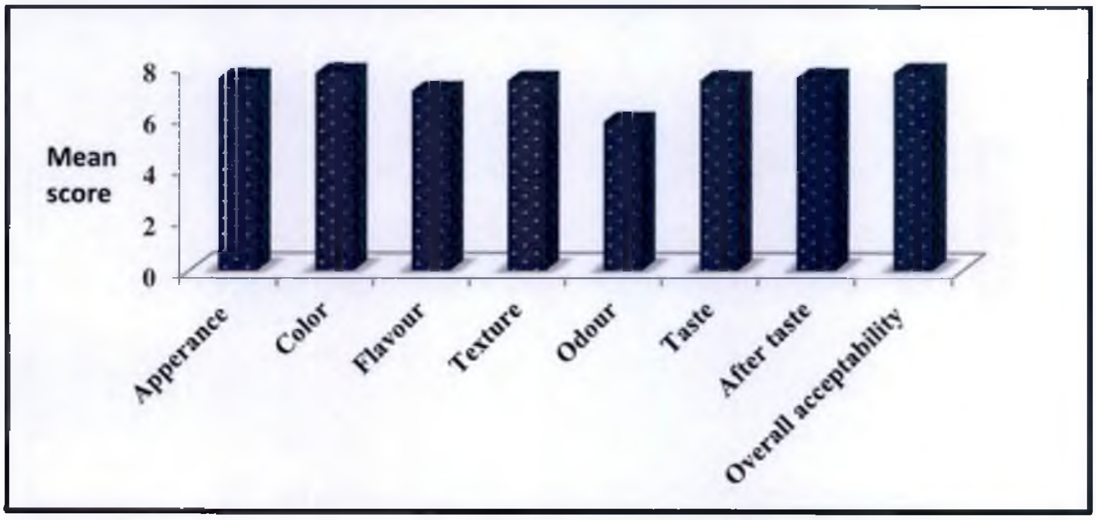

Fig.21. Mean scores for evaluation of *Elaeocarpus serratus* Candy

4.9. Comparison of organoleptic mean scores of fruit and products

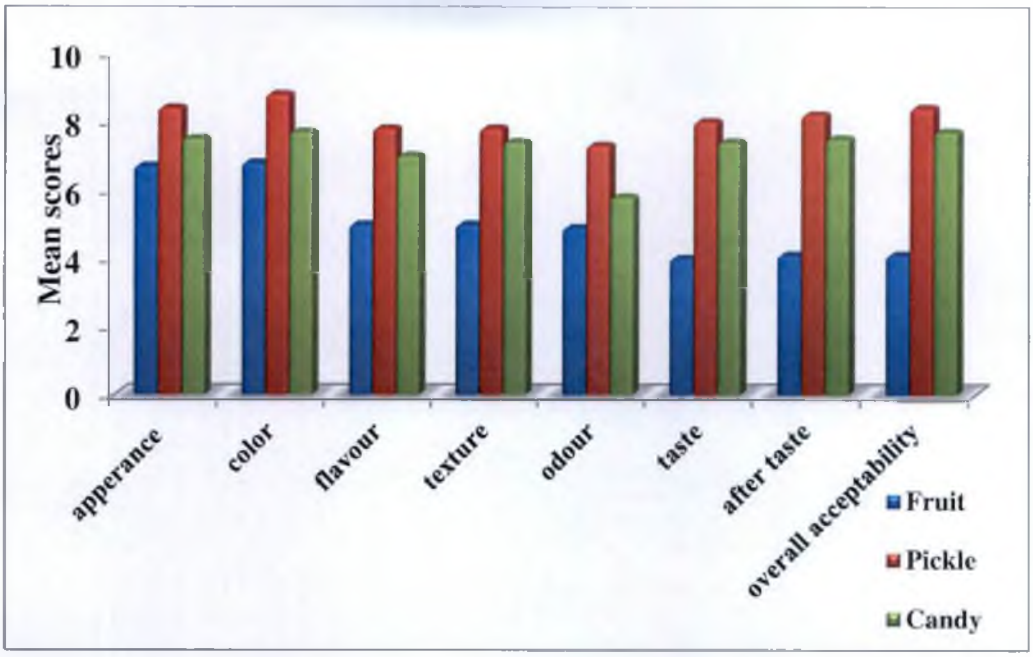

Fig. 22: Comparison of mean scores of Ceylon olive fruit, pickle and candy

The organoleptic qualities were found to differing between the matured fruit and the finished product. Higher scores were found for the Ceylon olive pickle in comparison with Fruit and Candy (Fig. 22.). The appearance and colour were found to have to highest values for the pickle next to candy and fruit respectively. Flavour and texture were also found to be higher to pickle next to candy. The overall acceptability score was highest for the pickle.

The mean score for fruit organoleptic qualities was found to be lower than that of the products as depicted in the Figure 22. The overall acceptability of the fruit was very less which indicate the better scope for processing of the fruit. The Figure 22 also indicated that in between the fruit products the Ceylon olive pickle has higher mean scores than Candy.

4.10. Chemical composition of *Elaeocarpus serratus* Pickle and Candy

Chemical composition such as acidity, TSS, Vitamin C, total sugar and reducing sugar in Ceylon olive pickle and candy was analysed.

Table 9: Chemical composition of *Elaeocarpus serratus* Pickle and Candy

Sl. No.	Chemical composition	Pickle	Candy
1	Acidity (%)	1.2	1.42
2	TSS (^{0}brix)	10.45	69.06
3	Vitamin C (mg/100g)	2.6	2.8
4	Total Sugar (g/100g)	6.05	40.10
5	Reducing sugar (g/100g)	0.76	15.01

The mean values of chemical constituents of Ceylon Olive Pickle and Candy are presented in the Table 9. From the results obtained, it was found that the acidity of the pickle (1.2 per cent) is found to be more than the fruit (1.36 per cent). Similarly fruit candy also shown an increase in the acidity with the value of 1.42 per cent.

The Total soluble solids of the pickle was found to be 10.45 ^{0} brix which showed an increase in comparison to that of fruit (5.99 ^{0} brix). Candy a sugar rich product showed a high value of 69.06 ^{0} brix. The Vitamin C content of the pickle was found to be 2.6 mg/100 g and the candy showed value of 1.8 mg/100 g. The total and reducing sugar content of the pickle and candy was estimated to be 6.05 g/100 g, 0.76 g/100 g and 40.01 g/100 g, 15.01 g/100 g respectively.

4.11. Confirmation of *Elaeocarpus serratus* products with FSSAI requirement

The products developed in the present study were compared with Food safety and standards authority of India (FSSAI) specification in its requirement for particular items. The data is presented in Table 10.

Table 10: Confirmation of *Elaeocarpus serratus* pickle with FSSAI standards

Sl. No.	**Pickle**	**FSSAI specifications**	**Analysed ingredient in the product**
1.	**Oil used for preparation**	Any edible oil	Gingelly oil used
2.	**Amount of preservative added (ppm)**	250	250

Table 11: Confirmation of *Elaeocarpus serratus* candy with FSSAI standards

Sl. No.	**Candy**	**FSSAI specifications**	**Analysed value in the product**
1	**Per cent of TSS in the final product (Per cent)**	68	69
2	**Per cent of fruit in the final product (Per cent)**	55	58
3	**Amount of preservative added (ppm)**	200	200

As per the FSSAI specification, a product indicates pickle, if that is prepared from any edible oil. The pickle of *Elaeocarpus serratus* is prepared from gingelly oil and thus it could be confirmed that this pickle detailed in present study are well competent with a standard pickle.

With relevant to candy, FSSAI prescribes a minimum of 68 per cent total soluble solids and 55 per cent fruits in final product as requirement for this product to be considered up to the mark. On analysis of candy prepared from Ceylon olive the value obtained was 69 per cent of TSS and 58 per cent of fresh fruit in the final product which satisfies the specifications.

4.12. Fruit product yield ratio

Fruit product yield ratio gives an estimation of the amount of product obtained for known quantity of the fruit utilised. Table (12) gives the fruit product yield ratio of two different product in the present trial.

Table 12: Fruit product yield ratio of *Elaeocarpus serratus*

Sl. No	**Fruit product**	**Fresh fruit (g)**	**Product yield (g)**	**Ratio**
1.	Pickle	1000	1540	1:1.54
2.	Candy	1000	1250	1:1.25

When the fruit product yield ratio was calculated, it was found that highest yield was obtained for Pickle with the value of (1:1.54) followed by Candy (1:1.25).

Discussion

5. DISCUSSION

Many under-exploited fruits are of enormous nutritive and economic value either as fresh or after processing. These minor fruits possess immense nutritional importance, which play a significant role in food industry. Many of these fruits are highly perishable. Therefore emphasis should be given to these underexploited minor fruits which are easily marketed in the fresh form. These should be processed and preserved so that the consumers all over the world get the opportunity to enjoy the fruit and its processed products.

The fruit of Ceylon olive does not have much of commercial value, but can be seen distributed all over the home gardens and forests of Kerala. The fruit has very good potential for developing value added products. The fruits are very sour and can be used for pickles and preserves.

Hence the study is proposed to evaluate the quality, characters, nutritive value and to develop value added products from the fruit. The results are discussed below.

5.1. Physical Characters of *Elaeocarpus serratus* fruits

Physical parameters of fruits are important indicators of their maturation, internal and external quality and act as decisive factors for accomplishment of market demands (Cavalcante *et al.*, 2012). Quality attributes like fruit shape and size are important in order to properly design machines for harvesting, processing and storage (Duckworth, 1966).

In *Elaeocarpus serratus* the mean values of fruit weight and fruit volume was found as 3.55 g and 5.97 cm^3 respectively (Table 1). Findings of this work were more or less comparable with the same species as reported by Kumar *et al.*, (2014). Fruit size in amla, bael and West indian cherry also lies in the same range. Similarly, in gingerbread plums cultivars, fruit volume was found to be varying from 4.41 cm^3 to 5.88 cm^3 (Akbarpour *et al.*, 2009). Since the fruit weight indicates the amount of solid tissue in the fruit and fruit volume indicates the relative pulp content, hence these parameters can be used as a potential indicator of yield per tree or unit area and satisfies the market demand.

Mean fruit length and mean fruit diameter in *Elaeocarpus serratus* was found to be of 22.5 mm and 15.58 mm (Table 1). In *Spondias mombin, Garcinia indica* and *Simarouba glauca,* almost similar fruit length has been reported (Bora *et al.*, 1991; Patil *et al.*, 2009; and Dash *et al.*, 2008). However, fruit diameter of lower than 40 mm has been mentioned by CSIR, (1985) for some wild species. Findings of this work were more or less comparable to with those reported in Kumar *et al.* (2014). Since the fruit length of the species signifies that it is short fruit and hence the small structured harvesting machines could be designed for further processing and packaging.

Pulp constitutes the major portion of the fruit which contributes many of the biochemical parameters and nutritive value. Pulp also is one of the decisive factors in organoleptic evaluation of the fruit which contributes the characteristic features like aroma, flavour, taste etc. Higher fruit weight, pulp weight and low peel weight are desirable attributes for processing (Khoshnam *et al.*, 2007). In *Elaeocarpus serratus* mean pulp weight and seed were found to be 2.03 g to 1.52 g respectively (Table 1). Pulp weight and seed weight in other tropical fruits have been reported to be are 67.85 g and 4.38 g in sapota, 3.91 g and 1.42 g in jamun, 103.16 g and 11.53 g in custard apple and 112.50 g and 1.32 g in carambola respectively (Pathak and Chakraborty, 2006). Higher pulp recovery should be obtained while going for processing and value addition of a fruit. Mean percentage of pulp, and seed for *Elaeocapus serratus* is reported as 57.5 per cent to 42.6 per cent respectively (Fig.13). From the findings, it was clear that pulp weight is higher than the seed weight. Although the pulp constitutes fewer portions of whole fruit, it can be compensated with the yield of large quantity of fruits from a single tree.

5.2. Relation among fruit parameters in *Elaeocarpus serratus*

A positive and significant correlation between fruit weight, volume, length and diameter obtained in this study indicates the possibility of selecting the *Elaeocarpus serratus* fruits based on size for further processing and packaging. (Table 2). High correlation could be attributed to close association of these physical parameters (Hossain and Abdul, 2007). Guleria *et al.,* 2011 also reported significant correlation for fruit and kernels of *Sapindus mukrossii.*

Linear regressions were obtained for physical parameters like fruit weight, volume, length and diameter of *Elaeocarpus serratus* fruit with significant r^2 values (Fig. 5, 6, 7, 8, 9, 10 and 11). Regression models have been developed for fruits of *Terminalia indica* (Sood *et al.*, 2009) and *Vitellaria paradoxa* (Nyarko *et al.,* 2012). These regressions can be useful in predicting pulp weight, seed weight and fruit volume based on fruit weight. Similarly, based on fruit length, fruit weight and fruit volume can be determined. These values can be used for selecting fruits of high quality parameters based on the requirement of processing methods.

5.3. Biochemical composition of fruits

Suitability of fruits for value addition depends upon their physico-chemical attributes. Biochemical composition determines the utilization potential of a fruit. Different products are prepared based on the proportion of biochemical contents present in a particular fruit (Cavalcante *et al.*, 2012).

Water content of a fruit indicates its perishability and is also important in determining the nutritive value of food sample (Boamponsem *et al.*, 2013). Mean moisture content of *Elaeocarpus serratus* fruits were found to be 62.45 per cent (Table 3). Observed values closely agreed to that reported in *Elaeocarpus serratus* by Khan *et al.* (2005). It has been reported that *Artocarpus altilis* and *A. integrifolia* contain 62 per cent and 67 per cent moisture content respectively

(Dignan *et al.*, 1994 and Wenkam, 1990). Moisture content controls and greatly influences the physical properties and product quality at all stages of processing and final product existence. As this *Elaeocarpus serratus* fruit showed less moisture content which indicates its less perishability and suitability for product development.

Total soluble solids mainly include sugars and minerals. Total soluble solids accumulation is strongly related to ripening of fruit and it caused falling off owing to decaying. Higher brix indicates better nutrition and higher mineral content indicates an increase in vitamins content as well (Boampson *et al.*, 2013). Mean total soluble solids of *Elaeocarpus serratus* fruits were found to be 5.99^0 Brix (Table 3). Total soluble solids have been reported in some tropical fruits like custard apple, carambola and tamarind to be ranging from 4 to 8 brix (Pathak and Chakraborthy, 2006). Total soluble solids acidity ratio is a useful parameter for deciding its use for preparation of different products (Yadav *et al.*, 2006). According to Patil *et al.* (2009), high total soluble solids and low acidity can be an ideal combination for product development like syrup and candy. Since the fruit *Elaeocarpus serratus* has shown a lower TSS value which indicates that it can be ideal for the preparation of preserves and pickles.

Acidity imparts sour taste to fruits and has a governing role in determining likeness of a fruit (Markose, 2008). Acidity is directly related to pH of a fruit. Mean titrable acidity of *Elaeocarpus serratus* fruits were observed as 1.36 per cent (Table 3). As the fruit showed low acidity sweetened products like candy could be prepared from the fruit. Similarly for the fruits like custard apple, jamun, sapota, bael etc., acidity was reported to be lower and used for candy and preserves. (Pathak and Chakraborty, 2006). However, these findings were in accordance with those reported by Sood *et al.* (2010) and Narain *et al.* (2001) in *Berberis lyceum* and *Averrhoa carambola* respectively.

Sugar, apart from its nutritional value also has other functions in food. They function as flavour producing agents, texturizing agents and sweeteners (Manay and Shadaksharaswamy, 2001). Data pertaining to the mean total sugars of *Elaeocarpus serratus* fruits revealed that it was found to be 12.05 per cent (Table 3). The results obtained in this work also corroborates with the results obtained in other tropical species like custard apple, jamun, sapota and cashew apple (Pathak and Chakraborthy, 2006; and Suman, 2006). Total sugar obtained in this fruit was found to be higher than that reported in wild fruits like *Alangium salvifolium, Antidesma ghaesembilla*, *Baccaurea courtallensis* etc. which ranged from 5 to 10 per cent. (Nazarudeen, 2010). Higher sugar acid ratio highlighted its feasibility in preparation of candy and beverages (Hema, 1997).

Reducing sugar content in food is partly responsible for browning as a result of Maillard reaction. However, this reaction does not pose any problem in those samples with low level of reducing sugars (Adewusi *et al.*, 1995). Perusal of data analysis of *Elaeocarpus serratus* fruit revealed reducing sugars found to be 8.26 per cent (Table 3). Some wild fruits such as *Antidesma ghaesembilla* registered value of 10.79 per cent and *Mimusops elengi* has 6.3 per cent of reducing sugar (Nazarudeen, 2010). Low reducing sugar in *Elaeocarpus serratus* fruit can be attributed to the presence of high amounts of non-reducing sugars compared to other fruits and hence suitable for the development of value added products.

Starch provides a reserve energy source in plants and supply energy in nutrition (Dauthy, 1995). It contributes to the texture and sensory properties of the processed foods and thus offers a scope to develop a variety of fabricated food products having varied texture and mouthfeel (Tharanathan, 2005). For starch content, mean values of *Elaeocarpus serratus* were reported to be 18.78 μ g /100 g (Table 3). In some tropical fruits like passion fruit, mango the starch content ranged from 3 – 30 per cent of starch (Pruthi, 1985). Since the fruits of *Elaeocarpus serratus* has less starch content it does not have mealy texture mouthfeel which makes it unsuitable to consume raw as such and reflects the scope for value addition in this fruit.

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5.4. Mineral composition of fruits

Mineral ions are of prime importance in determining the nutritional value of fruit, major ones being potassium, calcium, and iron. The importance of minerals like potassium, calcium, sodium etc. to human health is well known. Required amounts of these elements must be in human diet to pursue a good healthy life (San *et al.*, 2009). Amount of mineral elements present in plants depends to a high degree on the soils abundance, including the intensity of fertilization (Kruczek, 2005).

Phosphorus is a mineral that is part of every cell in our body. It is found mainly in our bones and teeth. Phosphorus works with calcium and other nutrients to build healthy bones and teeth. It also helps to maintain normal acid/base balance, supports growth, and is involved with the storage and use of energy. Phosphorus is needed for kidney function and cell growth (Fallon and Enig, 2001). In plants, phosphorus participates in some of the vital metabolic processes by supplying energy, increase acid neutralization, sugar synthesis resulting in less acidic fruits (Kader, 2008). In the present study, mean phosphorus content of *Elaeocarpus serratus* fruits reported to be 62.80 mg/100 g (Table 4). . Fruits of *Persea americana* showed almost similar values for phosphorus (Arukwe *et al.*, 2012). Phosphorus is found in high amounts in protein foods such as milk and milk products and meat and alternatives, such as beans, lentils and nuts. Grains, especially whole grains provide phosphorus. Phosporus is found in smaller amounts in vegetables and fruit (San *et al.*, 2009). It improves the quality of fruits and vegetables and also vital to seed formation hence contributing for the superiority of the product developed with high phosphorus content (Narain *et al.* 2001).

Potassium is a mineral that is necessary to keep the heart and other muscles functioning normally. It is also important for the nervous system and cellular enzymes. Potassium is an important element for synthesis of amino acids and proteins (Malik and Srivastava, 1982). A diet high in potassium may be protective against developing hypertension and potassium deficiency and may increase blood pressure. In *Elaeocarpus serratus fruits* mean value obtained for potassium content in the fruit was 331.48 mg/100 g (Table 4). Potassium content among the other tropical fruit like shea ranged from 250 to 340 mg/100 g and was comparable with that of wild fruits (Thomas, 2013). High levels of available potassium in the fruit improve the physical quality, disease resistance, and shelf life of fruits and fruit products.

Iron has several vital functions in the body. It serves as a carrier of oxygen to the tissues from the lungs by red blood cell haemoglobin, as a transport medium for electrons within cells, and as an integrated part of important enzyme systems in various tissues. Iron assists in the functioning of central nervous system and is an essential trace element for haemoglobin formation (Adeyeye and Otokiti, 1999). Iron functions in plant respiration, and plant metabolism. It is involved in nitrogen fixation in plants. Mean iron content in *Elaeocarpus serratus* fruits was found to be 2.14 mg/100 g (Table 4). These readings corroborated with the findings of Nazarudeen (2010) in wild edible fruits like *Alangium salvifolium, Antidesma ghaesembilla, Baccaurea courtallensis* etc in Kerala and similar values were reported by Narain *et al.* (2001) in *Averrhoa carambola.* The *Elaeocarpus serratus* fruits showed less content of iron as of which the fruit can be blended with other iron rich fruits for the development of value added product rich in iron.

Calcium is necessary for the growth and maintenance of strong teeth and bones, nerve signalling, muscle contraction, and secretion of certain hormones and enzymes. A deficiency in calcium can lead to numbness in fingers and toes, muscle cramps, convulsions, lethargy, loss of appetite, and abnormal heart rhythm (San *et al.*, 2009). Calcium is an essential part of plant cell wall structure and provides for normal transport and retention of other elements as well as strength of plant (Okello, 2010). Calcium content in *Elaeocarpus serratus* fruits found to be 10.94 mg/100 g (Table 4). In fruits of *Zizyphus jujuba, Persea americana* and *Zizyphus mauritiana* calcium content was found to be occurring almost near to this range (Li *et al.*, 2007, Arukwe *et al.*, 2012 and Nyanga *et al.*, 2013). In the tissue of many fruits, calcium is one of the mineral believed to be an important factor governing fruit storage quality (Lechaudel *et al.*, 2005).

5.5. Organoleptic evaluation of fruit

Sensory rating of fruits by panellists is a useful method in the evaluation of fruit acceptability by consumers. The sensory evaluation of the fruit is assumed to be of great significance as this provides information which can be utilised for product development and its improvement (Colaric *et al.*, 2005).

Appearance is one of the major factors leading to the increasing demand of the fruit (Ranganna, 1986). With regard to the appearance of Ceylon olive panellists were having moderate level of acceptability. This may be due to the small structure of the fruit.

The first impression of the fruit is usually visual and major part of our willingness to accept a fruit depends upon colour. Color increases the attractiveness of the fruit and in most cases it is used as a maturity index (Srivastava and Sanjeev, 2002). Ceylon olive fruit colour was pale green which showed good level of acceptability among the judges.

Ranganna (1986) stated that flavour is a unique character of odour and taste of fruit which ultimately determines the quality and acceptability of fruit. In the present study Ceylon olive fruit were having least flavour. This may be because of the fact that the fruit does not show any prominent flavour unlike other tropical fruits like mango, pineapple etc.

Texture is the property of the fruit which is associated with the sense of feel or touch experienced by fingers or the mouth which requires considerable trained personal. Taste is another major attribute which determines acceptability of fruit (Ranganna, 1986). Present study on Ceylon olive fruit showed the least value texture and taste. Some of the tropical fruits like sapota, jamun etc. showed pleasant tart flavour and texture (George *et al.*, 1999).

Overall acceptability of the fruit depends upon the above mentioned sensory attributes. In the aspect of Ceylon olive fruits, overall acceptability was least as the other sensory attributes did not show any prominent acceptability among the judges. This paves way for the development of value added product from the fruit in order to increase the acceptability among the consumers.

5.6. Development of products with fruits

Proper utilization of fruit available in our country is necessary for development of any product (Vaidehi *et al.*, 1977). Selecting fruit types according to their suitability for products will be highly useful. Such attempts had already been done in major fruit crops like mango, pineapple, banana etc. (Chadha *et at.*, 1994). Fruit products from certain unfamiliar fruits have been developed successfully by earlier workers (Majeeed, 1995; Dhan, 2000 and Hema, 1997).

Attempts were made by Edirisinghe *et al.* (2013) to develop a dessert which is rich in both medicinal and nutrition values by incorporating *Elaeocarpus serratus* pulp into ice cream. Priyanthi *et al, (*2009) reported that few value added products such as pickles and cordial are available in Sri Lankan market. They also carried out a study to develop RTS drinks with simple and low cost technology. In the present study an attempt was made to develop *Elaeocarpus serratus* fruits value added products like, pickle and candy.

According to Khurdiya and Singh (2001) ber fruits can be used for the preparation of murabba, candy, pickle, chutney etc. Karonda are used for making pickles, chutney, pudding and candy (Misra and Jaiswal, 2004). Bael fruits are mildly laxative and the slices of the unripe fruit in the form of murabba or candy are used in chronic cases of diarrhea and dysentery (Singh, 2004). Fresh fruits of aonla are commonly used for making murabba, pickles, jelly. Since the fruit is not sweet to taste, hence the higher acceptance were obtained the fruit pickle (Ram, 2000).

Pickles are usually prepared from whole or fruit or part of the unripe fruits which are simmered in spicy, sweet and sour syrup. Pickles are usually preserves which refer to the process of soaking fruit or vegetable in a solution of vinegar or brine, additional salt and possibly spices (Bhasin and Bhatia, 1981). Pickle may contain onion, garlic, ginger, edible vegetable oil, green or red chillies, spices, spice extracts, lime juice, vinegar or acetic acid, dry fruits or nuts. Fruits which are sour in taste can be used for preparation of variety of pickles (Ram, 2000).

Candy is one of the traditional Indian food product which are also described in ayurvedic and unani text. Candy is a fruit preserve soaked in a heavy sugar syrup, which is drained and dried later (Bhasin and Bhatia, 1981). Generally giner, amla are used for making candy. Fruit with pronounced flavour such as pineapple, peach, cherry are also suitable for making candy. Slightly unripe fruits should be used for candy products because fully ripened or ripe fruit develop jam like consistency in syruping process (Tripati *et al.*, 2001).

5.7. Organoleptic evaluation of Pickle and Candy

It is necessary to establish a relationship between the physical and chemical composition of the product and its sensory attributes such as color, texture, aroma (volatile compounds) and taste (sweet, sour, salty and bitter sensations), as well as between the sensory perceptions and the acceptability for the consumer (Escribano *et al.*, 2010).

Organoleptic evaluation of the pickle and candy revealed that overall scores for the fruits collected (Table 6, 7 and Fig. 20, 21). Appearance and colour are the most important factors, which added aesthetic values to the products. Poor products of deteriorated colour are not accepted by the consumers. Ceylon olive pickle obtained the highest score for the appearance and colour. Bhasin and Bhatia (1981) reported that the best pickle were obtained at early maturity of fruits in order to get good colour and appearance. Pickle also had a good score for the overall acceptability with a mean score of 8.4 which indicated that the product can be commercially well exploited.

Organoleptic qualities of Ceylon olive candy were found to have a good value for colour and after taste. This can be attributed to the addition of synthetic colour for the product, high sugar penetration, texture and also the mixture of taste the candy provides after chew. The improved acceptability of the candy can be attributed to the increased penetration of the sugar into the fruit tissues from the syrup and the improvement of texture (Tripati *et al.*, 2001). Alzomora *et al.* (1993), reported that the lower pH and penetration of sugar into the fruit chunks improved the sensory quality by establishing sugar acid ratio.

5.8. Chemical composition of products

Value addition to the underutilized fruits and development of popular products from them would be an ideal way to take them into the consumption successfully (Gunasena *et al.*, 2004). It is always considered better to analyse the nutrient quality of fruit products and necessary measures to maintain them at optimum possible levels are also important. Underutilized fruits have tremendous potential for introducing a variety of new products of commercial and nutritional importance and in turn finding their use in human diet, sheerly for high nutritive value (Hiremath *et al.*, 2006).

On the analysis of the pickle prepared from Ceylon olive, its composition was observed with a Total soluble solids (10.45 ^{0} brix), acidity (1.2 per cent), vitamin C (2.6 mg/100 g), total sugar (6.05 g/100 g) and reducing sugar (0.76 g/100 g). The above result supports to the findings of West Indian Cherry pickle of Bhasin and Bhatia (1981). Mango pickles usually contains 10-30% total soluble solids and 1.0- 3.5% acidity as acetic acid (Mathur and Purnanandam, 1976; Teotia and Prithi, 1987). Pickle prepared from the *Elaeocarpus serratus* fruit was showing optimum possible levels of nutrient quality which signifies that the product can be commercially exploited.

As per the analysis it was found that the Ceylon olive candy exhibited total soluble solids of (69.06 ^{0} brix), acidity (1.42 per cent), vitamin C (2.8 mg/100 g), total sugar (40.05 g/100 g) and reducing sugar (15.76 g/100 g). Tripati *et al.* (2001) analysed the values in Amla candy and the values were in par with the above study. Since the product candy satisfied the required nutrient quality it can be concluded that the *Elaeocarpus serratus* fruits are suitable for candy preparation.

5.9. Assessment of ensurance of FSSAI requirement in the products

The FSSAI (Food safety and standards Authority of India) conditions are mandatory on all processed fruit products sold in India such as packaged fruit beverages, fruit-jams, crushes and squashes, pickles, dehydrated fruit products, and fruit extracts, following the Food Safety and Standards Act of 2006. Food standards are made to ensure the quality and safety of natural and processed food for human consumption (Swaminathan, 1974). According to Ranganna (1986), as the consumer is unable to judge them easily, he is protected by stringent government controls in the shape of food laws.

Fruit product order has specified certain standards for fruit products (Siddappa, 1967). Specifications are indicated for pickle and candy. The products developed by *Elaeocarpus serratus* fruits such as pickle and candy were tested for conformity to FSSAI standards and the products satisfied the specifications (Table 10). The standards are meant to provide uniform and consistently good quality of food products to the consumers.

Similar FSSAI confirmations were reported by several workers for different minor fruit products like West indian cherry pickle, karonda candy, passion fruit jelly etc. (Majeed, 1995 and Pal, 1995).

5.10. Fruit Product Yield Ratio

Fruit product yield ratio gives an estimation of the amount of product obtained for known quantity of the fruit utilised. Yield of finished product from a specific unit of raw material is necessary information to people involved in the production of fruit products. Fruit product yield ratio was calculated by taking into account the quantity of fruit used and the final product obtained.

Pal (1995) found fruit product yield ratio of 1:1.2 and 1:0.60 for passion fruit beverages and passion rind jelly. Majeed (1995) reported fruit yield ratio of 5:4 and 20:17 with respect to Karonda pickle and candy.

In *Elaeocarpus serratus* fruit products the pickle was found to be having the highest yield ratio (1:1.54) than candy (1:1.25) (Table 11). This difference in the yield could be attributed to the addition of more ingredients during preparation to pickle in comparison to candy. Obtaining such information of these commodities is especially challenging because they widely fluctuate in different products and fruits (How, 1990).

5.11. *Elaeocarpus serratus* wild fruit for the future

Elaeocarpus serratus is a tree producing edible fruits which are not at all being utilised by people other than in a much localized manner. Such under and unutilised fruits of *Elaeocarpus serratus* was subjected to the detailed study for evaluating its physical, nutritive value, potential uses for other purposes and for possibilities of commercial cultivation.

The study showed that the nutritive and biochemical values of the fruit were in par with other tropical fruits like ber, cashew apples, custard apples, jackfruit, phalsa, bilimbi, west indian cherry, carambola etc. and hence shows a promising potential if utilised commercially. Since the fruit is not acceptable for fresh consumption as a table fruit, product diversification was thoroughly evaluated by developing two value added products such as pickle and candy. The products showed a high acceptability like any other tropical fruit products such as mango pickle, amla candy, cashew pickle and ber candy.

Hence, this study clearly reflects the potential of wild edible fruit *Elaeocarpus serratus* as one among the tropical fruits which can be commercially utilized and is a fruit for the future to achieve food and nutritional security both locally and globally.

Summary

SUMMARY

The study entitled "Quality evaluation and value addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)" was conducted to evaluate the physico-chemical characteristics of the fruit and to develop two value added products from the fruits. The fruits were collected from Vazhachal forest division in Thrissur district of Kerala state. The results obtained from the experiments are summarized in this chapter.

1. In *Elaeocarpus serratus* fruits, the mean values of fruit weight, volume, length, diameter, pulp weight and seed weight were 3.55 g, 5.97 cm^3, 23.07 mm, 15.58 mm, 2.03 g and 1.52 g respectively. The pulp and seed proportion in the fruit was estimated to be 57.50 per cent and 42.60 per cent respectively.

2. A correlation matrix revealed significant and positive relation between all physical parameters of *Elaeocarpus serratus* fruits. As the weight of the fruit increases there is a significant increase in the volume, diameter, pulp weight and seed weight of the fruit. But the length of the fruit showed a negative correlation with the weight and volume parameter of the fruit. Diameter of the fruit also showed a positive correlation with pulp weight and seed weight.

3. Linear regressions were obtained for physical parameters of fruit with significant R^2 values. The regression equation obtained for fruit weight and pulp weight showed a R^2 value of 0.80 which reflects the high correlation between the two parameters. Similarly strong correlation was obtained in the regression equations for fruit volume, diameter, fruit weight and seed weight showed R^2 values of 0.77 and 0.75 respectively. The regression equations obtained for parameters like fruit weight versus fruit volume, fruit weight versus fruit diameter, fruit diameter versus seed weight, fruit diameter versus pulp weight and pulp weight versus seed weight showed a weak correlation

4. Biochemical analysis of *Elaeocarpus serratus* fruits revealed that the mean moisture content, total soluble solids, titrable acidity, total sugar, reducing sugar, starch, fibre, beta carotene and vitamin C content were found to be 62.45 per cent, 5.99^0 brix, 1.36 per cent, 2.05 per cent, 8.26 per cent, 18.78 µg/100 g, 1.73 per cent, 1.04 µg /100 g and 2.9 mg /100 g respectively.

5. A correlation matrix computed for biochemical parameters of Ceylon olive fruit reveals that as the moisture content of the fruit increases there is a significant increase in the titrable acidity and total sugar content in the fruit. Titrable acidity has a positive and significant correlation with other biochemical parameters like total sugar, reducing sugar, starch and fibre. Percentage of total sugar showed a significant correlation with reducing sugar, starch, fibre and total soluble solids. The starch content of the fruit showed a positive correlation with TSS of the fruit. Fibre content of the fruit showed a positive correlation with total soluble solids.

6. Mineral analysis of fruit reported that mean phosphorus, potassium, iron and calcium content were found to be 62.80 mg/100 g, 331.48 mg/100 g, 2.14 mg/100 g and 10.94 mg/100 g respectively.

7. Organoleptic evaluation of fruits revealed that overall scores for fruits were lower because of the low scores obtained for fruit flavour, texture, taste and after taste.

8. Two products, pickle and candy were developed from the *Elaeocarpus serratus* fruits which were further subjected to sensory evaluation and biochemical analysis.

9. The chemical composition of the product pickle reveals the mean values for acidity, total soluble solids, vitamin C, total sugar, reducing sugar as 1.2 per cent, 10.45^0 brix, 2.6 mg/100g, 6.05 g/100g and 0.76 g/100g respectively.

10. Chemical analysis of Ceylon olive candy reveals the mean values for acidity, total soluble solids, vitamin C, and total sugar, reducing sugar as 1.98 per cent, 69.06^0 brix, 2.8 mg/100 g, 40.10 g/100g and 15.01 g/100g respectively.

11. Mean scores of organoleptic evaluation of pickle for appearance, colour, flavour, texture, odour, taste and after taste was 8.4, 8.8, 7.8, 7.8, 7.3, 8 and 8.2 respectively. Organoleptic evaluation of the Ceylon olive candy shows the mean score for appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability was 7.5, 7.7, 7, 7.4, 5.8, 7.4, 7.5 and 7.7 respectively.

12. As per the FPO specification, a product indicates pickle, if that is prepared from any edible oil. The pickle of *Elaeocarpus serratus* is prepared from gingelly oil and thus satisfied the specifications. With relevant to candy, FSSAI prescribes a minimum of 68 per cent total soluble solids and 55 per cent fruits in final product as requirement for this product to be considered up to the mark. On analysis of candy prepared from Ceylon olive the value obtained was 72 per cent of TSS and 58 per cent of fresh fruit in the final product which satisfies the specifications.

13. Fruit product yield ratio was calculated, it was found that highest yield was obtained for Pickle with the value of (1:1.54) followed by Candy (1:1.25).

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*Originals not seen

Appendices

APPENDICES

Appendix I. Score card for organoleptic evaluation of fruit

Evaluation of organoleptic qualities of *Elaeocarpus serratus* fruit and products

Name of judge:

Date:

Characteristics	Score
Appearance	
Colour	
Flavour	
Texture	
Odour	
Taste	
After taste	
Overall acceptability	

9 Point Hedonic Scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

QUALITY EVALUATION AND VALUE ADDITION OF FRUITS OF *ELAEOCARPUS SERRATUS* L. (CEYLON OLIVE TREE)

by

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ABSTRACT OF THE THESIS

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ABSTRACT

The present study "Quality evaluation and Value Addition of fruits of *Elaeocarpus serratus* L. (Ceylon Olive Tree)" was conducted in Vazhachal forest division of Thrissur district, Kerala. The fruits were collected from the selected trees to evaluate their physical parameters, biochemical and mineral composition. Two products were also, prepared from the fruits and their bio chemical parameters were analyzed.

The physical characteristics of the fruits revealed that the mean fruit weight, volume, length, diameter for the fruit were 3.55 g, 5.97 cm^3, 23.07 mm and 15.58 mm respectively. The mean pulp and seed weight was observed as 2.03 g and 1.52 g respectively for the fruits. The pulp and seed proportion was estimated to be 57.50 per cent and 42.50 per cent of the total *Elaeocarpus serratus* fruit content. Correlation matrix revealed a significant and positive relation among all the studied physical parameters.

The biochemical parameters of the fruit such as moisture, total soluble solids, total sugar, reducing sugar, starch, fibre, titrable acidity, beta carotene, vitamin C were obtained as 62.45 per cent, 5.99^0 brix, 12.05 per cent, 8.26 per cent, 18.78 per cent, 1.73 per cent, 1.36 per cent, 1.04 µg /100gm and 2.9 mg /100gm respectively. Minerals like phosphorous, potassium, iron and calcium were found to be 62.80 mg/100g, 331.48 mg/100g, 2.14 mg/100g and 10.94 mg/100g. The nutritional composition of the fruits was found to be in par with other tropical fruits like tamarind, passion fruit, jack fruit etc.

In terms of organoleptic evaluation the fruit showed the mean scores for appearance, colour, flavour, texture, odour, taste, after taste was found as 6.7, 6.8, 5, 5, 4.9, 4 and 4.1 respectively. Since the mean value for the above characteristics of the fruit are low, the overall acceptability of the fruit is low with the value of 4.1. Two products were developed from the fruit i.e. pickle and candy. The chemical composition of the fruit product pickle was analysed to evaluate the

acidity, total soluble solids, vitamin C, total sugar and reducing sugar which were found to be 1.2 per cent, 10.45^0 brix, 2.6 mg/100g, 6.05 mg/100g and 0.76 mg/100g respectively. Similarly Candy chemical composition analysed values was found to be 1.42 per cent, 68.06^0 brix, 2.8 mg/100g, 40.10 mg/100g and 15.01 mg/100g respectively. The organoleptic scores for the pickle and candy showed high values for all the parameters with the overall acceptability mean score of 8.4 and 7.7 respectively.

Hence, the present study of fruits of *Elaeocarpus serratus* clearly reflects the potential of this underutilized wild edible fruit for commercial utilization.