PROXIMATE ANALYSIS AND PRODUCT DEVELOPMENT IN NUTMEG (*Myristica fragrans* Houtt.) RIND

By

TEENA SIMENTHY

(2012-12-114)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University

Department of Processing Technology

COLLEGE OF HORTICULTURE
KERALA AGRICULTURAL UNIVERSITY

VELLANIKKARA

THRISSUR - 680 656

2015

DECLARATION

I hereby declare that the thesis entitled **"Proximate analysis and product development in nutmeg (*Myristica fragrans* Houtt.) rind"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara
12.05.2015

TEENA SIMENTHY

(2012-12-114)

CERTIFICATE

Certified that the thesis entitled **"Proximate analysis and product development in nutmeg (*Myristica fragrans* Houtt.) rind"** is a bonafide record of research work done independently by Ms. Teena Simenthy under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Smt. Meagle Joseph P.

(Chairperson, Advisory Committee)
Associate Professor
Department of Processing Technology
College of Horticulture
Kerala Agricultural University
Thrissur, Kerala

Vellanikkara
12.05.2015

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Teena Simenthy** (2012-12-114), a candidate for the degree of **Master of Science in Horticulture**, with major field in **Processing Technology**, agree that the thesis entitled **"Proximate analysis and product development in nutmeg rind (*Myristica fragrans* Houtt.)"** may be submitted by **Ms. Teena Simenthy** in partial fulfillment of the requirement for the degree

7/3/15

Smt. Meagle Joseph. P.

(Chairperson, Advisory Committee)
Associate Professor
Department of Processing Technology
College of Horticulture,
Vellanikkara

7/3/15

Dr. Sheela K. B.

Professor and Head
Department of Processing Technology
College of Horticulture
Vellanikkara

7/3/15

Dr. N. Mini Raj

Professor
Department of Plantation Crops
and Spices
College of Horticulture
Vellanikkara

7/3/15

Dr. Suman K.T

Assistant Professor
Department of Home Science
College of Horticulture
Vellanikkara

7/3/15

Dr. Jacob John P.

(External examiner)
Professor (Retd)
KAU, Vellanikkara

ACKNOWLEDGEMENT

And so comes the time to look back on the path traversed during the endeavour and to remember the faces and spirits behind the action with a sense of gratitude. Nothing of significance can be accomplished without the acts of assistance, words of encouragement and gestures of help from the other members of the society.

First and foremost I bow my head to the ALMIGHTY GOD who enabled me to successfully complete the thesis work.

I wish to express my deep regards to with immense and indebtedness, I consider myself extremely gifted and privileged to have ***Smt. Meagle Joseph P.,*** *Associate Professor, Department of Processing Technology as Chairperson of my advisory committee. Words cannot express my deep sense of gratitude to her. I extremely delighted to place on record my profound sense of gratitude for her expert guidance, critical and valuable suggestions, constant encouragement, unfailing patience, friendly approach and mental support during the course of investigation. I really consider it is my fortune in having her guidance for the thesis work. My sincere and heartfelt gratitude ever remains with her.*

Words are inadequate to express my sincere gratitude to ***Dr. K.B. Sheela,*** *Professor & Head, Department of Processing Technology, for her constant support, expert and valuable advice and whole hearted co-operation and guidance extended throughout the investigation.*

I consider it as my privilege to express my deep felt gratitude to ***Dr. P. Jacob John,*** *Rtd. Professor & Head, Department of Processing Technology, Kerala Agricultural University for his invaluable help, unbounded support, suggestions and constant encouragement throughout the period of the work.*

I take this opportunity to thank ***Dr. N. Mini Raj,*** *Professor, Department of Plantation crops and Spices, Kerala Agricultural University and member of my advisory committee for the critical comments, motivation and encouragement. I thank her for all the help and co-operation she has extended to me.*

I avail this opportunities to express my deep sense of gratitude and sincere thanks to ***Dr. Suman K. T,*** *Assistant Professor, Department of Home Science and member of my advisory committee for the valuable suggestions and whole hearted support extended throughout the course of study.*

I am deeply obliged to ***Dr. Saji Gomez,*** *Department of Processing Technology for the generous and timely help he has always accorded to me during the course of this study.*

I would like to exploit this opportunity to extend my profound sense of gratitude and sincere thanks to ***Dr. S. Krishnan,*** *Professor & Head, Department of Agriculture Statistics, College of Horticulture for immense help extended for the statistical analysis of the data.*

With ebullience I would like to thank ***Sruthi chechi*** *for her constant support and suggestions and also I express my deep sense of gratitude and obligation to her. I am genuinely indebted to* ***Reshmatta, Reshma chechi, Vikram chettan, Roshin chechi and Naveen chettan*** *for valuable assistance and guidance during the entire period of my research. With profound respects, I place my thanks to* ***Devika chechi, Remya chechi, Deepa chechi, Jiyana, Megha*** *and* ***Anjali*** *of Department of Processing Technology for their help and cooperation.*

I wish to express my sincere thanks to ***Lathika chechi, Prasanna chechi, Shinoy chettan, Preetha chechi, Linju chechi, Radha chechi, Mini chechi*** *and* ***Krishnettan*** *for their sincere help and whole hearted co-operation.*

Words fall short as I place on record my indebtedness to my classmates and friends ***Deepika, Mahsu, Aparna, Sandhya, Shanthi, Minnu*** *and* ***Indu*** *for their prompt help and cooperation for the entire period of study.*

I thank my juniors ***Divya, Naresh, Ashwini, Sachu, Pallavi, Supritha, Aiswarya, Greeshma, Sruthi, Charan*** *and* ***Seenath*** *for their timely help and co-operation.*

It is my fortune to gratefully acknowledge the support of two individuals ***Josena and Jerin*** *who were always beside me during the happy and hard moments in my life to push and motivate me.*

Special thanks to ***Mr. Aravind,*** *Student's computer club, COH for rendering necessary help whenever needed. The award of* ***KAU Junior research Fellowship*** *is thankfully acknowledged.*

Family is the compass that guides us, inspiration to reach great heights and our comfort when we occasionally falter. I would like to thank my ***parents, sister*** *and* ***brother in law*** *for their selfless sacrifice, boundless patience and unflagging interest throughout the period of my course. I owe everything to them.*

It is a pleasant task to express my thanks to all those who contributed in many ways to the success of this study and made it an unforgettable experience for me.

Teena Simenthy

Dedicated to

Andrea Rose

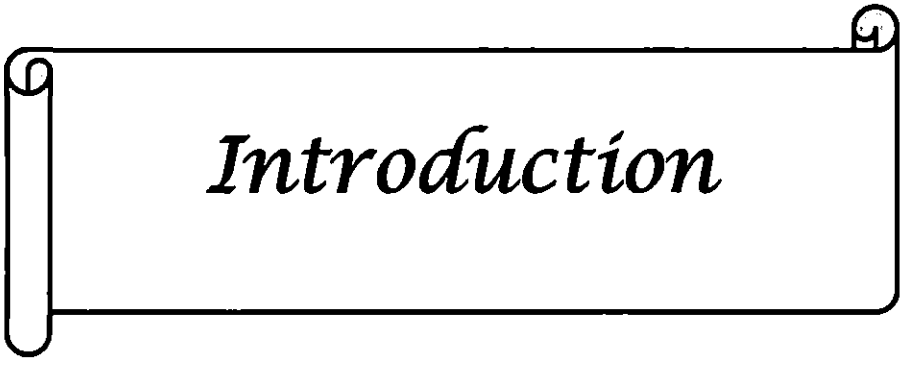
TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES


Introduction

1. INTRODUCTION

Nutmeg (*Myristica fragrans* Houtt.) belongs to the family Myristicaceae with about 18 genera and 300 species. It is believed to be a native of BandaIslands of Eastern Indonesia, formerly known as 'Spice Islands'. The name 'Myristica' is derived from the Greek word '*Myron*'meaning a sweet liquid distilled from the plant (Everett, 1981). In India it is mainly cultivated in Southern states particularly in certain pockets of Kerala, Tamil Nadu and Karnataka having been introduced by the British during the 18th century (Krishnamoorthy *et al.*, 2001).

Nutmeg is a dioecious or monoecious tree, bushy and evergreen, which is 9 to 12 m tall with spreading branches bearing yellow fleshy fruit similar in appearance to an apricot or peach. Nutmeg produces two spices of commerce namely nutmeg, dried kernel of the seed and mace, the dried aril surrounding the seed. The fruit is a one seeded fleshy drupe, succulent, pendulous, smooth, 6 to 9 cm long and broad. The fruit ripens and the aromatic orange yellow rindwhich is about 1.3 cm thick splits into two halves (Krishnamoorthy *et al.*, 2001).

The spice in general acts as antimicrobial, anti-inflammatory, anti-oxidant, anti-diabetic, antidepressant, anticonvulsant and anticancer agent. Nutmeg rind constitutes 80 to 85 per cent of its whole fruit weight and at ripe stage it has an acidic astringent taste with aromatic flavour.

Due to these qualities, the use of rind directly for food purpose is not possible. But at the same time, the therapeutic property in general and its antioxidant, antimicrobial and anti-diarrhoeal effects has given nutmeg rind an important place in folklore medicine. Generally during harvesting and processing, nutmeg farmers discard nutmeg rind considering it as a farm waste. If it can be converted to attractive value-added products it will be a boon to nutmeg farmers.

Attempts have been made for developing products from rind considering the high pectin content which plays an important role in maintaining the texture of processed products. Madhav and Pushpalatha (2002) have reported that rind can be used for making jelly.

The presence of major oil components like myristicin and elemicin was recorded in nutmeg rind. Antioxidant properties of essential oil and oleoresins from nutmeg are of great interest in the food industry, because of their possible use as natural additives has emerged from a growing tendency to replace synthetic antioxidants by natural ones.

Epidemiological evidences have supported the consumption of fruits in reducing the oxidative stress-related diseases. Many spices and herbs have also been found to possess a potent antioxidant activity and can be rich sources of natural antioxidants (Su *et al.*, 1986 and Weng *et al.*, 1998). Nutmeg, an important tree spice possesses strong antioxidant activities, good preservative action and it offers benefits in some medical treatments. Skin, pulp, mace and seed are parts of nutmeg which have been widely used as traditional ayurvedic, chinese and thai medicine (Somani *et al.*, 2008).

The chemical composition of rind is also very peculiar which requires detailed investigation. Hence, the present study was endeavoured to assess the proximate composition of nutmeg rind and possible ways to convert it to value-added products, as it may prove beneficial to the society in nutritional and pharmacological aspects.

Review of Literature

2. REVIEW OF LITERATURE

Nutmeg is an important tree spice yielding two spices of commerce. Tree spices refer to spices originating from tree crops and serving as source of flavour with therapeutic properties.

In Kerala homesteads, nutmeg is commonly grown as an intercrop and it earns fair income to the farmers. Krishnamoorthy (1987) reported that the average yield of a good tree in full bearing is estimated to be 3000 fruits between 15^{th} and 30^{th} year of growth.

Rind of nutmeg (*M. fragrans* Houtt.) contributing 80 to 85 per cent of total fruit weight, is widely considered as a farm waste due to its astringency and strong aroma. There are studies oriented towards improving methods for the effective utilisation of farm waste.

This study emphasise on analysing the biochemical parameters of nutmeg rind and exploiting the possibilities of its use in processed product development. The literature available on nutmeg is very meagre, hence related works are being quoted.

2.1. PROXIMATE COMPOSITION

Proximate composition is the composition of six categories of chemical compounds in any biological material, which can be quantified or determined by proximate analysis. It includes moisture, ash, crude protein, crude lipid, crude fibre and digestible carbohydrates. Of these, carbohydrate is determined based on calculation. Additional ingredients are dietary fibre, sugars, sugar alcohols, dietary minerals and vitamins. The proximate composition helps to evaluate the nutrient content in any food material. It also helps in the better utilization of the particular food material to meet the nutritional requirement.

Gopalakrishnan (1992) studied the proximate composition of mature nutmeg fruit parts like kernel, mace and rind and it showed variations in chemical composition and physical characteristics. Moisture content, acidity, total reducing sugars, total sugars, crude fibre, total ash and pectin were highest in the rind,

whereas the concentration of volatile oil and non-volatile substances extracted by ether were highest in the kernel. Starch and protein contents were highest in the mace. Essential oils of nutmeg kernel (77.38 %) and mace (60.76 %) analysed by gas chromatography (GC) had monoterpene hydrocarbons, mainly α-pinene, β-pinene and sabinene as the predominant constituents in both. The major hallucinogenic principles in both nutmeg fruit parts were myristicin and elemicin, which were higher in the mace oil (5.92 % and 3.14 % respectively), than in the nutmeg oil (3.28 % and 1.38 % respectively).

Pradeep *et al.* (1993) evaluated eight commonly used Indian spices like red chillies (*Capsicum annuum*), black pepper (*Piper nigrum*), coriander seeds (*Coriandrum sativum*), cumin seeds (*Cuminum cyminum*), garlic (*Allium sativum*), asafoetida (*Ferula foetida*), dry ginger (*Zingiber officinale*) and ajowan (*Carum copticum*) for its nutritive value and the study revealed that nutrient composition from spices ranged from 1.2 to 7.0 per cent of an average Indian adult.

Gul and Safdar (2009) conducted proximate and mineral analysis in cinnamon to evaluate its nutritional importance, and they have reported that, cinnamon contained ash (2.40 %), crude protein (3.50 %), crude fat (4.00 %), crude fibre (33.00 %), moisture (5.10 %) and carbohydrate (52.00 %).

Otunola *et al.* (2010) did comparative analysis of the proximate chemical composition of three spices namely garlic (*Allium sativum* L.), ginger (*Zingiber officinale* Rosc.) and pepper (*Capsicum frutescens* L.) and it was understood that, the spices had considerable amount of carbohydrate and crude protein content, but low ash, fibre, moisture and fat except pepper with high crude fat.

The proximate composition of ginger rhizome was determined by Mojani *et al.* (2014) and it contained moisture 90.90 per cent, crude fibre 3.80 g/100g, carbohydrate 6.30 g/100g, ash 0.70 g/100g, fat 1.40 g/100g and crude protein 0.70 g/100g.

Physico-chemical profiling and detection of phenolic compounds with antioxidant and antibacterial activities of nutmeg was done by Abdullah (2009). Padmavathy and Mekala (2013) did the phytochemical analysis of medicinal plants and methanolic extracts were found to contain alkaloids, flavanoids, saponins, tannins and terpenoids, whereas other extracts showed remarkable decrease in phytoconstituents.

2.1.1 PHYSICAL CHARACTERS

2.1.1.1. Colour and texture

Colour is an important quality trait for any product. Colour, texture and flavour of plant tissue are influenced by synthesis and polymerisation of many chemical compounds. In nutmeg the colour of mace is an important factor, influencing its commercial value. The red pigment of mace was identified to be lycopene by thin layer chromatography and absorption studies (Gopalakrishnan, 1979).

Abdullah (2009) conducted colour analysis in nutmeg mace, seed kernel and skin of pericarp and it revealed that the mace had the highest redness a* and C value (28.14 ± 0.49 and 29.92 ± 0.58 respectively) and least hue angle (h0) of 19.87 ± 0.35, skin of pericarp was detected to have the highest yellowness (b*) value (28.59 ± 0.78) and seed kernel exhibited the highest lightness (L*) parameter (72.85 ± 0.16).

A study was conducted by Silva *et al.* (2014) to evaluate the skin colour and physicochemical quality of passion fruit at different stages of maturity. Harvesting of passion fruit, when two third of skin turned yellow gave high valuefor total soluble solids (TSS).

Lawless and Heymann (1998) defined texture as "all the rheological and structural - geometric and surface attributes of the product perceptible by means of mechanical, tactile and where appropriate, visual and auditory receptors". For analysing the firmness in fruits and vegetables, the quasi static force deformation

technique was adopted by Tijskens *et al.* (2009). To overcome the limitations of sensory perception of food texture, objective measurement involving instrumental approaches have been developed (Costa *et al.*, 2011).

2.1.2. BIOCHEMICAL CHARACTERS

2.1.2.1. Moisture

The moisture analysis is an important physicochemical parameter to meet the standards of the product, material balance and to have product stability preventing deterioration.

It was reported by Sampathu and Krishnamoorthy (1982) that kokum rind used as a spice for flavouring curries has a moisture content of 80 per cent. Sara *et al.* (2000) has reported that Malabar tamarind rind contains 76 to 78 per cent moisture. Moisture content was at the highest for leaves, pericarp, mace and seed except for seed kernel in nutmeg (Abdullah, 2009).

Moisture is an important constituent in chilli and paprika, it is reported as 90 per cent in spice varieties and when allowed to dry on the plant itself it will be reduced to 70 per cent (Shiva *et al.*, 2010). In ginger rhizome, the moisture content was reported as 90.90 per cent (Mojani *et al.*, 2014).

2.1.2.2. Total soluble solids (TSS)

Soluble sugars are a universal component of most living organisms and a fundamental building block in biosynthetic process. Since soluble carbohydrates are soluble in cells aqueous environment they may be analysed from liquids obtained from plants or they may require extraction from plant medium. The TSS is primarily represented by sugars, acids and minerals.

The reports of Bhat *et al.* (1982) on aonla candy showed that during storage the TSS content of the fruit increased from 9.7 to 10.5°brix. Ferreira *et al.* (2004) reported that the TSS changes for quince jams were not significant by storage time, temperature or the interaction between those factors. According to

the Codex Alimentarius Standard (CODEXSTAN, 2009) normal fruit conserves or preserves must contain 60 per cent soluble solids.

A study was conducted by Das *et al.* (2011) on the physico-chemical changes in jam of three cultivars of aonla during storage. Banarasi aonla jam was found to be excellent in quality by recording the ideal TSS (57.82 %). They also revealed that the total soluble solids content in the jam slightly increased during storage in all the three cultivars of aonla.

2.1.2.3. Crude fibre

Crude fibre content in kokum as reported by Sampathu and Krishnamoorthy (1982) is 14.28 per cent and in Malabar tamarind is 5.12 per cent (Sara *et al.*, 2000).

Larrauri *et al.* (1996) opined that mango peel is a good source of tropical fruit fibre. Gopalan *et al.* (2000) estimated the crude fibre values of some tropical fruits where in aonla contained a higher crude fibre content (3.40 g/100g) followed by sapota (2.60 g/100g), fig (2.20 g/100g) and peach (1.20 g/100g).

Chilli pericarp has fibrous material accounting for 20 per cent of the dry weight of which 77 per cent was soluble fibre and 80 per cent total dietary fibre (Shiva *et al.*, 2010). In fully matured ginger, fibre content varies from 3 to 8 per cent and it separates at the last phase of maturity (Kumar *et al.*, 2010).

2.1.2.4. Acidity

The titrable acidity (TA) is an important physicochemical parameter which affects the product quality and protects against the development of microorganisms to a large extent.

Dabhade and Khedkar (1980) reported a significant decrease in acid content of guava powder in all varieties during storage. Kumar (1990) reported that an increase in acidity has been observed in jamun jelly, aonla jam and papaya

jam. Kalsi and Dhawan (2001) also reported similar results for mango powder. Firoz *et al.* (2003) observed that the total acid content of pulse based papaya powder was decreased upto second month of storage packed in glass bottles.

2.1.2.5. Vitamin C (Ascorbic acid)

Ascorbic acid is the most abundant antioxidant in plants. Its biosynthetic pathway is via GDP-D-mannose and L-galactose (Smirnoff, 2000).

The ascorbic acid content of aonla fruits decreased continuously during storage under ambient conditions (Kumar *et al.* 2005 and Singh *et al.* 2005). The candy prepared from fresh aonla fruits showed maximum ascorbic acid content (113 mg/100g) when compared to those prepared from 3 days stored fruits (103 mg/100g). One fruit of West Indian cherry was found to furnish 53 to176 milligram (mg) of ascorbic acid and thus supply the daily requirement (Jyothi, 2006) and from this, products such as squash, pickle, sauce and preserve were made.

The ascorbic acid content of bael pulp decreased gradually during the storage period (Chand *et al.*, 2007). Sanusi *et al.* (2008) reported that the ascorbic acid loss was more than 10 per cent in marmalades and jams after storage for 12 months at ambient temperature.

Ascorbic acid is not synthesised in human beings and therefore the requirement must be from dietary sources (Sanusi *et al.*, 2008). In fruits ascorbic acid was formed from sugar during photosynthesis. Therefore, plants which received the highest amount of sunlight would be able to form more ascorbic acid and contributed to higher content of vitamin C (Okiei *et al.*, 2009).

2.1.2.6. Total, reducing and non-reducing sugars

A study was conducted by Das *et al.* (2011) on the physico-chemical changes in jam of three cultivars of aonla during storage. The reducing sugars and total sugars increased gradually in jam during storage period in all the three cultivars of aonla and the trend in increase was more or less uniform.

The candy prepared from sapota also showed a slight increase in total sugars during the storage period (Totad, 2013).

2.1.2.7. Starch

Starch is the most vital carbohydrate in the human diet and is major constituent of staple foods such as potatoes, rice, wheat, cassava, and corn. Depending on the plant, starch contains 20 to 25 per cent amylose and 75 to 80 per cent amylopectin. Starch is a carbohydrate made up of glucose units linked together by glycosidic bond. Plants store glucose as the polysaccharide starch (Whistler and BeMiller, 1997).

2.1.2.8. Pectin

Pectins are mixtures of polysaccharides originating from plants, contain pectinic acids as major components and are water soluble. Pectin exists in varying amounts in fruit cell walls and has important nutritional and technological properties, mainly because of their ability to form gels (Westerlund *et al.*, 1991). Pectin occurs in varying amounts in fruits' cell walls and contains nutritional and technological properties because of its ability to form gels.

Sampathu and Krishnamoorthy (1982) has studied the chemical composition of garcinia and reported that it contains 5.70 per cent pectin on moisture free basis.

Extraction of pectin is generally done using hydrochloric acid (HCl) and citric acid. Pruthi and Krishnankutty (1985) reported that HCl is better than citric acid for extraction of pectin from nutmeg rind. More than 93 per cent of the total pectin in nutmeg pericarp could be extracted using 0.25 per cent HCl and 0.75 per cent citric acid and with citric acid, two extraction steps are necessary. The pectin extracted using this method was found to be of good quality.

A valuable by-product that can be obtained from fruit wastes is pectin. The pectin is used in manufacturing jams, jellies, marmalades, preserves etc. It is also useful as a thickening agent for sauces, ketchups, flavoured syrups and as a

texturizing agent in fruit-flavoured milk desserts. Besides, it finds numerous applications in pharmaceutical preparations, pastes, cosmetics etc. (GITCO, 1999).

Madhav and Pushpalatha (2002) reported that passion fruit rind was identified as a rich source of pectin (252.68 g/kg) followed by lime peel (180.48 g/kg).

2.1.2.9. Protein

Protein has a number of important functions as part of the human diet. Apart from its essential function to provide amino acids for human nutrition, protein also serves prominent physical functional roles in food preparation, processing, storage and consumption which contribute to the quality and sensory attributes of food products. The most important functional properties of protein in food include its solubility, water and fat binding capacities, gel forming and rheological behaviours, emulsifying capabilities, foaming and whipping abilities.

Sara *et al.* (2000) has reported that Malabar tamarind contains 4.79 per cent protein. Chitturi *et al.* (2013) studied the protease activity of different air dried fruit peels. The highest protease activity was found in peel of jujube (2.61 %) followed by pineapple (1.84 %) and papaya peels (1.58 %). Highest concentration of protein was also found in kiwi peel (1.79 %).

2.1.2.10. Total phenol

Phenolics are naturally occurring compounds widely distributed in the plant kingdom and beneficial components of human daily diet. Polyphenolic compounds contribute multiple biological effects including anti-oxidant activities in both edible and inedible plants (Edoga *et al.*, 2005). It was reported by Kotilainen *et al.* (2006) that certain processing methods were employed to release the anti-oxidant phenolic compounds in plants, which are present as covalently bound form to enhance the anti-oxidant capacity.

They are important constituents of plants with multiple functions and as dietary phytochemicals for human, they display a broad range of functional and

biological activities (Le *et al.*, 2007). Total phenol content in Malabar tamarind is 313.10 mg/100g (Sara *et al.*, 2000).

2.1.2.11. Oleoresin

Oleoresin of nutmeg and mace is used almost entirely in the flavouring of processed foods. It is sold on a neutral base such as salt, dextrose, flour or rusk.

Nutmeg seed yield 18 to 26 per cent oleoresin and 10 to 80 per cent oil and mace yield 27 to 32 per cent oleoresin and 8.50 to 22 per cent oil. The clove buds yield 10 to 12 per cent oleoresin and 70 to 80 per cent oil and from cinnamon bark, 8 to 10 per cent oleoresin was recovered as reported by Zachariah and Parthasarathy (2006). Oleoresins are natural isolates obtained by extracting the comminuted spice with suitable solvents and recovering the solvent mostly by evaporation (Parthasarathy and Madan, 2010).

The nutmeg oleoresins in ethanol, ethyl acetate, and iso-propyl alcohol showed, respectively, the presence of 40 components (84.0 %), 51 components (95.30 %), and 37 components (95.70 %) of the total amounts. In ethanol oleoresin, the major components present were elemicin (9.30 %) and myristic acid (7.3 %). In ethyl acetate and iso-propyl alcohol oleoresin these compounds were present. In the case of ethyl acetate oleoresin, there was 11.5 per cent elemicin and 5.0 per cent myristic acid and for iso-propyl alcohol oleoresin, elemicin concentration of 17.8 per cent and 5.3 per cent myristic acid (Kapoor *et al.*, 2013).

2.1.2.12. Oil and its profile using GC-MS

Nutmeg oil obtained from seed is a colourless or yellow liquid with the characteristic odour and taste of nutmeg. The oil is insoluble in water, but soluble in alcohol. It keeps best in cool, tightly closed containers protected from light. Maya *et al.* (2004) reported that the essential oil content in nutmeg from South India ranged from 3.9 to 16.5 per cent, whereas in mace it varied from 6 to 26.1 per cent. The major constituents of the oil were sabinene, myristicin, elemicin and safrole. The chief flavour contributing components, namely myristicin and

elemicin are present in low concentrations. Myristicin is reported to be a potent hepatoprotective principle in nutmeg.

The chemical analysis of volatile oil and oleoresins of *M. fragrans* were undertaken by gas chromatography-mass spectroscopy (GC-MS). Essential oil and oleoresins (ethanol, ethyl acetate, and iso-propyl alcohol) of *Myristica fragrans* were extracted by using Clevenger and Soxhlet apparatus respectively. Gas chromatography-mass spectrometry analysis of essential oil showed the presence of 38 components representing about 99.6 per cent of the total weight. Sabinene (29.4 %) was found to be a major component along with beta pinene (10.6 %), alpha pinene (10.1 %), terpene-4-ol (9.6 %), and several other minor components (Kapoor *et al.*, 2013).

2.1.2.13. Anti-oxidant value

Antioxidants are compounds that inhibit or delay oxidation of other molecules by terminating the initiation or propagation of oxidizing chain reactions. Restriction on the use of synthetic antioxidants due to their carcinogenic nature (Lindenschmidt *et al.*, 1986) has led to a growing interest in recent years in natural antioxidants of plant origin for application in food industry to combat food deterioration. The potential value of antioxidants has prompted researchers to look for natural antioxidants with low cytotoxicity.

DPPH radical is a stable long-lived nitrogen-centered free radical, the colour of which changes from violet to yellow upon reduction either by the process of hydrogen or electron donation. Substances that are able to perform this reaction can be considered as antioxidants and therefore, radical scavengers (Brand-Williams *et al.*, 1995). Singh *et al.* (2002) reported that the degree of discoloration of violet colour of DPPH, as it gets reduced, indicates the radical scavenging potential of the antioxidant. The DPPH scavenging activity has been widely used to evaluate the antiradical activities of various samples in its maximum absorption at about 517 nm. It is expressed as percentage reduction of the initial DPPH absorption by the test compound. Many antioxidants that react

quickly with transient radicals such as peroxyl radical may react slowly or may be even inert to DPPH (Huang *et al.*, 2005).

Most antioxidants are phenolic substances, more rarely nitrogen heterocycles. Unlike synthetic antioxidants, which are phenolic compounds with varying degrees of alkyl substitution, natural antioxidants can be flavonoids, phenolic acids, tannins, nitrogen containing compounds like alkaloids, amino acids, peptides, amine, carotenoids, tocopherols or ascorbic acid and its derivatives (Amarowicza *et al.*, 2004).

In recent years, researchers have focused on spicy and medicinal plants for extracting natural antioxidants which play an important role in the food industry to combat food deterioration (Szabo *et al.*, 2010).

Antioxidant properties of essential oil and oleoresins from nutmeg are of great interest in the food industry, since their possible use as natural additives emerged from a growing tendency to replace synthetic antioxidants by natural ones.Exploration of antioxidant properties in nutmeg is significant since consumption of plant-based food is favourable for reduction of oxidative stress related diseases (Carlsen *et al.*, 2010).

Bamidele *et al.* (2011) have opined that volatile oil obtained from *Myristica fragrans* Houtt. is an excellent radical scavenger of DPPH and the phenolic compounds present in it exhibited strong correlation with antioxidant capacity.

Antioxidant activity of nutmeg (*Myristica fragrans* Houtt) seed extracts was evaluated by Gupta *et al.* (2013). Seeds were extracted with acetone, ethanol, methanol, butanol and water and the extracts showed significant antioxidant property of which acetone extract showed the highest activity.

2.1.2.14. Phytochemical analysis

Successive isolation of botanical compounds from plant material is largely dependent on the type of solvent used in the extraction procedure. According to Abdullah (2009), the extraction of polyphenols in nutmeg was optimized by using

80 per cent methanol along with its high antioxidant capacities compared with hexane, chloroform and 70 per cent acetone. Plants containing tannin, alkaloid, saponin, flavonoid and glycoside showed broad spectrum antimicrobial activity (Tiwari *et al.*, 2011).

2.2. PROCESS STANDARDISATION FOR PRODUCT DEVELOPMENT

Standardisation is an important measure prior to product development. The quality, acceptability and storage stability of the products can be enhanced by proper standardisation.

2.2.1. PRE TREATMENTS

Pre-treatments confer some nutritional benefits (Deosthale, 1982) they are reported to alter the content and physico-chemical properties of components (Siljestrom *et al.*, 1986). Kingsly *et al.* (2007) stated that the pre-treatment of food materials like blanching, chemical pre-treatment, osmotic dehydration, soaking in ascorbic acid before or on drying have been found to improve the effect of drying and give eventual dried products of good nutritional quality.

2.2.1.1. Salt water treatment

Mature, green carambola (*Averrhoa carambola*) were pre-treated with 5, 10 or 15 per cent Sodium Chloride (NaCl) for 24 hours, hot-filled with vinegar, sucrose and spices, and pasteurized at 78±1°C for 15 minutes. It was found out that no differences ($P \leq 0.05$) in appearance, taste and texture were observed due to prebrining treatments, but most panelists (62 %) preferred pickles in 10 per cent brine (Mano-Francis and Badrie, 2007).

Obenland and Aung (1997) reported that NaCl reduced damage during treatments given to *Prunus persica* by reducing the amount of water entering the cells. Mao *et al.* (2006) has reported that discolouration in fresh cut watermelon pieces was prevented by immersing in 2 per cent NaCl solution. Ying and Jian-

xian (2009) stated that dipping in 2 per cent NaCl for 1 minute reduced discolouration in apple.

2.2.1.2. Steam blanching

Blanching is a mild heat pre-treatment performed prior to further processing of fruits and vegetables. It consists of heating the food rapidly to a predetermined temperature, holding for a specified time, then either cooling rapidly or passing immediately to the next processing stage. Cano *et al.* (1990) suggested that blanching is primarily done to inactivate natural enzymes. It affects the distribution of soluble components within the tissues during drying. This also results in the leakage of soluble components to the surrounding environment of water and loss of these solutes affects the rate of drying.

Blanching can be done in a number of ways which usually includes water, steam and oil blanching (Akanbi *et al.*, 2003). Blanching causes cell death, physical and metabolic chaos within the cells. The heating effect leads to enzyme destruction as well as damage to the cytoplasmic and other membranes, which become permeable to water and solutes.

Thermal processing also has a significant effect on natural antioxidants in the plant materials. It has been reported that the antioxidant activities of kale, spinach and swamp cabbage were reduced significantly after 1 minute of blanching. Phenolic compounds are also reported to be very sensitive to heat treatment even for short period of cooking (Ismail *et al.*, 2004).

Blasco *et al.* (2006) conducted a study on turmeric processing which involved blanching and drying. Blanching is a common step in the traditional processing of rhizomes, and hot air drying is an alternative to traditional solar drying. They reported that blanching previous to drying increased the process rate at all the temperatures tested, although its effect was reduced when the air drying temperature increased.

Kingsly *et al.* (2007) have reported that blanching increased the drying rate of some fruits including peach slices (*Prunus persica* L.), red pepper (*Capiscum annuum*) and carrot cubes (*Daucus carota* L.).

2.2.1.3. Hot water blanching

Postharvest heat treatment is a non-contaminating physical treatment that delays the ripening process, reduces chilling injury and controls the activity of pathogens and hence is currently used commercially for quality control of fresh products (Ferguson *et al.*, 2000). Hot water successfully eradicates incipient infections in several fruits. Produce may be immersed in hot water before storage or marketing to control diseases.

Thermal postharvest treatments have also improved the quality and shelf life of pomegranate (Artes *et al.*, 2000). It is proposed that hot water treatment of Sapote Mamey at 60°C for 60 minutes may be useful in the shelf life extension of the fruit, as well as the control of fruit flies and internal rots (Diaz-perez *et al.*, 2001). Reduction of TSS content and lowering the sweetness are disadvantage of heat treatment. Heat treatments especially hot water treatment is widely used in many countries for insect and decay control in mango (Aveno and Orden, 2004). Hot water dip treatment of 1 min at 52°C slowed the rate of rot development in litchi (Olesen *et al.*, 2004).

Dhas *et al.* (2004) reported that blanching nutmeg mace followed by drying yielded a good quality product and the dry recovery of blanched and unblanched mace was 37.14 and 37.80 per cent respectively. Blanched mace acquired a uniform deep red colour with a glossy appearance.

Heat treatment technology is a safe and environmental friendly procedure with increasing acceptability in commercial operations. It is used successfully, to control the incidence of postharvest disease in several commodities (Fallik, 2004). Fruits after harvest dipped in hot water (45-55°C) for about few minutes can enhance uniform and rapid ripening and it will control the decay. It can be used to control fungal pathogens, spores and latent infections (John, 2008). The effects of

the pre-treatments and blanching methods on curcumin, oleoresin and essential oil contents of finger rhizomes of three turmeric cultivars were determined and found that among the processing treatments, boiling rhizomes at a pressure of 0.5 Kg/cm^2 for 5 to 15 minutes showed the highest percentage of curcumin, oleoresin and essential oil (Athmaselvi, 2009).

Hot water treatment is highly effective in reducing the load of pathogens, which reduces the incidence of postharvest diseases during storage and transportation (Pal and Sharma, 2010). Rathore *et al.* (2012) reported that hot water dip is safe for controlling fungal growth in fruits which can tolerate hot water at 50 to 60°C up to 10 minutes but shorter exposure at the temperature can control many postharvest plant pathogens.

2.2.1.4. Lime water treatment

Calcium plays a very important role in the maintenance of quality in vegetable foods and it is used as a texturing agent (Lee *et al.*, 2003). Carrot shreds, sticks and slices when dipped in solutions of $CaCl_2$ alone, or with chlorine and stored at 0, 5 or 10°C showed that 0.5 per cent or 1 per cent $CaCl_2$, treatment maintained firmness and reduced microbial growth of carrot shreds at all temperatures (Izumi and Watada, 1994).

Kays (1999) studied the effect of post-harvest treatments of calcium (Ca) on cashew apple (*Anacardium oxidentale* L.) Cv. Ullal-2, during storage and found that the cashew apple treated with 0.50 per cent calcium chloride recorded minimum percentage of physiological loss in weight (PLW) and less rotting during storage.

Torres *et al.* (2006) studied the influence of osmotic treatments using 45 and 65° brix sucrose containing calcium lactate at different levels on the mechanical properties of mango samples. The mechanical properties measured were affected by treatment conditions. Calcium obviously made samples stiffer, shorter and firmer.

Kowalska *et al.* (2009) reported that temperature, sucrose concentration and time of osmotic dehydration had a significant influence on the mechanical properties of osmodehydrated apples which were simultaneously impregnated with calcium.

2.3. Product development

Value added products make any produce commercially available throughout the year and helps to promote its use.

2.3.1. Wine

Vyas and Joshi (1982) standardised a method for making wine from plums. Organoleptic evaluation of wine showed that 1:1 diluted pulp produced an acceptable quality of wine though it was little more astringent. Wine is characterised by flavours of bitterness, sourness, sweetness, saltiness and a savoury taste (Lee, 1986).

Joshi *et al.* (1990) developed a method of preparation of wild apricot wine and opined that wine prepared from 1:2 dilution was comparatively better due to balanced diet, alcohol, sugar taste, appealing colour and flavour.

Total sugars and total acids are generally considered as the two main factors for the production of wines from any juice while ethanol content is the most important parameter for evaluating wine quality. The ethanol content in wine is influenced by the type of yeast used, method of wine preparation and initial TSS before fermentation (Joshi *et al.*, 1991).

Kotecha *et al.* (1995) reported that wine from custard apple was comparable to that of grape in terms of body taste and alcohol content of 7.92 per cent. However, it scored less for colour appearance, flavour and overall acceptability than grape wine.

Jover *et al.* (2004) described the seven dimensions of wine quality as origin, the balance, flavour and bouquet of the drink, vintage, ageing ability, image, presentation, and 'acuteness' – the aromatic complexity and the intensity of the bouquet.

Reddy and Reddy (2005) reported pH, titratable acidity and ethanol percentage in the range of 3.6 to 4.0, 0.6 to 0.82 and 6.5 to 8.0 for the wine samples prepared using 6 different varieties of mango. Singh and Kaur (2009) reported the highest ethanol formation at the fermentation temperature in the range of 25 to 30°C for litchi juice, whereas Hong-Guang *et al.* (2012) reported 22.65°C as the optimum for the preparation of blue berry wine.

The sweet potato wine prepared from reconstituted juice indicated that decreasing TSS to 18° brix with inoculums size of 10 per cent (v/v) favoured highest ethanol formation (Paul *et al.* 2014).

2.3.2. Powder

The main objective of drying is the reduction of the moisture content to a level, which allows safe storage over an extended period thus extending the shelf-life. Drying of food usually results in loss of nutrients and other undesirable changes, which include discolouration and browning and hence dried products obtained are of reduced nutritional quality.

The moisture content of guava powder ranged from 1.91 to 2.36 per cent on dry weight basis. The moisture content of the spray dried powder was lower than that of freeze dried powder. Similar results were reported for orange (Brennan *et al.*, 1991), mango (Kalil and Sidel, 1994) and pineapple (Abadio *et al.*, 2004) in the dried fruit powders.

Kordylas (1991) opined that dried products have other advantages over fresh food products, which include reduced bulk and hence are easier to transport and package

Sagar *et al.* (2000) observed a rapid change in moisture content of mango powder upto two months of storage at ambient and low temperatures. This may be due to changes in weather conditions during storage.

Drying is carried out traditionally by sun drying because it is a cheap and simple method that needs low capital investments. The main disadvantage of sun drying are that it is tedious, requires long drying time and is subject to changes in weather conditions (Ispir and Togrul, 2009). The use of alternative drying

methods such as industrial drying methods (hot-air drying) to replace the traditional sun drying technique has been observed to overcome the disadvantages of sun drying.

2.3.3. Candy

Sagar and Khurdia (2000) reported that heating of ripe mango (cv. Dasehari) slices in an equal weight of sugar syrup (70° brix) containing 0.1 per cent KMS at 90°C for 2 minutes followed by drying in cabinet drier at 60°C gave the best dehydrated product

Saima (2002) reported that candy, preserve, jelly and tuti fruity under ambient and refrigerated storage were found to be free from fungi and bacteria up to six months The processed products like murabba and candy prepared from bael fruit achieved market acceptability (Tandon and Kumar, 2006).

Pineapple candy can be prepared steeping fruit pieces in 2 per cent lime solution and blanching with erythrosine colour followed by syruping so as to maintain 78° brix (Singh and Gautam 2010).

Sivakumar (2013) standardized sweet candy from aonla fruit is known for its antioxidant activity and medicinal properties with different blanching time *viz.*, 5, 10 and 15 minutes and found that candy prepared with 10 minutes blanching time was the best.

2.3.4. Osmodehydrated chunks

The fundamental purpose of food dehydration is to lower the water content in order to minimise rates of chemical reactions and to facilitate distribution and storage. In osmotic dehydration, foods are immersed or soaked in a saline or sugar solution (Ponting, 1973). The effect of sugars on cell components results mainly from protecting functionality of proteins. Yoo and Lee (1993) reported that stabilisation of three-dimensional structure of protein may be attributed to increase hydrophobic interactions and hydrophilic properties due to formation of a protein-sugar complex.

Osmotic dehydration has also been coined as 'Dewatering and Impregnation Soaking (DIS) process' (Raoult-Wack*et al.*, 1991). Osmotic dehydration considerably increases sugar content and reduces sourness with no significant damage to colour, texture and original taste of the fruits. Singh *et al.* (2011) opined that the osmotic dipping of wild apricot was presumed to reduce the fruit acidity due to leaching effect and increase the sweetness due to osmosis, so as to make them acceptable.

Mundada *et al.* (2011) studied effect of sucrose concentration on mass transfer during osmotic dehydration of pomegranate arils. Pomegranate arils immersed into 60° brix sucrose solution showed higher water loss and solid gain compared to those immersed in 40° brix and 50° brix osmotic solution.

Osmodehydration, a novel approach towards preservation, is done by immersing the fruit in an aqueous solution with a greater osmotic pressure. It involves two major processes, one being the outflow of water from the fruit and the other being inflow of solute into the fruit (Khan *et al.*, 2012).

Osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts (Pandharipande *et al.*, 2012).

Osmotic dehydration is a traditional water removal process that decreases the water activity in high water content foods such as fruits. Placing foods in a hypertonic solution, two major processes take place simultaneously *i.e.*, water flow from the food into the solution and solute transfer from the solution into the food matrix. The natural cell surface acts as a semi-permeable membrane. Since the membrane responsible for osmotic transport is not perfectly selective, other natural solutes present in the cells such as sugars, organic acids, minerals, salts, etc. can also be leached into the osmotic solution (Naknean, 2012).

2.3.5. Syrup

In modern industrial foods, syrups are often made from a less expensive fruit such as apples, pears, or pineapples and used to sweeten more expensive fruits or products and to extend their quantity.

The juice of ripe jamun fruit was used for preparing syrup and wine (Khurdiya and Roy, 1985). Products like syrup, jam and jelly were prepared from fig other than dried and dehydrated products (Woodroof, 1985). Ramdas (1988) prepared squashes, cordials, syrups and jellies from the pulp of passion fruit.

Quality juice was made from the rind of *Garcinia indica* (Rao *et al.*, 2006). This juice contained high antioxidants and radical scavenging capacities due to their higher flavonoids, anthocyanins and phenol contents.

The two cultivars of bael (*Aeagle marmelos*) *viz.*, Local cultivar of West Bengal and NB-5 were used for making syrup by combining sugar, acid, water and preservative and it was found best when stored at room temperature (25 to 37°C) and refrigerated temperatures (8 to 10°C) up to 8 to 12 months (Singh *et al.*, 2014)

2.3.6. Jam

Historically, jams and jellies were originated as an early effort to preserve fruits for consumption in the off-season (Baker *et al.*, 2005). It is an intermediate moisture food prepared by boiling fruit pulp with sugar, pectin, acid and other ingredients like preservatives, colouring and flavouring substances until a reasonably thick consistency is obtained.

Jam is usually prepared from pulp but it can be prepared from mango peel also (Pruthi, 1992). Generally, fruit jam when stored at high temperature leads to a significant decrease of nutritive values and sensorial properties (Wicklund *et al.*, 2005 and Vidhya and Narain, 2011).

Patras *et al.* (2011) observed a significant decrease in lightness of strawberry jam during storage for 28 days at 15°C. However, in another study,

Igual *et al.* (2013) showed that lightness values of grapefruit jam stored under room temperature were maintained during 90 days.

Chauhan *et al.* (2013) described that the sensory attributes for colour, appearance, flavour and overall acceptability of the coconut jam samples showed a decreasing trend, while the spread ability remained almost constant throughout the storage period of 6 months. Storage conditions are important factors for jam quality.

Touati *et al.* (2014) reported that apricot jam showed no significant variations of sensorial parameter scores after storage, except for both spread ability and overall acceptability at 5°C and taste and overall acceptability at 37°C. The overall acceptability was less affected by storage temperature of 5°C and 25° C than 37°C.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on the ''Proximate analysis and product development in nutmeg (*Myristica fragrans* Houtt.) rind'' was carried out at the Department of Processing Technology, College of Horticulture, Vellanikkara, Thrissur during 2012-2015. Vellanikkara lies between 10°32' N latitude and 70°10' E longitude and 22.25m above mean sea level. The area enjoys warm humid tropical climate throughout the year.

The whole programme was divided into 2 major experiments

3.1. Proximate analysis of nutmeg rind

3.2. Process standardization for product development

3.1. Proximate analysis of nutmeg rind

Nutmeg pericarp were collected from five locations (Plate 1) namely,

1) Shine Joseph, Kadukutty

2) Ciby George, Pattikad

3) Banana Research Station (BRS), Kannara

4) Jose Pullan, Potta

5) Joby C., Manalayi

Nutmeg fruits were collected from the trees when they were fully ripe during the main harvesting season (June – July). Nuts along with mace were separated immediately and sorting of pericarp was done to remove the damaged and undesirable ones. The selected nutmeg rinds were then carefully transported to the analytical laboratory of the Department of Processing technology in polythene bags. They were then thoroughly washed in clean water in order tominimize the field heat. The physiochemical property of nutmeg rind was

Plate 1. Nutmeg trees from five different locations

Location 1
Kadukutty

Location 2
Pattikkad

Location 3
BRS Kannara

Location 4
Potta

Location 5
Manalayi

studied without any delay and the mean value of the biochemical constituents were found out.

3.1.1. Observations

Physical and biochemical characters were studied in unpeeled nutmeg pericarp.

3.1.1.1. Physical characters

3.1.1.1.1. Colour

Pericarp colour of sample was visually observed and identified with the help of Universal Colour Language (UCL). The Universal Colour Language is a colour menu defined by the Inter-society Colour Council, National Bureau of Standards in 1946 and approved by Royal Horticultural Society (Anonymous, 1999). A valid UCL colour name contains a value, plus hue and a hue modifier.

3.1.1.1.2. Texture

The texture of the nutmeg rind was objectively analysed by measuring the pressure required to penetrate the firm tissues using a Penetrometer.

3.1.1.2. Biochemical constituents

3.1.1.2.1. Moisture

Moisture content of the product was estimated by oven drying method. 10 grams (g) of the product was kept in hot air oven and dried until its weight became constant. The moisture content was calculated and expressed in percentage (Ranganna, 1986).

3.1.1.2.2. Total Soluble Solids (TSS)

TSS of the juice extracted from the rind was measured using a hand refractometer (range 0 - 32° brix) expressed in degree brix (A.O.A.C, 1980).

3.1.1.2.3. Crude fibre

Crude fibre content of the sample was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

A known weight of the sample was first treated with acid and subsequently with alkali. The residue obtained after final titration was weighed, incinerated, cooled and weighed again. The crude fibre was given by the difference in weight and expressed as percentage.

3.1.1.2.4. Acidity

Acidity was determined by titration with standard sodium hydroxide solution (0.1N NaoH), and expressed as per cent of citric acid.

A known weight of the pulped fruit rind was weighed accurately and placed in 250 ml conical flask. 100 ml of water was added and boiled for 15 minutes on the gas burner. The extract was cooled and made up to 250 ml in a volumetric flask. It was mixed well and filtered through filter paper. An aliquot of the digest was treated with standard alkali using phenolphthalein as indicator (Ranganna, 1997).

3.1.1.2.5. Total, reducing and non-reducing sugars

Total sugars and reducing sugars were determined according to the procedure described by Ranganna (1997) using Fehling's solution and expressed as grams of glucose per 100 grams of pulp. The estimation of non-reducing sugars was done by subtracting the reducing sugars from the total sugars and expressed as grams of glucose per 100 grams of pulp.

3.1.1.2.6. Pectin

Pectin was determined by gravimetric method as per the procedure described by Ranganna (1986).

Pectin was extracted from the plant material and saponified. It was precipitated as calcium pectate by the addition of calcium chloride to an acid solution. After thoroughly washing to eliminate chloride ions, the precipitate was dried and weighed.

3.1.1.2.7. Total phenol

Total phenol estimation was carried out with Folin – Ciocalteau reagent. Phenols react with phosphomolybdic acid in alkaline medium and produce a blue coloured complex (Molybdenum blue).

The sample (1 g) was ground well in a mortar and pestle with 10 to 15 ml of 80 per cent ethanol. It was centrifuged and the residue was re-extracted twice and pooled. The supernatant was evaporated to dryness. The residue was dissolved with 5 ml of distilled water. The supernatant used for total phenol estimation was pipetted out into a series of test tubes. Sample extract (0.2 ml) was pipetted out in other test tubes.

To each test tube including blank, 3ml distilled water was added. It was mixed with 0.5 ml Folin-Ciocalteau reagent. It was mixed well and allowed to stand for 3 minutes. To all test tubes, 20 per cent sodium carbonate (2 ml) was added, mixed thoroughly and kept for 1 hour. All the tubes were kept in boiling water for exactly one minute and cooled. Optical density values were recorded in a spectrophotometer at 650 nm. A standard graph was drawn and the amount of total phenol in the sample was calculated.

3.1.1.2.8. Tannin

Tannin content of nutmeg pericarp was determined by the Folin-Dennis method.

Weighed 0.5 g sample and transferred it to a 250 ml conical flask. Water (75 ml) was added and the flask was heated gently for 30 minutes. Aliquot was centrifuged at 2000 rpm for 20 minutes. The supernatant was collected in 100 ml volumetric flask and made up the volume. 1 ml aliquot was transferred into 100

ml volumetric flask containing 75 ml water, 5 ml of Folin-Denis reagent and 10 ml sodium carbonate was added and made up to 100 ml. Optical density was recorded at 700 nm in a spectrophotometer after 30 minutes. Blank was prepared with water.

A standard graph was drawn using serial dilution of tannic acid solution and from the graph tannin content of pericarp was estimated. Tannin was expressed as mg/g.

3.1.1.2.9. Ascorbic acid

Five grams of the rind was taken and extracted with four per cent oxalic acid. Ascorbic acid was estimated by using standard indicator dye 2, 6-dichlorophenol indophenol and expressed as mg/100g of fruit (Sadasivam and Manickam, 1996).

3.1.1.2.10. Protein

The protein content of nutmeg rind was determined by Lowry's method.

The sample (0.5 g) was ground well in a mortar and pestle with 5 to 10 ml of phosphate buffer. It was centrifuged and supernatant used for protein estimation was pipetted out into a series of test tubes. Sample extract (0.2 ml) was pipetted out in other test tubes. Tubes with one ml water served as blank.

To each test tube including blank, Reagent C (5 ml) was added. It was mixed well and allowed to stand for 10 minutes. To all test tubes Reagent D (0.5 ml) was added, mixed well and incubated at room temperature in the dark for 30 minutes till blue colour was developed. Optical density values were recorded in a spectrophotometer at 660 nm. A standard graph was drawn and the amount of protein in the sample was calculated.

3.1.1.2.11. Starch

The starch content was analysed colorimetrically using anthrone reagent as suggested by Sadasivam and Manickam (1996).

Starch content wasestimated by hydrolysing starch into simple sugars. The sample (0.5 g) was treated with 80 per cent ethanol to remove sugars and then starch was extracted with perchloric acid. Sample extract (0.2 ml) was pipetted and tubes with one ml water served as blank. To each test tube including blank, anthrone reagent (4 ml) was added. The tubes were kept in boiling water bath for 8 minutes and cooled rapidly. This compound formed a green coloured product and its absorbance was measured at 630 nm which was expressed as percentage.

3.1.1.2.12. Carotene

β-carotene was estimated by procedure suggested by Ranganna (1997).

The sample was extracted using petroleum ether. To five gramme of nutmeg rind in a mortar, 15 ml of petroleum ether was added, the mixture crushed thoroughly and the clear extract was transferred immediately into a separating funnel. Likewise, the extraction was done until the sample became colourless and pooled together. More petroleum ether (15 ml) along with water was added, the bottle shaken for 5 to10 minutes, allowed to stand. The water settled at the bottom was removed and the petroleum ether extract was separated out which is passed through sodium sulphate. The extract was made up to mark with more petroleum ether in a known volume of standard flask and the absorbancy was observed at 452 nm in a spectrophotometer.

The standard curve for spectrophotometric readings was derived using absorbancy readings obtained for standard β-carotene dissolved in petroleum ether at concentrations of 0.005 to 0.02 mg/ml. The β-carotene measurements were at 450 nm. The calculation of β-carotene was as follows:

$$\beta\text{-carotene content } (\mu g/100g) = \frac{\text{Observed } \beta\text{-carotene content } (\mu g/ml) \times OD \times V \times 100}{W}$$

Where,

V = volume of extract made up

D = optical density

W = sample weight

The biochemical characters of peeled rind were also carried out in the same way.

3.1.1.2.13. Anti-oxidant value

The antioxidant activity of the dried nutmeg pericarp was estimated by the method suggested by Blois (1958) using DPPH (1,1-diphenyl-1-picryl hydrazine). To various concentrations of the sample, methanolic solution containing DPPH radicals (0.1 mM) was added and shaken vigorously. The reaction mixture was then left to stand for thirty minutes in dark (Plate 2). After the incubation period the absorbance was measured at 517 nm against the corresponding test blanks. The percentage inhibition of DPPH free radical was calculated using the formula,

$$\text{Per cent Inhibition} = \frac{\text{Control-sample}}{\text{Control}} \text{ X } 100$$

The sample concentration providing 50 per cent inhibition (Inhibitory concentration - IC_{50}) was calculated from the graph of RSA (Radical Scavenging Activity) percentage against sample concentration. Gallic acid was used as standard.

3.1.1.2.14. Oil and its profile using GC-MS

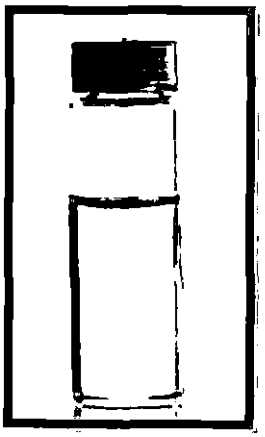
The volatile oil content of the fresh and dried rind was determined by distillation method using Clevenger apparatus. As the oil recovery was very less, further extraction of oil from nutmeg rind was carried out in a steam distillation unit (Plate 3).

Fifty grams of dried sample and 700 ml of distilled water were taken in a round bottom flask attached to Clevenger apparatus with condenser. The flask was heated with frequent agitation, until distillation commenced and the distillation was continued at the rate of 60 to 70 drops per minute. The flask was rotated occasionally to wash down any material adhering to the upper part of the wall. The distillation was carried for three hours and the oil was collected in the receiver of the Clevenger apparatus, which contained distilled water. The

Plate 2. Antioxidant activity of methanol extract of nutmeg rind using DPPH

Plate 3. Essential oil extraction from nutmeg pericarp

Essential oil extracting unit



Essential oil

extracted oil was cooled to room temperature and allowed to stand until oil layer was clean. The volume of oil collected after cooling was expressed as per cent volume (V) per unit mass of sample.

$$\text{Volatile oil (per cent)} = \frac{V}{W}$$

Where, V = Volume of oil collected (ml)

W = Total weight of the sample (g)

The volatile oil profiling of *Myristica fragrans* was carried out using gas chromatography-mass spectroscopy (GC-MS). The GC-MS profiling was done with Agilent technologies of GC model 7890 A and MS model of 5975 C provided with a GC column (DB-5MS) of 30 m length, 0.25 mm breadth and 0.25 µm film thickness. Helium was used as carrier gas with a flow rate of 1.0 ml/min. The essential oil (1 µl) is fed to the injector at a temperature set as 250°C and the column temperature was programmed from 60 to 280°C at an increasing rate of 5°C/min, held at initial and final temperature for 5 min. The major peaks were analysed by comparing its mass fragments patterns with the standard spectra available in the main library.

3.1.1.2.15. Oleoresin

The oleoresin was extracted with acetone (60°C boiling range) by employing a solvent extraction method using a Soxhlet apparatus.

15 g of powdered sample was packed in a thimble and kept in the extraction tube of the soxhlet apparatus. About 75 ml of acetone was taken in the soxhlet flask and attached to the extraction tube along with a condenser. The extraction was continued for three to four hours on a water bath until no colour was observed in the soxhlet apparatus. At the end of the extraction, the thimble was removed from the apparatus and distilled further for the removal of the solvent. The traces of the solvent were removed at room temperature by gentle heating.

$$\text{Oleoresin (per cent)} = \frac{\text{Weight of extracted oleoresin}}{\text{Initial weight of sample}} \times 100$$

3.1.1.2.16. Preliminary phytochemical screening

The preliminary phytochemical screening of nutmeg pericarp extracts was analysed using the method suggested by Sazada *et al.* (2009). The pericarp was air dried under shade and powdered to obtain a fine powder. About 25 g of fine powderedsample was extracted in a soxhlet apparatus using three different solvents like petroleum ether, acetone and methanol. The preliminary screening of the three extracts from nutmeg rind was carried out.

3.1.1.2.16.1. Test for carbohydrate

Fehling's test: Dissolved 2 ml of extract in 4 ml distilled water and heated with 2 ml of Fehling's reagent (A and B). Reddish brown colour indicated the presence of carbohydrates.

3.1.1.2.16.2. Test for flavonoids

Lead acetate test: To 5 ml of extract, added 1 ml of lead acetate. Flocculent white precipitate indicates the presence of flavonoids.

To 1 ml of the extract, added 1 ml of sulphuric acid along the sides of the test tubes. Orange colour formation indicated the presence of flavonoids.

3.1.1.2.16.3. Test for tannins

Braemer's test: To 3 ml of the extract added 3 ml of 10 per cent alcoholic ferric chloride solution. Dark blue or greenish colouration of the solution indicates the presence of tannins in the sample.

3.1.1.2.16.4. Test for alkaloids

Wagner's test: To 3 ml of the extract added 2 ml of Wagner's reagent. Reddish brown precipitate indicated the presence of alkaloids.

3.1.1.2.16.5. Test for saponins

Foam test: Dilute 1 ml of the extract with 20 ml distilled water and shaken in a graduated cylinder for 15 minutes. A one centimetre layer of foam indicated the presence of saponins.

3.1.1.2.16.6. Test for amino acids

Ninhydrin test: To 3 ml of the extract added 1ml of Ninhydrin reagent and heated for few minutes. Purple colour indicated the presence of amino acids.

3.1.1.2.16.7. Test for fixed oils and fats

Pressed small quantity of the extract between two filter papers. Oil stains on the paper indicates the presence of fixed oils.

3.1.1.2.16.8. Test for phenols

To 1 ml of the extract, added 2ml of 5 per cent ferric chloride solution along the sides of the test tube. A dark green colour indicated the presence of phenolic compound.

3.1.1.2.16.9. Test for terpenoids

To 1 ml of the extract, added 1 ml of chloroform followed by a few drops of concentrated sulphuric acid. A reddish brown precipitate produced immediately indicated the presence of terpenoids.

3.1.1.2.16.10. Test for steroids

To 1 ml of the extract added 1 ml acetic acid, 1 ml of chloroform followed by 0.5 ml sulphuric acid. If the test solution shows violet to blue green formation, it denoted the presence of steroids.

3.1.1.2.16.11. Test for quinones

1 ml of the extract was treated with 5 ml of concentrated hydrochloric acid. Formation of yellow coloured precipitate denoted the presence of quinone.

3.1.1.2.16.12. Test for coumarin

Treated 2 ml of the extract with 3 ml of 10 per cent sodium hydrochloride in a test tube. If the solution turns to yellow colour, then it contains coumarin.

3.1.1.2.17. Mineral composition in nutmeg rind

The powdered nutmeg rind was analysed for the presence of potassium, calcium, magnesium, copper, iron, zinc and manganese. Minerals like iron, copper, manganese and zinc was determined using Perkin Elmeratomic absorption spectrophotometry (Model: Analyst 400). The potassium content was estimated by flame photometry.

3.2 Process standardization for product development

Nutmeg rinds were collected from nutmeg plants maintained by Mr. Jose Pullan, Potta. Since the nutmeg grafts were used for raising the garden, the rinds were of uniform quality and the phenol content of the rinds was comparatively less.

3.2.1 Standardization of pre-treatments

The fruits were peeled using a sharp stainless steel knife and pre-treatments were given to reduce astringency for both peeled and unpeeled rind.

3.2.1.1 Pre-treatments

T_1 - Hot water blanching (80°C for 5 min)

T_2 – Steam blanching (5 min)

T_3 – Lime water treatment (2 % for 2 hours)

T_4 – Salt water treatment (10 % for 4 hours)

T_5 – Salt water treatment (3 % for 48 hours)

T_6 – Control

3.2.1.1.1. Observations

3.2.1.1.1.1. Total sugars

Same as mentioned in 3.1.1.2.5.

3.2.1.1.1.2. Titrable acidity

Same as mentioned in 3.1.1.2.4.

3.2.1.1.1.3. Ascorbic acid

Same as mentioned in 3.1.1.2.9.

3.2.1.1.1.4. Total phenol

Same as mentioned in 3.1.1.2.7.

The best pre- treatment which reduced the astringency was selected for product development.

3.2.2. Lay out

The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications each with a sample size of ten fruits.

3.2.3. Product diversification

The products were prepared by using the rind taken from the best pre-treatment.

3.2.3.1. Wine

A preliminary comparison was made to find out the quality of wine prepared from peeled and unpeeled rind of nutmeg by keeping in 3 per cent brine for 48 hrs. The wine was prepared with rind, sugar and water in the ratio 1:1:1, 1:0.75:1 and 1:0.5:1 respectively.

The treated nutmeg rind was taken in porcelain jars. Starter solution with yeast was prepared and kept for 10 to 15 minutes until frothing was observed. After that, this starter solution was added to the treated fruits and the jar was

sealed airtight. The contents were stirred without opening the jars daily for a period of 2 weeks. The wine was kept for clarification and the clear wine was decanted after

45 days, transferred to sterilized glass bottles and sealed airtight.

Sensory attributes of the wine were evaluated on a nine point hedonic scale at monthly intervals with a panel of 10 semi trained judges. The alcohol percentage of the samples was also analysed. The bottles were stored at an ambient temperature for a period of 3 months. The microbial counts were observed during the initial and final months.

3.2.3.2. Powder

Nutmeg rind was dried by two methods namely solar drying and cabinet drying.

One kilogram of pre-treated unpeeled rind was chopped into small pieces and dried in a cabinet drier RRLT NC drier at a temperature of 60°C for a period of 48 hrs and same quantity of rind was kept in sun for 72 hrs until it attained a constant moisture level. It was further powdered and stored in standard Polyethylene Terephthalate (PET) bottles.

3.2.3.3. Candy

Pre-treated peeled nutmeg rinds (1 Kg) were steam blanched for 10 minutes, sliced into longitudinal flakes and also into small bits. The slices of nutmeg rind were steeped in sugar syrup of 40° brix along with 1.0 g potassium metabisulphite (KMS) and 1.0 g citric acid and kept overnight. The syrup was drained and concentration was increased by 5° brix daily until it reaches 70° brix by boiling the syrup everytime.

The slices were kept in 70° brix syrup for a period until the equilibrium was reached between the slices and the sugar concentration. The slices were drained free of syrup, rinsed immediately in lukewarm water and kept in cabinet

drier at 60°C for 6 to 8 hours. The candy was packed in air tight food grade plastic containers and stored under ambient condition.

3.2.3.4. Osmodehydrated chunks (OD)

Pre-treated peeled nutmeg rinds were steam blanched for 10 minutes, sliced into longitudinal flakes and1 kg immersed in sugar syrup of 70° brix along with 1.0 g KMS and 1.0 g citric acid for a period of 12 hrs, 24 hrs and 48 hrs respectively. The slices were drained free of syrup, washed in lukewarm water and kept in cabinet drier for 6 to 8 hours. The dried slices were coated with powdered sugar and packed in air tight food grade plastic containers and stored under ambient condition

3.2.3.5. Syrup

Syrup was prepared by using two types of pre-treated unpeeled nutmeg rind extracts *viz.,* pressure cooked extract and hot water extract.

Equal quantities of water and chopped nutmeg rinds were steam blanched for 15 minutes. The extract was strained out and mixed with the sugar and boiled until the TSS reached 65° brix.

Rinds were chopped and double quantity of water was boiled in a low flame for a period of 30 minutes. The extract obtained was mixed with the sugar and boiled until the TSS reached 65° brix. The syrup was then packed in glass bottles and sealed airtight.

3.2.3.6. Jam

Nutmeg rind jam was prepared by boiling equal quantities of pre-treated steam blanched peeled fruit pulp and sugar in 1:1, 1:1.5 and 1:2 ratios. The citric acid (1.0 g) and 1.0 g KMS was added and the final TSS with not less than 68° brix. The pectin in the fruit along with sugar and acid gave a jel like consistency which resulted in the formation of jam, these were filled in sterilized glass bottles, sealed and stored under ambient temperature.

3.2.3.6.1. Observations

3.2.3.6.1.1. Total sugars

Same as mentioned in 3.1.1.2.5.

3.2.3.6.1.2. Titrable acidity

Same as mentioned in 3.1.1.2.4.

3.2.3.6.1.3. Ascorbic acid

Same as mentioned in 3.1.1.2.9.

3.2.3.6.1.4. Total phenol

Same as mentioned in 3.1.1.2.7.

3.2.3.6.1.5. Sensory evaluation at monthly intervals

3.2.3.6.1.6. Benefit cost ratio

3.2.3.6.1.7. Microbial load – Initial and 3 months after storage

3.2.3.6.1.5. Sensory evaluation

The prepared products were evaluated at monthly intervals using a nine point hedonic scale to assess the colour, appearance, flavour, taste, texture, after taste and overall acceptability of the products by a panel of 10 semi trained judges. For organoleptic test, Kendalls co-efficient of concordance was performed and the mean rank scores were taken to differentiate the best product.

3.2.3.6.1.6. Benefit cost ratio

The benefit cost ratio of all the products were calculated and given in Appendix (IV).

3.2.3.6.1.7. Enumeration of total microorganisms

The microbial population of the above products were assessed initially as well after a period of 3 months. The quantitative assay of the microflora was carried out by serial dilution pour plate technique (Johnson and Curl, 1972). Nutrient agar medium, Rose Bengal agar medium and Sabourd Dextrose agar

medium were used for the enumeration of bacterial, fungal and yeast population of the products respectively (Appendix III).

One gram of sample was suspended in 100 ml of sterile distilled water taken in a conical flask and shaken thoroughly for 20 minutes in an orbit shaker. From this 1 ml of the supernatant was accurately pipetted out using a micropipette into a test tube containing 9 ml of sterile distilled water to get 10^{-2} dilution. This procedure was again repeated to get 10^{-5} dilution. One ml each of 10^{-5} and 10^{-3} dilution was used for enumeration of total bacterial, fungal and yeast count of the sample respectively. The bacterial count was recorded after two days whereas fungal and yeast count was recorded four days after inoculation. The number of microorganisms per gram of sample was calculated by the formula

$$\text{No. of colony forming units (CFU) per gram of the sample} = \frac{\text{Mean number of CFU}}{\text{Quantity of the sample weight}} \times 100$$

Results

4. RESULTS

The results of the present study entitled "Proximate analysis and product development in nutmeg (*Myristica fragrans* Houtt.) rind" is presented in this chapter under the following sections.

1. Proximate analysis

2. Standardization of pre-treatments

3. Product diversification

4.1 PROXIMATE ANALYSIS

The nutmeg rind harvested during the active monsoon season was used for analysis. When the fruits reach full maturity, the rind splits at the base of the fruit and it falls down. At this stage the rind was collected. Observations on the physical and biochemical attributes of nutmeg rind were recorded and presented below. A wide variation was observed in experiment I.

4.1.1. Physical characters

The physical characters observed are colour and texture. Colour is an important character which determines the maturity stage of the fruit and the acceptance of any produce by a consumer. The colour measurement is also an indicator of some inner constituents of the material. The colour analysis done by visual comparison of rind colour using Universal Colour Language (UCL) showed that the colour was pale greenish yellow (UCL code - RHS 104 10D). The colour was changed to moderate orangish yellow (UCL code – RHS 164 71C) when kept under room temperature.

Texture is also an important parameter influencing the quality of fresh and processed products. Textural quality attributes of food may be evaluated by descriptive sensory (subjective) or instrumental (objective) analyses. The texture of the nutmeg rind was objectively analysed and it was observed that, at harvest

maturity, the texture obtained as pressure for penetrating the fruit flesh using penetrometer was 1.85 Kg/cm^2.

4.1.2. Biochemical constituents

The biochemical characters of nutmeg rind were estimated and are given in Table 1. Nutmeg rind, botanically known as the rind of the fruit constituting 80 to 85 per cent of whole fruit weight was having a high moisture content of 88.45 per cent. The fresh rind contains an acidic astringent juice with an aromatic flavour. The acidity recorded in rind was 1.43 per cent. The astringent nature of the rind may be due to its high total phenol (35.20 mg/100g) and tannin content (33.80 mg/100g). The TSS of nutmeg rind was less (3.38° brix) and therefore it had low total sugars (2.69 %). In the present study, the rind showed the presence of 1.25 g/100 protein, 2.55 per cent crude fibre and 0.78 per cent pectin. Nutmeg rind is a poor source of ascorbic acid (11.45 mg/100g) and it contains starch (0.95 g/100g) and carotene (37.82 µg/100g).

4.1.3. Mineral composition

The mineral content in rind were also analysed and given in Table 2. The important minerals present in the nutmeg rind are potassium (0.810 %), calcium (0.413 %), magnesium (0.130 %), copper (1.150 mg/100g), iron (6.078 mg/100g), zinc (2.940 mg/100g), and manganese (0.470 mg/100g) of which the iron content was comparatively high (6.078 mg/100g).

4.1.4.Anti-oxidant activity

Natural antioxidants have gained considerable interest in recent years for their role in preventing the auto oxidation of fats, oils and fat containing food products. The DPPH assay was conducted and initially the solution was deep violet in colour which was changed to light yellow. The activity of nutmeg rind was compared to that of gallic acid and was found that the IC_{50} value of sample

was 120 µg/ml while that of standard was 1.25 µg/ml showing the presence of antioxidants in the rind (Fig 3.)

4.1.5. Essential oil and Oleoresin

The nutmeg rind oil is colourless in nature and the oil recovery percentage in fresh sample is 0.05 per cent and that of dried sample was 0.10 per cent. The GC-MS profiling of the nutmeg rind oil (Fig. 1) exhibited a six peak chromatogram and the compounds (Fig 2.) found were myristicin (1.52 %), elemicin (25.67 %), terpenen-4-ol (35.89 %), alpha-terpineol (20.49 %), methyl (Z)-N-hydroxybenzenecarboximidate (13.45 %) and 1,2–dimethoxy–4[(Z)-1-methoxyprop-1-enyl] benzene (2.98 %). The oleoresin recovery was estimated to be 3.17 per cent (Plate 4).

4.1.6. Phytochemical studies

The rind which is not having any uses conventionally was analysed for the presence of these phytochemical compounds as shown in Plate 5. Petroleum ether, acetone and methanol extracts of nutmeg rind were screened for phytochemicals and given in Table 3. It showed that flavonoids, saponins and terpenoids were present in all the three extracts. Tannins and phenols were present in acetone and methanol extracts. Carbohydrate was observed only in methanol extract. Steroids, quinones, amino acids, fixed oils and fats, alkaloids and coumarins were not seen in all the three extracts.

4.2. STANDARDIZATION OF PRE-TREATMENT

Nutmeg rind is having astringent taste due to the presence of tannins and other phytochemicals. There is ample scope to improve the texture, and taste of rind by mechanical, physical and chemical treatments of the rind. In this study, all these three methods were tried to improve the rind quality. Manual peeling was done and the biochemical parameters were studied. In addition, the physical and

Fig 1. Chromatogram of nutmeg rind oil using GC-MS

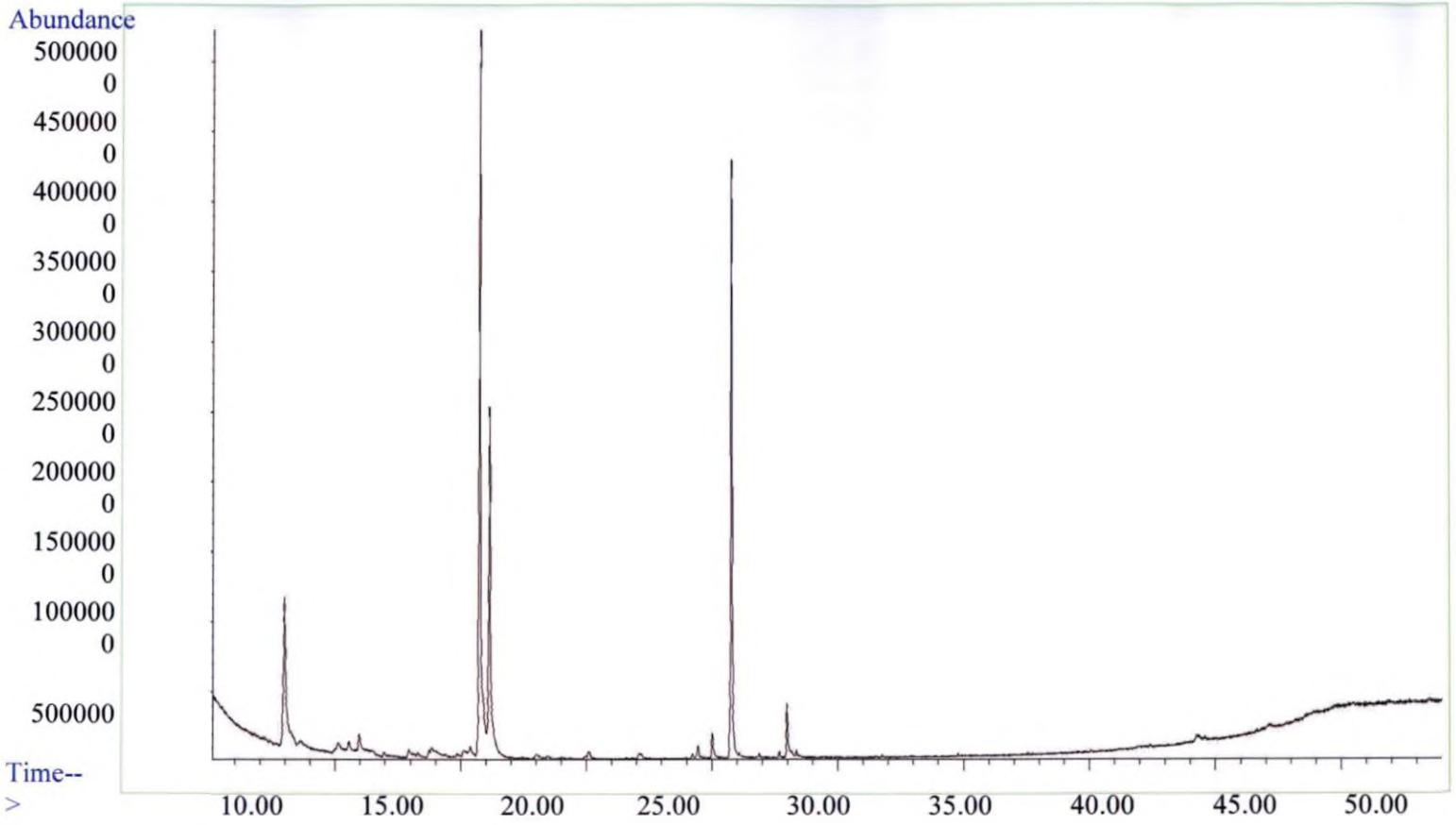


Fig 2. Essential oil composition of nutmeg rind

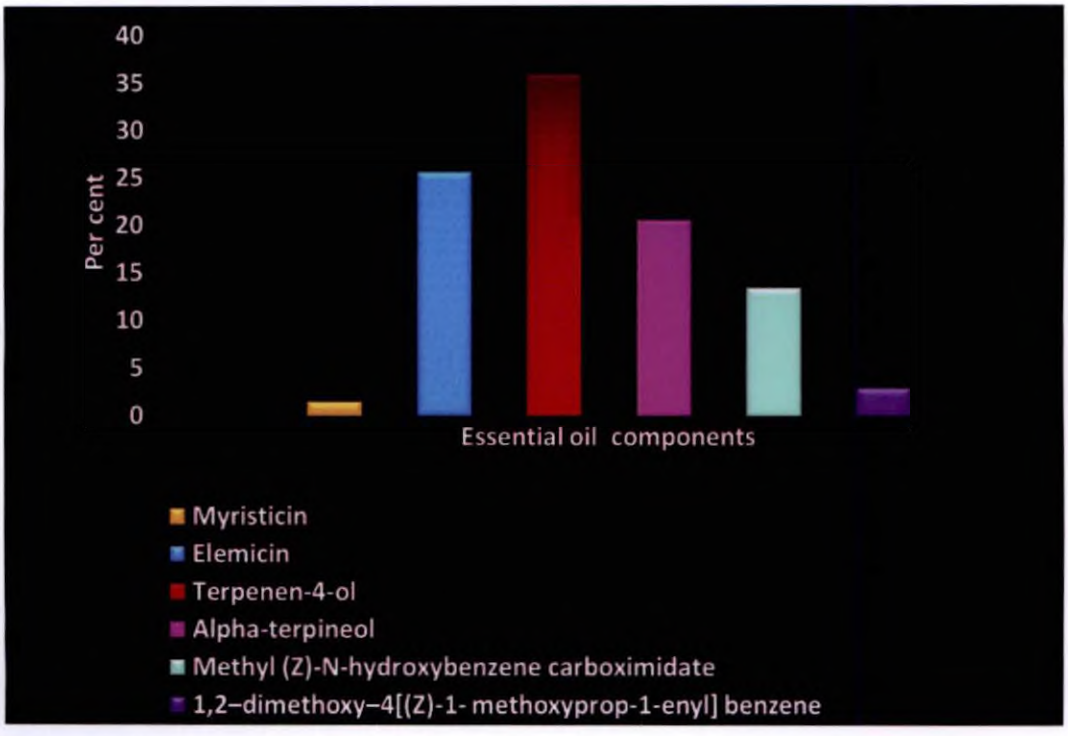


Fig 3. Antioxidant activity of nutmeg rind

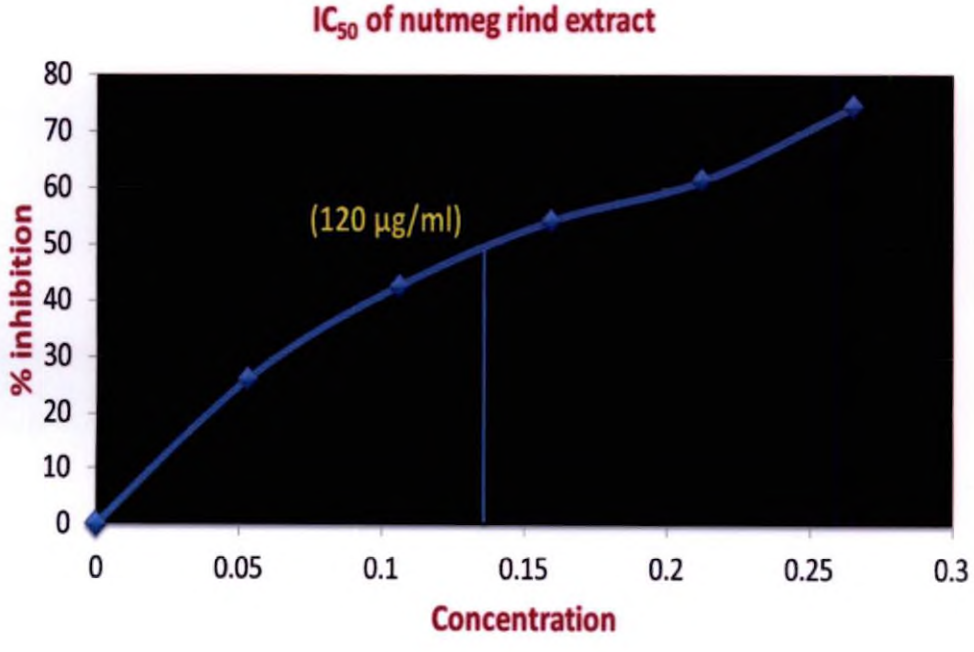
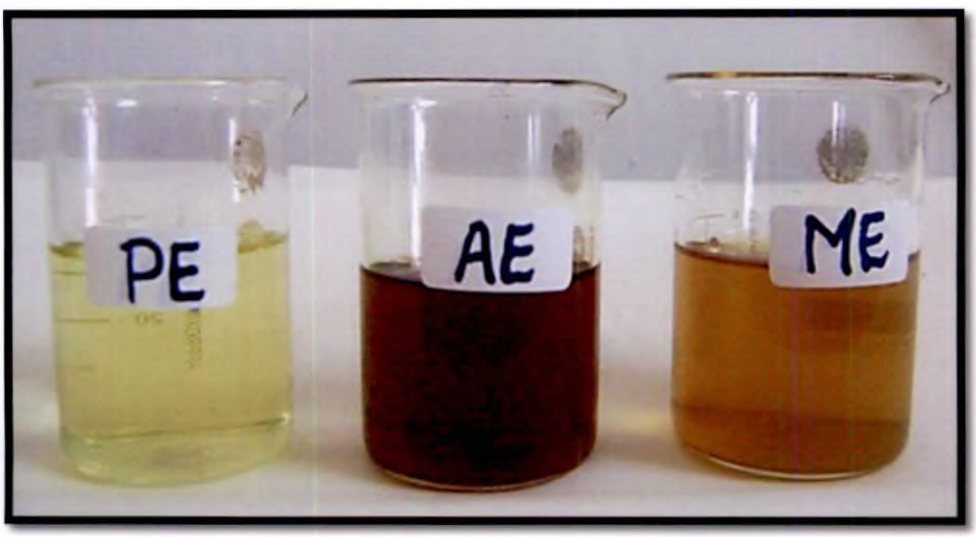


Plate 4. Oleoresin extracted from nutmeg rind

Plate 5. Phytochemical analysis of extracts from nutmeg rind



Petroleum ether extract **Acetone extract** **Methanol extract**

Table 1. Biochemical constituents of nutmeg rind from 5 locations

SL No.	Characters observed	Location 1 Kadukutty	Location 2 Pattikkad	Location 3 Kannara	Location 4 Potta	Location 5 Manalayi	Mean Value
1	Moisture (%)	89.17	86.10	89.39	88.90	88.68	88.45
2	TSS (° brix)	3.40	3.00	3.00	4.20	3.30	3.38
3	Crude fibre (%)	2.15	2.45	1.73	3.75	2.66	2.55
4	Acidity (%)	1.39	1.28	1.65	1.22	1.63	1.43
5	Total sugar (%)	2.56	2.49	2.27	3.66	2.48	2.69
6	Reducing sugar (%)	1.98	1.89	1.77	2.90	1.92	2.09
7	Non reducing sugar (%)	0.58	0.60	0.50	0.76	0.56	0.60
8	Pectin (%)	1.03	0.55	0.79	0.95	0.60	0.78
9	Total phenol (mg/100g)	44.00	48.00	33.00	25.00	26.00	35.20
10	Tannin (mg/100g)	36.00	23.00	48.00	34.00	28.00	33.80
11	Vitamin C (mg/100g)	13.32	19.04	9.52	10.25	5.12	11.45
12	Protein (g/100g)	1.46	0.90	0.97	1.58	1.35	1.25
13	Starch (g/100g)	0.72	0.90	0.86	1.01	1.27	0.95
14	Carotene (µg/100g)	38.57	33.25	39.40	40.10	37.80	37.82

*Mean value of 3 replications from 5 locations

Table 2. Mineral composition in unpeeled nutmeg rind

Mineral composition	Value
Potassium	0.810 %
Calcium	0.413 %
Magnesium	0.130 %
Copper	1.150 mg/100g
Iron	6.078 mg/100g
Zinc	2.940 mg/100g
Manganese	0.470 mg/100g

Table 3. Preliminary phytochemical screening of nutmeg rind extracts

Sl. No.	Tests	Extracts		
		Petroleum Ether	Acetone	Methanol
1	Carbohydrate	–	–	+
2	Flavonoids	+	+	+
3	Tannins	–	+	+
4	Alkaloids	–	–	–
5	Saponins	+	+	+
6	Amino acids	–	–	–
7	Fixed oils and fats	–	–	–
8	Phenols	–	+	+
9	Terpenoids	+	+	+
10	Steroids	–	–	–
11	Quinone	–	–	–
12	Coumarin	–	–	–

(-) Absence (+) Presence

chemical treatments were given to the peeled and unpeeled rind. The biochemical constituents of peeled rind are given in Table 4.

The moisture, acidity and total phenol content were higher for peeled sample when compared to that of unpeeled rind whereas the biochemical constituents like crude fibre, pectin, tannin, vitamin C, protein, carotene, reducing sugar, non-reducing and total sugars were relatively higher for the unpeeled nutmeg rind.

The treatments given for peeled and unpeeled rind are as follows:

1. Hot water blanching 80°C for 5 min (T_1)
2. Steam blanching for 5 min (T_2)
3. Lime water treatment 2 % for 2 hrs (T_3)
4. Salt water treatment 10 % for 4 hrs (T_4)
5. Salt water treatment 3 % for 48 hrs (T_5)
6. Control (T_6)

The effect of pre-treatments on acidity, total sugars, total phenols and ascorbic acid was observed and their interactions were also studied, as given in Table 6. There was no significant difference in the titrable acidity and total phenol content between peeled and unpeeled nutmeg rind. But the ascorbic acid content showed a significant difference between peeled (12.92 mg/100 g) and unpeeled (12.34 mg/100 g) rinds. There was significant difference in total sugar content of peeled and unpeeled nutmeg rind. The unpeeled nutmeg rind had a higher total sugar per cent of 2.57 as compared to that of peeled rind (2.22 %).

4.2.1. Effect of pre-treatment on the biochemical constituents

4.2.1.1. Firmness analysis of pre-treated nutmeg rinds

The texture of the pre-treated samples was estimated using penetrometer and the results are presented in Table 5. As far as the texture of the samples is considered, the control samples (T_6) possessed the least firmness (1.86 Kg/cm^2)

Table 4. Comparison of biochemical constituents of peeled and unpeeled rinds

Biochemical analysis	Peeled	Unpeeled
Moisture (%)	89.50	88.45
TSS (° brix)	3.00	3.38
Crude fibre (%)	1.95	2.55
Acidity (%)	1.60	1.43
Total Sugar (%)	2.25	2.69
Reducing Sugar (%)	1.78	2.09
Non reducing Sugar (%)	0.47	0.60
Pectin (%)	0.04	0.78
Total phenol (mg/100g)	45.00	35.20
Tannins (mg/100g)	26.00	33.80
Vitamin C (mg/100g)	9.28	11.45
Protein (g/100g)	0.88	1.25
Starch (g/100g)	0.92	0.95
Carotene (µg/100g)	33.45	37.82

Table 5. Effect of pre-treatments on firmness of nutmeg rinds

Pre-treatments	Texture (Kg/cm^2)
Hot water blanching 80°C for 5 min - T_1	4.81
Steam blanching for 5 min - T_2	4.04
Lime water treatment 2 % for 2 hrs - T_3	4.83
Salt water treatment 10 % for 4 hrs - T_4	4.22
Salt water treatment 3 % for 48 hrs - T_5	3.70
Control - T_6	1.86

and among the treatments, 2 per cent lime water treatment for 2 hrs (T_3) showed the maximum firmness (4.83 Kg/cm^2). The salt water treated rind (T_5) showed medium penetrance (3.70 Kg/cm^2).

4.2.1.2. Total sugars

Within the pre-treatments, the highest total sugars was seen in hot water blanched rinds at 80°C for 5 minutes (3.75 %) followed by steam blanching for 5 minutes and the least was observed in 3 per cent salt water for 48 hrs (1.58 %). There observed a significant difference in the pre-treatments.

4.2.1.3. Acidity

Among the six pre-treatments, the salt water treated rind (3 % for 48 hrs) possessed the least titrable acidity of 0.64 per cent followed by lime water treatment (2 % for 2hrs) and the highest acidity observed was 1.60 per cent in steam blanched sample and salt water treatment (10 % for 4 hrs). There was no significant difference in the interaction of pre-treatments.

4.2.1.4. Ascorbic acid

The highest ascorbic acid content of 19.04 mg/100 g was observed in rinds treated with 2 per cent lime water for 2 hours followed by rinds treated in 3 per cent salt water for 48 hours. The least observed was 8.35 mg/100 g in salt water treatment (10 % for 4 hrs).

4.2.1.5. Total phenol

The least phenol content of 0.26 mg/g was noticed in rinds treated in 3 per cent salt water for 48 hrs followed by 0.35 mg/g in hot water treatment. The highest phenol content was observed in steam blanching treatment.

Therefore, considering all the biochemical constituents, 3 per cent salt water treatment for 48 hours was found to be the best pre-treatment (Plate 6). The titrable acidity and total phenol content were least and ascorbic acid content was

Plate 6. Effect of pre-treatments on colour retention of nutmeg rinds

A) Hot water blanching 80° C for 5 minutes

B) Steam blanching for 5 minutes

C) Lime water treatment 2 % for 2 hours

D) Salt water treatment 10 % for 4 hours

E) Salt water treatment 3 % for 48 hours

F) Control

White – Peeled Orange - Unpeeled

comparatively high in this treatment. The texture of the salt water treated rind possessed firmness which was acceptable for product development.

Table 6. Effect of pre-treatments on biochemical constituents of nutmeg rind

	Acidity (%)	Ascorbic acid (mg/100g)	Total sugars (%)	Total phenol (mg/g)
Peeled	1.39	12.34	2.22	0.43
Unpeeled	1.28	12.92	2.57	0.44
Significance	NS	**	**	NS
T_1	1.44	11.50	3.75	0.41
T_2	1.60	11.10	2.76	0.68
T_3	1.28	19.04	1.83	0.35
T_4	1.60	8.35	2.10	0.47
T_5	0.64	14.49	1.58	0.26
T_6	1.44	11.30	2.36	0.45
CD	-	0.12	0.03	0.02
PT_1	1.60	9.28	3.63	0.29
PT_2	1.60	8.88	2.35	0.77
PT_3	1.28	19.04	1.77	0.36
PT_4	1.6	7.42	1.767	0.44
PT_5	0.64	12.88	1.573	0.27
PT_6	1.6	9.28	2.243	0.45
UT_1	1.28	13.72	3.88	0.53
UT_2	1.6	13.32	3.163	0.58
UT_3	1.28	19.04	1.89	0.33
UT_4	1.6	9.28	2.423	0.50
UT_5	0.64	16.10	1.577	0.25
UT_6	1.28	13.32	2.483	0.44
CD	-	0.16	0.05	0.02

T_1 - Hot water blanching 80°C for 5 min

T_2 - Steam blanching for 5 min

T_3 - Lime water treatment 2 % for 2 hrs

T_4 - Salt water treatment 10 % for 4 hrs

T_5 - Salt water treatment 3 % for 48 hrs

T_6 - Control

NS – Non singnificant

4.3. Product diversification

The nutmeg rind pre-treated with 3 per cent brine for 48 hours was found to be the best among the pre-treatments and it was further used for the development of nutmeg rind products. The value added products prepared were wine, powder, candy, chunk, syrup and jam. The biochemical quality like titrable acidity, total phenols, total sugars and ascorbic acid content of the products were also evaluated. The agreement regarding the scoring of judges on the various parameters like appearance, flavour, texture, odour, taste and overall acceptability for the product was analysed using Kendall's coefficient of concordance (W) and shown in appendix (II). Sensory evaluation was performed at monthly intervals up to three months of storage and the benefit cost ratios of the products were calculated and shown in appendix (IV). The microbial load during storage was also recorded, and reported as initial and final microbial population.

4.3.1. Wine

Wine was prepared with peeled and unpeeled rind during preliminary evaluation using three different proportions of rind: sugar: water (W_1, W_2, and W_3). It was seen that wine prepared using unpeeled rind had more TSS ranging from 16.2 - 29° brix and higher alcohol (11.68 %) as given in Table 7. The visual colour of the wine was yellowish orange with a better clarity. Hence for further study the unpeeled rind was used.

As shown in Table 8, the best quality wine as determined by total sugars, titrable acidity, ascorbic acid and total phenol was obtained when the nutmeg rind was mixed with sugar and water in equal proportion. The organoleptic evaluation shown in Table 9 also indicates that the wine prepared in 1:1:1 ratio secured the highest score.

4.3.1.1. Effect of storage on the quality of wine

4.3.1.1.1. Total sugars (%)

Among the different proportions of sugar used, in the initial month, the total sugar content was highest for W_3 (31.87 %) where equal quantity of sugar, rind and water followed by W_2 (19.51 %) and W_1 (13.18 %). On storage for three months, it was observed that total sugar content decreased in low sugar proportion (W_1) but increased in higher proportion *i.e.*, W_3.

4.3.1.1.2. Titrable acidity (%)

Theacidity was least in W_3 (0.16 %) and maximum in W_1 (0.21 %). Titrable acidity increased during 2nd month of storage (0.90 % - 0.96 %) but decreased during 3rd month (0.82 % – 0.87 %).

4.3.1.1.3. Ascorbic acid (mg/100g)

In the initial month, the ascorbic acid content observed in all the three ratios was 12.88 mg/100g. There was no significant difference in the ascorbic acid content. In the ratios 1:0.5:1 (W_1) and 1:0.75:1 (W_2), a decreasing trend was observed throughout the storage period.

4.3.1.1.4. Total phenol (mg/g)

The lowest phenol content was recorded in W_3 (0.99 mg/g) followed by W_2 (1.03 mg/g) and the maximum phenol content in W_3 (1.10 mg/g). The phenol content showed an increasing trend throughout the storage period and finally reached to 3.72 mg/g in W_1 and the least in W_3 (1.17 mg/g) .

4.3.1.2. Organoleptic evaluation

Sensory evaluation was carried out on a nine point hedonic scale using score card for eight attributes namely appearance, colour, odour, flavour, texture, taste, after taste and overall acceptability. Throughout the storage period, the maximum scores for all the attributes except flavour and odour were recorded in W_3 (1:1:1). The 1:1:1 ratio was mostly preferred by the panel and gained the overall acceptance. Each character was scored on the scale and the total scores calculated out of seventy two. The ratio of 1:0.5:1 was least preferred and out of

Table 7. Effect of peeling and unpeeling on the sugar and alcohol content of wine

Characters/Treatments	TSS (° Brix)		Alcohol content (%)	
	Peeled	Unpeeled	Peeled	Unpeeled
W_1 - 1:0.5:1	15.5	16.2	9.90	11.68
W_2 - 1:0.75:1	20	21.3	8.48	11.38
W_3 - 1:1:1	29	29	6.92	11.68

Table 8. Effect of storage on biochemical constituents of wine

Biochemical constituents	Wine	Months of storage			
		Initial	1 MAS	2 MAS	3 MAS
Total sugars (%)	W_1	13.18	7.78	6.90	7.29
	W_2	19.51	14.76	15.50	15.82
	W_3	31.87	30.94	32.18	42.42
Titrable acidity (%)	W_1	0.21	0.44	0.96	0.87
	W_2	0.17	0.40	0.93	0.86
	W_3	0.16	0.35	0.90	0.82
Ascorbic acid (mg/100g)	W_1	12.88	10.69	9.66	9.66
	W_2	12.88	9.66	9.66	9.66
	W_3	12.88	12.88	12.88	12.88
Total phenol (mg/g)	W_1	1.10	2.93	3.72	3.72
	W_2	1.03	2.02	2.24	2.13
	W_3	0.99	1.12	1.17	1.17

MAS – Months after storage

Rind : Sugar: Water (W_1)– 1:0.5:1
Rind : Sugar: Water (W_2)– 1:0.75:1
Rind : Sugar: Water (W_3)– 1:1:1

72 score, secured only 34.5 score while the wine prepared using 1:1:1 ratio scored 52.9. The mean sensory score of wine is shown in Table 9. Kendall's coefficient of concordance (W) was significant for all the parameters indicating an agreement between judges in evaluation of these parameters (Appendix I (a)). Hence the mean scores were taken to differentiate the acceptability of the products with regard to the characters.

4.3.1.3. Microbial population

The microbial population of the stored products was assessed initially and after three months and the results are presented in Table 10. The initial population of bacteria in all the three ratios of wine was negligible, while yeast present in the wine were 1.5 cfu/ g$\times 10^{-2}$, 1.00 cfu/ g$\times 10^{-2}$ in 1:0.5:1 and 1:0.75:1 ratio respectively. The presence of yeast was not observed in 1:1:1 ratio. The fungal colonies present in the ratios 1:0.75:1 and 1:1:1 were 1.00 cfu/ g$\times 10^{-2}$ and 1.5 cfu/g x10^{-3} respectively. Fungal growth was absent in 1:0.5:1 ratio. A gradual increase in the population of microbes during storage was also observed.

At the end of three month storage period, the population of microbes in 1:0.5:1 ratio were 1.0 cfu/ g$\times 10^{-3}$ (bacteria), 2.5 cfu/ g $\times 10^{-2}$ (yeast) and 3.0 cfu/ g$\times 10^{-2}$ (fungi). The microbial count recorded three months after storage in 1:0.75:1 was bacteria (1.0×10^{-3}), yeast (2.0×10^{-2}) and fungi (2.0×10^{-2}) and 1:1:1 ratio was bacteria (1.00×10^{3}), yeast (2.0×10^{-2}) and fungi (1.5×10^{2}). Among the samples, 1:1:1 ratio recorded the lowest microbial count.

4.3.2. Powder

Nutmeg powder was prepared from nutmeg slices by sun drying and dehydration in a cabinet drier at 60°C for a period of 48 hrs. The slices were also kept in sun for a period of 72 hrs stirred occasionally, powdered and stored in airtight plastic containers. The maximum temperature recorded at the time of sun drying was 32.4°C.

Table 9. Effect of storage on the mean sensory attributes of wine

INITIAL								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
W_1	4.10	4.20	3.75	4.55	5.05	4.55	4.20	4.10
W_2	5.50	5.30	4.60	5.20	4.90	4.70	4.70	4.70
W_3	6.75	6.90	6.55	5.65	6.50	6.85	6.55	7.15
1 MAS								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
W_1	4.60	4.30	4.05	4.75	4.85	4.30	3.85	3.95
W_2	5.80	4.95	4.30	5.25	5.50	5.10	4.40	4.25
W_3	6.70	6.60	6.10	6.10	6.15	6.35	6.55	7.00
2 MAS								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
W_1	4.30	4.30	4.60	4.80	4.60	4.00	3.80	4.00
W_2	5.25	5.10	4.70	5.50	5.20	4.85	4.30	4.40
W_3	6.55	6.65	6.10	5.80	6.40	6.40	6.45	6.85
3 MAS								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
W_1	4.15	4.35	4.55	4.65	4.65	4.25	4.10	3.90
W_2	5.00	5.10	4.90	5.80	5.00	4.90	4.35	4.70
W_3	6.20	6.40	6.25	5.95	6.45	6.50	6.60	6.60

Table 10. Effect of storage on the microbial population of wine

Products		Initial (cfu/ml)			3 MAS (cfu/ml)		
		Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2
Wine	W_1	0	1.5	0	1	2.5	3
	W_2	0	1	1	1	2	2
	W_3	0	0	1.5	1	2	1.5

The nutmeg prepared by sun drying recorded maximum retention of all the biochemical attributes as shown in Table 11. The overall acceptability of the product was good for sun dried powder when compared to the cabinet dried powder.

4.3.2.1. Changes in quality attributes of nutmeg powder during storage

4.3.2.1.1. Total sugars (%)

During the initial month of storage, the cabinet dried sample (D_1) recorded a sugar content of 14.43 per cent while that of sun dried powder (D_2) was 15.47 per cent. The sugars decreased during the storage period and reached to 13.21 per cent and 14.14 per cent during the final month of storage.

4.3.2.1.2. Titrable acidity (%)

In the initial month, the acidity was 3.71 per cent and 5.76 per cent in cabinet dried and sun dried powders respectively. An increasing trend in acidity was observed during the storage period and finally it reached to 7.30 per cent in sun dried powder and 4.48 per cent in cabinet dried powder.

4.3.2.1.3. Ascorbic acid (mg/100g)

The vitamin C content of the cabinet dried powder (16.10 mg/100g) remained the same during the storage period. The maximum ascorbic acid content of 19.32 mg/100g was observed in sun dried powder as compared to that of cabinet dried powder.

4.3.2.1.4. Total phenol (mg/g)

Initially, the powders had a total phenol content of 2.24 mg/g and 1.94 mg/g in cabinet dried and sun dried powders respectively. A decreasing trend was observed in the total phenol content during storage. Among the powders, during the last month of storage, the cabinet dried powder had the least phenolic content of 1.70 mg/g followed by 1.85 mg/g in sun dried powder.

Table 11. Effect of storage on biochemical constituents of nutmeg rind powders

Biochemical constituents	Powder	Months of storage			
		Initial	1 MAS	2 MAS	3 MAS
Total sugars (%)	D_1– Cabinet dried	14.43	13.93	13.59	13.21
	D_2- Sun dried	15.47	15.05	14.58	14.14
Titrable acidity (%)	D_1– Cabinet dried	3.71	3.90	4.16	4.48
	D_2- Sun dried	5.76	6.27	6.91	7.30
Ascorbic acid (mg/100g)	D_1– Cabinet dried	16.10	16.10	16.10	16.10
	D_2- Sun dried	19.32	19.32	19.32	19.32
Total phenol (mg/g)	D_1– Cabinet dried	2.24	2.20	2.20	1.70
	D_2- Sun dried	1.94	1.89	1.85	1.85

Table 12. Effect of storage on the mean sensory attributes of nutmeg rind powders

INITIAL								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
D_1	6.83	7.05	6.85	6.50	6.70	6.35	6.60	7.05
D_2	7.40	7.75	7.05	6.90	6.85	6.60	7.00	7.50
1 MAS								
D_1	6.60	7.00	6.70	6.50	6.55	6.20	6.45	6.90
D_2	7.15	7.45	6.90	6.80	6.95	6.45	6.85	7.25
2 MAS								
D_1	6.75	7.20	6.15	6.25	6.50	5.85	6.15	6.75
D_2	7.25	7.65	6.30	6.65	6.75	6.10	6.25	6.90
3 MAS								
D_1	6.80	7.10	5.95	6.40	6.35	5.90	5.95	5.75
D_2	7.25	7.35	6.10	6.55	6.50	6.00	6.10	6.20

D_1 – Cabinet dried D_2 – Sun dried

4.3.2.2. Organoleptic evaluation

The powders were organoleptically evaluated by a selected panel of judges and the mean sensory scores are recorded in Table 12. Among the treatments, sun dried powder (D_2) recorded the maximum score for all the attributes like appearance (7.40), colour (7.75), flavour (7.05), texture (6.90), odour (6.85), taste (6.60), after taste (7.00) and overall acceptability (7.50) throughout the storage period.

4.3.2.3. Microbial population

The microbial count of nutmeg rind powder was assessed immediately after development and in the final month of storage and the results is presented in Table 13. The bacterial population in the initial period was 1.0 cfu/g $x10^{-3}$ and 1.5 cfu/g $x10^{-3}$ in cabinet dried and sun dried samples respectively. On storage, the microbial load of cabinet dried powder and sun dried powder were (2.0 cfu/g $x10^{-3}$) and (2.0 cfu/g $x10^{-3}$) respectively. The yeast count was 2.0 cfu/g $x10^{-2}$ in D_1 and 1.0 cfu/g $x10^{-2}$ in D_2 initially and increased to 3.0 cfu/g $x10^{-2}$ and 1.5 cfu/g $x10^{-2}$ at the end of storage. The fungal colonies present in the CD and SD powders were (2.5 cfu/g $x10^{-2}$) initially which increased to (3.0 cfu/ g$\times10^{-2}$) and (4.0 cfu/g $x10^{-2}$) respectively after 3 months.

4.3.3. Candy

Candy prepared by increasing the brix content of nutmeg pieces was also analysed for biochemical constituents like total sugars, titrable acidity, vitamin C and total phenol content. It was prepared as small pieces, titbits (C_1) and flakes (C_2).

The biochemical changes and organoleptic quality of candy was assessed during storage and given in Table (14 and 15). The results indicated that the flakes had a lower phenol content, high ascorbic acid and maximum overall acceptability.

Table 13. Effect of storage on the microbial population of powder

Products	Initial (cfu/ml)			3 MAS (cfu/ml)		
	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2
Cabinet dried powder (D_1)	1	2	2.5	2	3	3
Sun dried powder (D_2)	1.5	1	2.5	2	1.5	4

Table 14. Effect of storage on biochemical constituents of candy

Biochemical constituents	Candy	Months of storage			
		Initial	1 MAS	2 MAS	3 MAS
Total sugars (%)	C_1- Titbits	76.09	79.09	74.07	82.35
	C_2- Flakes	71.07	76.92	72.16	74.87
Titrable acidity (%)	C_1- Titbits	0.28	0.28	0.26	0.21
	C_2- Flakes	0.32	0.32	0.13	0.19
Ascorbic acid (mg/100g)	C_1- Titbits	12.88	12.88	12.88	12.88
	C_2- Flakes	19.32	12.88	16.10	16.10
Total phenol (mg/g)	C_1- Titbits	1.88	1.83	1.83	1.30
	C_2- Flakes	1.44	144	1.40	1.40

4.3.3.1. Effect of storage on biochemical constituents of nutmeg candy

4.3.3.1.1. Total sugars (%)

In the initial month, the candied bits showed a high percentage of total sugars (76.09 %) while that of flakes was 71.07 per cent. The total sugars showed an increasing trend in the first and third month of storage. But in the second month, it was decreased to 74.07 per cent and 72.16 per cent in titbits and flakes respectively.

4.3.3.1.2. Titrable acidity (%)

In the initial month, the candied flakes recorded the mean maximum acidity of 0.32 per cent while that of titbits was 0.28 per cent. It was observed a decrease in titrable acidity during storage. During the second and third months, the acidity was considerably reduced. At the end of storage period the acidity recorded in titbits was 0.21 per cent and flakes 0.19 per cent.

4.3.3.1.3. Ascorbic acid (mg/100g)

The ascorbic acid content was maximum inflakes (19.32 mg/100g) than that of titbits (12.88 mg/100g). In the case of titbits, the vitamin C content remained the same throughout the storage period. The ascorbic acid content showed a decreasing trend in flakes and reached to 16.10 mg/100g in the third month of storage.

4.3.3.1.4. Total phenol (mg/g)

The total phenol content did not show any significant changes on storage of candies. The initial phenol level was maximum in titbits (1.88 mg/g) when compared to flakes (1.44 mg/g). It was then reduced to 1.3 mg/g in titbits and 1.4 mg/g in candied flakes during the last month of storage.

4.3.3.2. Organoleptic evaluation

The mean sensory scores of candy are shown in Table 15. The result indicates that the flakes (T_2) secured the maximum acceptance with a mean

sensory score of 54.7 and that of titbits was 52.8 out of 72. Higher scores for sensory attributes like appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability was recorded for flakes.

4.3.3.3. Microbial population

The total microbial load of candy in the initial and final month was estimated (Table 16). The initial bacteria, yeast and fungi recorded in the titbits were 1.5 cfu/g $x10^{-3}$, 3 cfu/g $x10^{-2}$ and 2 cfu/g $x10^{-2}$ and that of flakes were 2.0 cfu/g$x10^{-3}$, 1.5 cfu/g $x10^{-2}$ and 1 cfu/g $x10^{-2}$ respectively. After storage, the bacterial count was 2.5 cfu/g$x10^{-3}$ and 3.0 cfu/g$x10^{-3}$ in titbits and flakes respectively. The yeast and fungal population in titbits and flakes were 4.0 cfu/g $x10^{-2}$, 2.5 cfu/g $x10^{-2}$ and 2.0 cfu/g $x10^{-2}$, 12cfu/g $x10^{-2}$ respectively.

4.3.4. Osmodehydrated chunks

Osmodehydration method was used for the preparation of chunks. Table 17 shows the effect of titrable acidity (%), total phenol (mg/g), total sugars (%) and ascorbic acid content of chunks prepared in 70° brix with different duration of immersion – 12 hrs, 24 hrs, 48 hrs.

As shown in Table 17, the osmodehydrated chunks immersed in 48 hours retained all the biochemical constituents throughout the storage period and had the best overall acceptance compared to chunks immersed for 12 and 24 hours.

4.3.4.1.Changes in quality attributes of nutmeg chunks during storage

4.3.4.1.1. Total sugars (%)

The total sugar was highest for nutmeg chunks when compared to all other products. Chunks prepared by immersion in sugar solution for 48 hrs (T_3) had the highest sugar content of 98.11% followed by T_2 (24 hrs - 94.40%) and T_1 (12 hrs - 91.74%). The total sugar was decreased on storage to 85.89 per cent, 82.84 per cent and 73.30 per cent for T_3, T_2, T_1 respectively.

Table 15. Effect of storage on the mean sensory attributes of nutmeg rind candy

INITIAL								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
C_1	7.20	7.45	7.10	7.40	6.50	7.40	6.50	7.20
C_2	7.95	7.90	7.60	7.30	6.50	7.55	6.80	7.60
1 MAS								
C_1	6.85	6.85	6.20	6.90	6.15	6.35	6.90	7.10
C_2	7.20	7.15	6.40	6.50	5.70	6.60	7.00	7.85
2 MAS								
C_1	6.95	6.95	5.40	6.40	5.55	6.20	6.25	6.90
C_2	7.25	7.05	6.05	6.70	5.35	6.25	6.65	7.50
3 MAS								
C_1	5.95	6.25	6.60	5.90	6.15	6.50	6.50	6.85
C_2	6.35	6.50	7.10	6.10	5.80	6.50	6.80	7.30

C_1 – Candy titbits C_2 – Candy flakes

Table 16. Effect of storage on microbial population of candy

Products	Initial (cfu/ml)			3 MAS (cfu/ml)		
	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2
C_1- Titbits	1.5	3	2	2.5	4.0	2.5
C_2 - Flakes	2	1.5	1	3.0	2.5	2.0

4.3.4.1.2. Titrable acidity (%)

The titrable acidity of chunks with different duration of immersion was found to be same in the initial month (0.13 %). It was evident from the table that, on storage, the acidity of the product increased and reached to a maximum of 0.38 per cent, 0.32 per cent and 0.26 per cent in T_1, T_2 and T_3 respectively.

4.3.4.1.3. Ascorbic acid (mg/100g)

In the initial month, the ascorbic acid content was found to be same for 24 and 48 hrs of immersion *i.e.*, 16.10 mg/100g and least was seen in 12 hrs immersion (12.88 mg/100g). The vitamin C content remained the same for T_1 and T_3 throughout the storage period but in the case of T_2, ascorbic acid was decreased to 12.88 mg/100g

4.3.4.1.4. Total phenol (mg/g)

The phenol content was found to be the highest in the initial month and was 2.86 mg/g, 1.78 mg/g, 1.64 mg/g for T_1, T_2 and T_3 respectively. Among the three, the T_1 showed the maximum phenol content. A decreasing trend was observed on storage.

4.3.4.2. Organoleptic evaluation

The mean sensory scores of chunks were evaluated and given in Table 18. In the initial month, the scores obtained for sensory attributes like appearance (7.30), colour (6.90), flavour (6.50), texture (6.85), odour (6.30), taste (6.70), after taste (6.70) and overall acceptability (6.85) were highest for chunks immersed for 48 hrs followed by 24 hrs and 12 hrs of immersion. The same trend was followed in the consecutive months of storage. The mean sensory ranks of chunks are given in Appendix (I (b)).

4.3.4.3. Microbial population

The initial and final microbial population of chunks were estimated and given in Table 19. In 12 hrs duration, the initial bacterial load is 3.5 cfu/g $x10^{-3}$,

2.5 cfu/g $x10^{-2}$, 2.5 cfu/g $x10^{-2}$ in bacteria, yeast and fungi respectively. This duration showed the maximum microbial load in the final month with 4.0 cfu/g $x10^{-3}$, 3.0 cfu/g $x10^{-3}$ and 3.5 cfu/g $x10^{-3}$

In the initial month, the bacteria, yeast and fungi were 2.0 cfu/g $x10^{-3}$, 2.0 cfu/g $x10^{-2}$, 1.0 cfu/g $x10^{-2}$ and 1.5 cfu/g $x10^{-3}$, 1.0 cfu/g $x10^{-3}$, 1 cfu/g $x10^{-3}$ in 24 hrs and 48 hrs respectively. During the last month of storage, bacteria (3.0 cfu/g $x10^{-3}$), yeast (2.0 cfu/g $x10^{-2}$) and fungi (2.0 cfu/g $x10^{-2}$) in 24 hrs duration and the least count of bacteria (2.0 cfu/g $x10^{-3}$), (1.5 cfu/g $x10^{-3}$) and (2.0 cfu/g $x10^{-3}$) was observed in 48 hrs duration.

Table 17. Effect of duration of immersion in osmotic solution on the biochemical constituents of chunks

Biochemical constituents	Chunks	Months of storage			
		Initial	1 MAS	2 MAS	3 MAS
Total sugars (%)	T_1	91.74	85.37	80.92	73.30
	T_2	94.40	91.5	82.35	82.84
	T_3	98.11	95.37	84.84	85.89
Titrable acidity (%)	T_1	0.13	0.13	0.26	0.38
	T_2	0.13	0.13	0.19	0.32
	T_3	0.13	0.13	0.19	0.26
Ascorbic acid (mg/100g)	T_1	12.88	12.88	12.88	12.88
	T_2	16.10	16.10	12.88	12.88
	T_3	16.10	16.10	16.10	16.10
Total phenol (mg/g)	T_1	2.86	2.86	2.83	1.80
	T_2	1.78	1.75	1.75	1.70
	T_3	1.64	1.58	1.58	1.50

T_1- Chunks immersed for 12 hrs

T_2 - Chunks immersed for 24 hrs

T_3 - Chunks immersed for 48 hrs

Table 18. Effect of storage on the mean sensory attributes of chunks

INITIAL								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
T_1	5.80	5.80	5.80	5.50	5.60	5.10	4.90	5.40
T_2	6.00	5.90	6.00	5.55	5.60	5.50	5.60	5.65
T_3	7.30	6.90	6.50	6.85	6.30	6.70	6.70	6.85
1 MAS								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
T_1	5.60	5.70	5.30	5.40	5.10	5.30	5.20	5.35
T_2	5.90	5.85	5.70	5.55	5.20	5.55	5.50	5.65
T_3	7.10	6.75	6.10	7.15	5.85	6.90	6.70	7.05
2 MAS								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
T_1	5.70	5.75	5.65	5.25	5.60	5.10	5.40	5.00
T_2	6.05	6.15	5.90	5.60	5.60	5.50	5.65	5.70
T_3	7.15	7.00	6.50	6.90	6.30	7.00	6.90	7.15
3 MAS								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
T_1	5.50	5.60	5.40	5.10	5.65	5.35	5.10	5.30
T_2	6.10	5.95	5.80	5.75	5.65	5.80	5.60	5.70
T_3	7.30	6.95	6.70	7.00	6.40	7.10	6.70	6.85

Table 19. Effect of storage on microbial population of chunks

Treatments	Initial (cfu/ml)			3 MAS (cfu/ml)		
	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2
T_1-12 hrs	3.5	2.5	2.5	4	3	3.5
T_2-24 hrs	2	2	1	3	2	2
T_3-48 hrs	1.5	1	1	2	1.5	2

4.3.5. Syrup

Syrup was prepared with peeled and unpeeled rind during preliminary evaluation using two extraction methods. It was seen that syrup prepared using unpeeled rind had more flavour and colour compared to peeled and hence gained maximum acceptance. The visual colour of the syrup was creamish yellow with thick consistency. Hence for further study the unpeeled rind was used.

The effect of storage on total sugars (%), titrable acidity (%), ascorbic acid (mg/100g) and total phenol (mg/g) of syrups made from pressure cooked extract (E_1) and hot water extract (E_2) were studied and given in Table 20. The syrup prepared from unpeeled rind using hot water extraction method gained the maximum score for organoleptic attributes and had the better retention of biochemical parameters.

4.3.5.1. Effect of storage on biochemical constituents of nutmeg rind syrup

4.3.5.1.1. Total sugar (%)

The syrup was prepared using pressure cooked extract (E_1) and hot water extract (E_2). The total sugar was maximum in E_1 (68.29 %) and least in E_2 (65.12 %). During the following months, there was no significant change in sugar content and was finally increased to 70 per cent and 68.56 per cent in E_1 and E_2respectively.

4.3.5.1.2. Titrable acidity (%)

The titrable acidity of E_1 and E_2 were 0.41 per cent and 0.42 per cent initially and was increased to 0.45 per cent and 0.51 per cent in the first month. The acidity remained same in the second month and finally reached to 0.53 per cent and 0.54 per cent respectively in E_1 and E_2.

Table 20. Effect of storage on biochemical constituents of nutmeg rind syrup

Biochemical constituents	Syrup	Months of storage			
		Initial	1 MAS	2 MAS	3 MAS
Total sugars (%)	E_1	68.29	68.29	66.67	70.00
	E_2	65.12	66.19	65.12	68.56
Titrable acidity (%)	E_1	0.41	0.45	0.45	0.53
	E_2	0.42	0.51	0.51	0.54
Ascorbic acid (mg/100g)	E_1	32.20	17.13	16.10	16.10
	E_2	32.20	19.32	19.32	19.32
Total phenol (mg/g)	E_1	1.42	1.28	1.16	1.35
	E_2	1.18	1.11	1.01	1.14

E_1 – Pressure cooked extract

E_2 – Hot water extract

Table 21. Effect of storage on the mean sensory qualities of nutmeg rind syrup

INITIAL								
Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
E_1	6.45	6.80	5.30	6.15	5.50	5.15	5.20	5.70
E_2	6.35	5.75	6.45	6.00	6.25	6.20	6.10	6.15
1 MAS								
E_1	5.05	6.85	5.30	6.20	5.50	5.15	5.25	5.25
E_2	5.90	5.75	5.50	5.95	5.85	6.05	5.80	5.80
2 MAS								
E_1	4.90	6.85	5.30	6.20	5.50	5.00	5.25	5.20
E_2	5.65	5.75	5.55	5.95	5.45	5.45	5.35	5.70
3 MAS								
E_1	5.05	6.70	5.30	6.05	5.50	5.25	5.25	5.35
E_2	5.50	5.70	5.75	5.95	5.85	6.10	5.85	5.50

4.3.5.1.3. Ascorbic acid (mg/100g)

In the initial month, the vitamin C content was 32.20 mg/100g in E_1 and E_2. A decreasing trend was observed throughout the storage period and finally reached to 16.10 mg/100g and 19.32 mg/100g in E_1 and E_2 respectively.

4.3.5.1.4. Total phenol (mg/g)

The initial phenol content was highest for E_1 (1.42 mg/g) than that of E_2 (1.18 mg/g). In the following months it was reduced to 1.28, 1.16, 1.35 mg/g and 1.11, 1.01, 1.14 mg/g in E_1 and E_2 respectively.

4.3.5.2. Organoleptic evaluation

The mean sensory scores of nutmeg syrup made by the two extraction methods like pressure cooking and hot water boiling were evaluated by a panel of 10 semi trained judges and given in Table 21. The sensory attributes were least for the syrup prepared from the rind pre-treated by immersing in 3 per cent brine for 48 hrs and the juice extracted by hot water method gained the maximum acceptance when compared to the pressure cooked syrup.

4.3.5.3. Microbial population

The total microbial load of nutmeg rind syrup in the initial and final month was estimated (Table 22). The initial bacterial population in E_1 and E_2 were insignificant. In E_1 and E_2, the yeast population observed was 2.0 cfu/g $x10^{-2}$, 1.0 cfu/g $x10^{-2}$ and that of fungi was 3.0 cfu/g $x10^{-2}$ and 1.0 cfu/g$x10^{-3}$ respectively.

After storage, the bacterial count was increased to 2.0 cfu/g$x10^{-3}$ and 1.0 cfu/g$x10^{-3}$ in E_1 and E_2 respectively. The yeast and fungal population in E_1 were 3.0 cfu/g$x10^{-2}$and 1.5 cfu/g$x10^{-2}$ and 3.0 cfu/g$x10^{-2}$, 2.0 cfu/g$x10^{-2}$ in E_2 respectively.

Table 22. Effect of storage on the microbial population of syrup

Products	Initial (cfu/ml)			3 MAS (cfu/ml)		
	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2
Pressure cooked extract (E_1)	0	2	3	2	3	3
Hot water extract (E_2)	0	1	1	1	1.5	2

Table 23. Effect of storage on biochemical constituents of nutmeg rind jam

Biochemical constituents	**Jams**	**Months of storage**			
		Initial	**1 MAS**	**2 MAS**	**3 MAS**
Total sugars (%)	J_1	59.65	63.92	52.32	60.09
	J_2	68.19	72.54	64.43	67.96
	J_3	70.25	74.23	71.79	70.71
Titrable acidity (%)	J_1	0.96	0.64	0.56	0.64
	J_2	0.96	0.32	0.48	0.38
	J_3	0.74	0.16	0.32	0.32
Ascorbic acid (mg/100g)	J_1	19.32	19.32	19.32	19.32
	J_2	19.32	19.32	16.1	16.1
	J_3	19.32	19.32	16.1	16.1
Total phenol (mg/g)	J_1	0.66	0.58	0.58	0.55
	J_2	0.82	0.84	0.80	0.80
	J_3	0.84	0.77	0.70	0.75

J_1 – Rind : Sugar (1:1 ratio)

J_2 – Rind : Sugar (1:1.5 ratio)

J_3 – Rind : Sugar (1:2 ratio)

4.3.6. Jam

The nutmeg rind jam was prepared from peeled pre-treated rinds in three different proportions of rind and sugar *viz.*, 1:1, 1:1.5 and 1:2 ratios. The effect of titrable acidity (%), total phenol (mg/g), total sugars (%) and ascorbic acid content of different ratios of jams were observed and given in Table 23. The jam prepared with double the quantity of sugar had the better preference and had the better retention of all the biochemical constituents throughout the storage period.

4.3.6.1. Changes in quality attributes of nutmeg rind jams during storage

4.3.6.1.1. Total sugars (%)

The total sugars was found to be highest for 1:2 ratio (70.25 %) followed by 1:1.5 ratio (68.19 %) and 1:1 ratio (59.65 %). There was no significant change in the total sugars throughout the storage period. In the third month, the sugar content observed was 60.09 per cent, 67.96 per cent and 70.71 per cent for 1:1, 1:1.5 and 1:2 ratios respectively.

4.3.6.1.2. Titrable acidity (%)

In the initial month, the titrable acidity was same for 1:1 and 1:1.5 ratio (0.96 %) followed by 1:2 (0.74 %). In the following months, it was considerably reduced and finally reached to 0.64 per cent, 0.38 per cent and 0.32 per cent for 1:1, 1:1.5, 1:2 ratios respectively.

4.3.6.1.3. Ascorbic acid (mg/100g)

Initially the ascorbic acid content recorded in all the ratios were 19.32 mg/100g and remained the same for 1:1 ratio up to the last month of storage. The vitamin C content decreased to 16.10 mg/100g during the second month and thereafter no change was observed in J_1 and J_2.

4.3.6.1.4. Total phenol (mg/g)

Among the jams, the total phenol content was found to be maximum for 1:2 ratio (0.84 mg/g) followed by 1:1.5 ratio (0.82 mg/g) and 1:1 ratio (0.66 mg/g). During the first month, the phenol content was reduced to 0.58 mg/g (1:1 ratio), 0.77 mg/g (1:2 ratio) but remained the same for 1:1.5 ratio. In the last month of storage, phenol content was reduced to 0.55 mg/g, 0.80 mg/g and 0.75 mg/g for 1:1, 1:1.5 and 1:2 ratios respectively.

4.3.6.2. Organoleptic evaluation

The mean sensory scores of jams were assessed and given in Table 24. Throughout the storage period, apart from texture (6.40), all the other attributes like appearance (6.15), colour (5.60), flavour (5.33), odour (5.95), taste (6.80), after taste (6.35) and overall acceptability were highest for 1:2 ratio. The ratio of 1:2 attained 49.4 score out of 72 while the least acceptance was for 1:1 ratio (36.9).

The jam with equal quantity of pulp and sugar (1:1 ratio) was discarded after first month, as it did not maintain the quality and was contaminated. From the second month onwards, the mean sensory scores of T_2 and T_3 were observed. The mean ranks in the initial and first month are shown in Appendix (I (c)).

4.3.6.3. Microbial population

The microbial load of nutmeg rind jam was enumerated and is given in Table 25. In the jam ratios 1:1 (J_1), 1:1.5 (J_1) and 1:2 (J_3) the initial bacterial load was insignificant. The yeast population in the three ratios J_1, J_2 and J_3 were 4.0 cfu/g $x10^{-2}$, 2.0 cfu/g $x10^{-2}$ and 3.0 cfu/g $x10^{-2}$ respectively. In the initial month, the fungal population observed was 2.5 cfu/g $x10^{-2}$, 2.0 cfu/g $x10^{-2}$ and 2.0 cfu/g $x10^{-2}$ in J_1, J_2 and J_3 respectively.

In the final month, the bacteria, yeast and fungi in J_1 was 1.5 cfu/g $x10^{-3}$, 329 cfu/g $x10^{-2}$, 266 cfu/g $x10^{-2}$ and for the ratio J_2, the bacteria, yeast and fungal

population recorded were 0.5 cfu/g $x10^{-3}$, 3.0 cfu/g $x10^{-2}$ and 3.0 cfu/g $x10^{-2}$ respectively. During the last month of storage, in 1:2 ratio (J_3), the yeast count was 3.5 cfu/g $x10^{-2}$ and that of fungi was 3.0 cfu/g $x10^{-2}$.

4.4. Benefit cost ratio of nutmeg rind products

The wine prepared with rind : sugar : water in 1:1:1 ratio showed highest B:C ratio (4.26) as shown in Table 26. The B:C ratio was high (1.72) for rind powder prepared by sun drying and it was very low (0.92) when powder was prepared by cabinet drying. The candy prepared as flakes had a high B:C ratio (1.82) when compared to titbits, as the recovery percentage for flakes was better (60 %) than titbits (50 %). Chunks prepared by immersing nutmeg pieces in 70° brix sugar syrup showed significant difference in quality when the duration of immersion was changed. The best accepted product was obtained when the duration was 48 h. The B:C ratio of all the treatment were same (2.52). Syrup was prepared by taking nutmeg rind extract after pressure cooking and making hot water extract. The extraction method influenced the B:C ratio as shown in Table 26. Syrup prepared by using hot water extract had less B:C ratio (2.45), even though it had good sensory scores. The pressure cooked extract when used for making syrup had a higher B:C ratio of 2.82. Jam was prepared in three proportions and it was found that, when sugar was used in the ratio 1:2, the recovery percentage was 83.33 per cent and hence it had high B:C ratio of 2.30 when compared to other treatments where the B:C ratio was 1.99 and 2.22 for 1:1.5 and 1:1 ratio of pulp and sugar.

Table 24. Effect of storage on the mean sensory attributes of jam

INITIAL								
Treatments	**Appearance**	**Color**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
J_1	4.85	4.25	4.90	5.05	5.65	4.00	3.90	4.30
J_2	5.95	4.90	5.10	6.75	5.30	5.40	5.20	5.50
J_3	6.15	5.60	5.33	6.40	5.95	6.80	6.35	6.80
1 MAS								
Treatments	**Appearance**	**Color**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
J_1	3.65	5385	3665	3.00	3.20	3.65	2.50	2.50
J_2	5.85	6.75	5.10	6.20	5.00	5.40	3.50	5.00
J_3	6.50	5.90	5.33	6.20	6.00	6.80	5.50	6.50
2 MAS								
Treatments	**Appearance**	**Color**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
J_2	5.65	4.95	5.20	6.75	5.05	5.55	4.85	5.65
J_3	5.95	5.70	5.15	6.30	5.55	6.80	5.90	6.80
3 MAS								
Treatments	**Appearance**	**Color**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
J_2	5.40	4.90	4.80	6.30	4.90	5.45	5.40	5.30
J_3	5.90	5.70	5.00	6.30	5.65	6.45	6.25	6.05

Table 25. Enumeration of microbial load in nutmeg rind jam

Products	Initial (cfu/ml)			3 MAS (cfu/ml)		
	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2	Bacteria x 10^3	Yeast x 10^2	Fungi x 10^2
Rind : Sugar - 1:1 (J_1)	0	4	2.5	1.5	329	266
Rind : Sugar - 1:1.5 (J_2)	0	2	2	0.5	3	3
Rind : Sugar - 1:2 (J_3)	0	3	2	0	3.5	3

Table 26. Benefit cost ratio of nutmeg rind products

Products	Treatments	B : C ratio
Wine	Rind : sugar : water (1:0.5:1)	3.80
	Rind : sugar : water (1:0.75:1)	4.10
	Rind : sugar : water (1:1:1)	4.26
Nutmeg rind powder	Cabinet dried powder	0.92
	Sun dried powder	1.72
Candy	Titbits	1.20
	Flakes	1.82
Chunks	Immersion for 12 h	2.52
	Immersion for 24 h	2.52
	Immersion for 48 h	2.52
Syrup	Pressure cooked extract	2.82
	Hot water extract	2.45
Jam	Rind : sugar (1:1)	1.99
	Rind : sugar (1:1.5)	2.22
	Rind : sugar (1:2)	2.30

Discussion

5. DISCUSSION

Nutmeg is a widely cultivated spice in India popular for its flavouring and medicinal properties. The name nutmeg is derived from the Latin word *nux muscatus* meaning 'musky nut'. Nutmeg was introduced to India quite a long time ago. It is seen mainly in Kerala, Tamil Nadu and Karnataka and in India five species occur, including *M. fragrans*, *M. Beddomeii* and *M. Malabarica* (Anon., 1999). World production of nutmeg is estimated to an average between 10,000 hectare and 12,000 tons per year, with annual world demand estimated at 9700 tons (ITC, 2003) while the production of mace is estimated at 1500 to 2000 tons.

Value added products, namely oleoresin, nutmeg butter and essential oil, are also derived from *M. fragrans*. These find varied use in the food, medicine and perfume industries. Average weight of a single fruit is 60 g of which the seed weighs 6 to 7 g, mace 3 to 4 g and the rest is rind. Even though many value added products can be prepared from nutmeg rind, due to its astringent taste, palatability is less and good consumer acceptability could not be achieved. It is the major reason for its non-production on a commercial scale and hence is a major waste material in cultivator's field.

Knowledge of the physico-chemical properties of food is fundamental in analysing the characteristics of food during processing. The study of these food properties and their responses to process conditions are necessary because they influence the treatment received during the processing and also because they are good indicators of other properties and qualities of food.

The present study entitled 'Proximate analysis and product development in nutmeg (*Myristica fragrans* Houtt.) rind' was taken up mainly to enhance the utilization of nutmeg rind on a small scale. Standardization of pre-treatments for reducing astringency of the rind and improving the acceptability of products is highly essential for its commercial adoption.

The research programme was conducted under two experiments, the results of which are discussed below.

5.1. Proximate analysis of nutmeg rind

This study was conducted to evaluate the physical characteristics and biochemical constituents as well as the antioxidant property, essential oil, oleoresin and mineral composition. The volatile oil constituents of essential oil from nutmeg rind was analysed by GC-MS. Preliminary phytochemical screening of nutmeg rind extract was also done for identifying the primary and secondary metabolites.

5.1.1. Physical characters

The colour analysis using Universal Colour Language (UCL) indicated the colour of nutmeg rind as pale greenish yellow which changed to moderate orangish yellow during storage at room temperature. Hooker (1973) reported that *M. fragrans* had a yellowish skin with white fleshy rind and *M. anadmanica* had a thick brown rind. It was reported by Weiss (2002) that *M. fragrans* possess yellowish skin with perpendicular groove around the fruit and whitish flesh.

Texture is a multimodal sensory property and the sensory crispiness or hardness often has good correlation with puncture or penetration force (Brookfield *et al.*, 2011). The freshly collected nutmeg rind possessed a firmness of 1.86 Kg/cm^2 whichis due to its thick fleshy rind having about 1.3 cm thickness and contributes the major portion of the fruit.

5.1.2. Biochemical constituents

The prime component of interest for the processors is the biochemical characters of the fruits. The chemical composition and quality of nutmeg (*Myristica fragrans* Houtt.) grown in major producing areas of the world have been reported to vary widely (Yen *et al.*, 1996). The variation in chemical composition may be due to the geographic, climatic and maturity conditions.

The nutmeg rinds collected from different locations were used to analyse the chemical constituents.

The average moisture content of the nutmeg rind in this study was 88.45 per cent. The rind which constitutes 80 to 85 per cent total fruit weight is thick and absorbs moisture during the peak monsoon period coinciding with the harvesting season of nutmeg.The studies conducted at Indian Institute of Spices Research (IISR) also revealed that the moisture content of nutmeg rind was 86 per cent.

Gopalan *et al.* (1984) reported that the moisture content of 14.30 per cent in nutmeg. The present study was in accordance with the findings of Gopalakrishnan (1992). According to him, the moisture content of the seed kernel and mace were equal (40.00 %) and the moisture content was highest in the nutmeg rind when compared to mace and seed kernel.

Because of the high percentage of moisture in nutmeg rind, there are chances of microbial spoilage and poor organoleptic qualities. The removal of water from solid foods is a form of food conservation, inhibiting the growth of microorganisms, besides preventing biochemical reactions, which occur in the presence of moisture (Park *et al.*, 2002). Hence adequate measures have to be taken before further processing.

The results of the study showed that, the total soluble solid (TSS) of nutmeg rind was 3.38° brix and it also contributed to the low total, reducing and non-reducing sugars (2.69 %, 2.09 % and 0.60 % respectively). The acidity of rind rind was 1.43 per cent. At the same time, the phenol (35.20 mg/100g) and tannin (33.80 mg/100g) was also detected in the rind. Vitamin C is also low (11.45 mg/100g). Thus nutmeg rind is not naturally sweet and has an acidic and astringent taste. This is in concordance with the studies conducted by Gopalakrishnan (1992) where the reports show that acidity, total and reducing sugar was high in rind when compared to seed kernel and mace. Tan *et al.* (2013) also observed that nutmeg seed contained the highest total phenol content followed by mace, skin and pulp.

The starch, protein, pectin and crude fibre present in nutmeg rind was 0.95 g/100g, 1.25 g/100g, 0.78 per cent and 2.55 per cent respectively, showing that the rind can contribute to nutrition. The presence of pectin also helps to improve the quality of processed products. Preethi and Krishnankutty (1986) reported that nutmeg rind contained 14 per cent pectin and 27 per cent fibre. Zheng *et al.* (1992) reported that the nutmeg rind contained protein, pectin and crude fibre.

5.1.3. Mineral composition

Nutmeg rind can be considered as a good source of minerals due to the presence of potassium (0.81 %), calcium (0.412 %) and iron (6.078 mg/100g), as revealed in the study. Gopalan *et al.* (1984) has also reported that, nutmeg rind contain mineral matter (1.7 %), calcium (0.12 %) and phosphorous (4.6 mg/100g) iron (12.6 mg/100g), thiamine, riboflavin and niacin. Abdullah (2009) analysed nutmeg for the presence of major elements (Ca, Na, K and Mg) and for the minor and trace elements (Cu, Mn, Fe and Zn) and noted that the highest concentration of potassium (K) and calcium (Ca) was in the rind while manganese (Mn) was the predominant microelement detected.

5.1.4. Anti-oxidant activity

Spices and herbs have good anti-oxidant activity and hence considered as a rich source of natural anti-oxidants (Chirathaworn *et al.*, 2007). Among the spices, *M. fragrans* is considered as an important source of antioxidants. Nutmeg seeds are reported to possess anti lipid-peroxidant properties (Hattori *et al.*, 1993). Nutmeg essential oils are powerful antioxidants (Dorman *et al.*, 2000).

The antioxidant activity of methanol extract of nutmeg rind powder was tested by the DPPH radical scavenging assay where the consumption of a stable free radical (DPPH) was measured. DPPH radical is a stable free radical and when it reacts with an antioxidant compound which can donate hydrogen it is reduced to diphenylpicrylhydrazine. Initially the solution was deep violet in colour which was changed to light yellow. The nutmeg rind had a medium antioxidant capacity

with IC_{50} value of 120 µg/ml and the change in colour was due to the reduction of DPPH with the antioxidant compounds present in the nutmeg rind.

Tan *et al.* (2013) studied the antioxidant activity of nutmeg seed and reported that it possessed the highest ferric reducing antioxidant power (FRAP) and trolox equivalent antioxidant capacity (TEAC) values, while nutmeg pulp had the lowest value as compared to other parts. Phenolic compounds in nutmeg samples have exhibited strong correlation with antioxidant capacity. Antioxidant properties of essential oil and oleoresin from nutmeg are of great interest in the food industry, since their possible use as natural additives emerged from a growing tendency to replace synthetic antioxidants by natural ones.

5.1.5. Essential oil and Oleoresin

Nutmeg oil obtained from seed and mace is widely used due to its pharmacological effects. Gopalakrishnan (1992) has made extensive studies on the composition of nutmeg and mace and revealed that the seeds contained 25 per cent to 30 per cent fixed oils like myristic, stearic, palmitic, oleic, linoleic and lauric acids. Jellin *et al.* (2005) has also reported that, nutmeg and mace contained volatile oils which showed pharmacological effects. Verghese (2001) has stated that volatile oil can be extracted from the bark, flowers and fresh rind.

In the present study, investigations were carried out to find the presence of essential oil in nutmeg rind. The recovery of oil was very less (0.05 %) on fresh weight basis. The oil profiling was also done using GC-MS. The chromatogram exhibited 6 peaks which were quantified after identification were terpenen-4-ol (35.89 %), elemicin (25.67 %), myristicin (1.52 %), alpha-terpineol (20.49 %), methyl (Z)-N-hydroxybenzenecarboximidate (13.45 %) and 1,2–dimethoxy–4[(Z)-1- methoxyprop-1-enyl] benzene (2.98 %).

Similar studies conducted elsewhere, have shown that these compounds are present in seed, mace, rind and leaf. Madhav (2001) has reported the presence of safrole, myristica (metoxysafrole), methoxyeugenol, caphene, B-terpineol, B-pinene, myrcene, limonene and sabinene in nutmeg oil obtained from seed and Sonavane *et al.* (2002) has detected the presence of myristicin and elemicin, in the

seed of nutmeg and stated that it is one of the reasons for its intoxicating effects. Myristicin, present in the volatile oil of *M. fragrans* is a potential cancer chemopreventive agent (Zheng *et al.*, 1992). The essential oil of nutmeg had shown sabinene (41.7 %), α-pinene (9.4 %), β-pinene (7.3 %), terpine-4-ol (5.8 %), limonene (3.7 %), safrole (1.4 %) and myristicin (2.7 %) (Sonavane *et al.*, 2002). Kokate *et al.* (2005) has also reported the pharmacological effect of volatile oil from nutmeg.

Thus from the present study on volatile oil estimation and GC-MS profiling of essential oil, it is clear that, nutmeg rind can be of much use in areas where kernel and mace are used for pharmaceutical purposes.

5.1.6. Phytochemical studies

The nutmeg rind extract was obtained using three organic solvents *viz.*, petroleum ether, acetone and methanol and showed the presence of phytochemicals like flavonoids, saponins and terpenoids. Min *et al.* (2011) found out that the extracts of *M. fragrans* had also shown alkaloids, saponins, anthraquinones, cardiac glycosides, flavonoids and phlobatanins. The phytochemistry of *M. fragrans* have been reviewed by (Sathyavathy *et al.*, 1987) and concluded that seeds contained saponins, polyphenols, tannins, epicatechin, triterpenic sapogenins and fats.

5.2. Process standardisation for product development

The product development from nutmeg rind is of prime concern when the amount of waste generated in nutmeg farms of Kerala is concerned. The astringency due to tannin (33.80 mg/100g) and high acidity (1.43 %) make the rind unpalatable. For the matter, the product prepared from raw nutmeg rind has very low acceptability. The important sensory attributes for any product are texture, colour, flavour, taste and overall acceptability. In order to improve the quality of final produce, treatments were given to the rind, prior to processing.

The biochemical constituents of rind were estimated after peeling and compared with unpeeled control. Peeling along did not have significant effect on

the quality. But the treatments showed significant effect on the biochemical parameters and when interaction of peeling with pre-treatments was studied, significant difference could be noted.

5.2.1. Pre-treatments

The fruits and vegetables are usually subjected to pre-treatments before processing in order to minimize undesirable changes occurring during product development and subsequent storage. Pre-treatments stop the metabolism of wounded tissue, reduce the microbial contamination and quality of the final product.

Pre-treatment procedures are classified as chemical and non-chemical treatments. This includes blanching, osmotic dewatering, sulfiting and immersing in such diverse solutions as calcium chloride, ascorbic acid and gelatinised starch.

The pre-treatments provided in this study are hot water blanching (80° C for 5 minutes), steam blanching (5 minutes), lime water treatment (2 % for 2 hours), salt water treatment (10 % for 4 hours), salt water treatment (3 % for 48 hours) and these were compared with the control.

5.3 Product diversification

In recent years, emphasis is focused on product diversification, by products utilization and development of value added products like wine, rind powder, candy, osmodehydrated chunks, syrup and jam (Plate 7) to improve the farmers' economy.

5.3.1 Wine

The standardization of procedure for making wine was done after conducting a preliminary evaluation of wine prepared from peeled and unpeeled rind in three proportions of pulp, sugar and water. The highest TSS (29° brix was observed when rind, sugar and water were used in equal proportion. The alcohol

Plate 7. Value added products from nutmeg rind

1:1:1 1:0.75:1 1:0.5:1

A) WINE - Rind : Sugar : water

Titbits Flakes

B) CANDY

Sun dried powder Cabinet dried powder

C) POWDER

Hot water extract Pressure cooked extract

D) SYRUP

12 h 24 h 48 h

E) CHUNKS

1:1 1:1.5 1:2

F) JAM

content was highest (11.68 %) when rind was not peeled before fermentation procedure. The rate and extent of fermentation depends on process parameters like total soluble solids (TSS) fermentation duration etc. Kulkarni *et al.* (1980) has stated that, variation in concentration of alcohol might be due to the difference in the composition of sugar in the case of mango wine. Mango wine recorded 13 per cent alcohol.

Jarezyk and Wzorek (1977) stressed the need for sweetening of musts because of the low sugar content in majority of the fruits.The high alcohol strength in nutmeg wine may be due to the susceptibility of cells and their enzymes to the variation in favourable temperature and pH.

Further among the treatments used for making wine, the best score for sensory attributes and biochemical parameters was obtained when unpeeled rind was mixed with equal quantity of sugar and water. During storage also, sugars (42.42 %) and ascorbic acid (12.88 %) was high in this treatment. The total phenol (11.7 mg/100g) and titrable acidity (0.82 %) was lowest.

Ethanol content in wine is a key parameter for the characterization of wine into various categories. Table wine usually contains 11 to 14 g/100 g of alcohol and it may be as low as 7 g/100 g (Joshi *et al.*, 1991). Thus, the wine prepared using nutmeg rind in the present study can be considered as a light table wine.

The wine also had an acceptable good after taste and colour. However, the clarity of the wine was assigned quite low scores by the panelists. This may be due to lack of aging and presence of polysaccharide molecules that might have resulted in insufficient malolactic fermentation including other physicochemical improvement. Almost all sensory parameters were stable at shorter storage period with almost no change in organoleptic sensation. However, at longer storage period, the wine developed recognizable alteration in quality. It was observed that the taste, aroma, after-taste and body characteristics got improved in 1:1:1 ratio (W_3) with time and temperature during storage making its overall acceptability high (Fig. 4).

Fig 4. Sensory rank scores of wine three months after storage

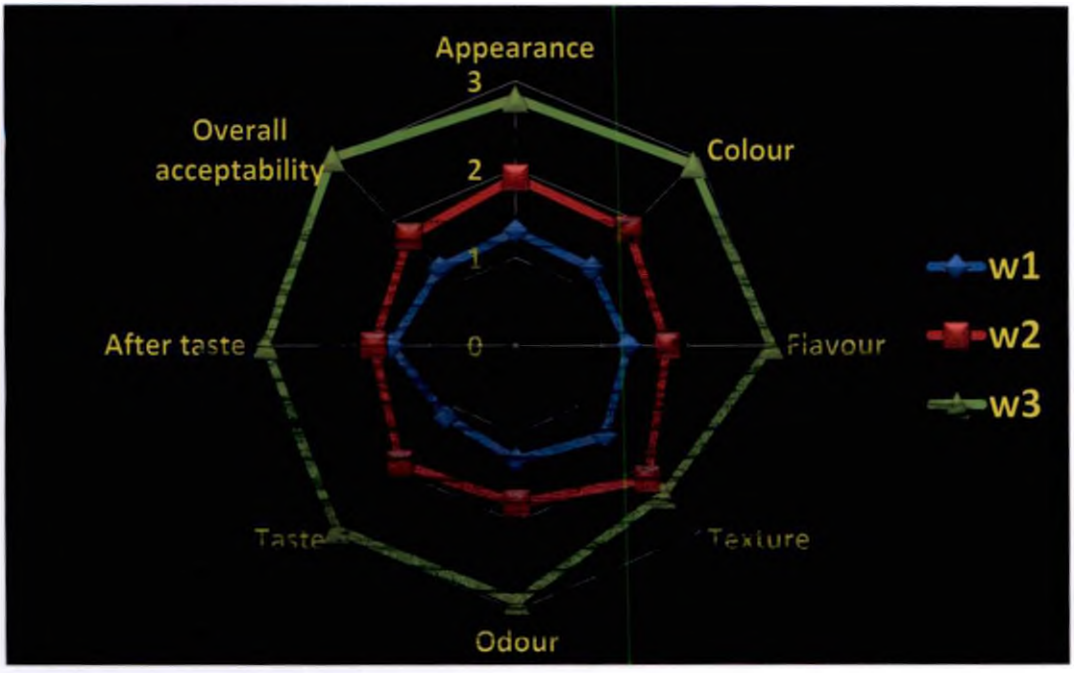
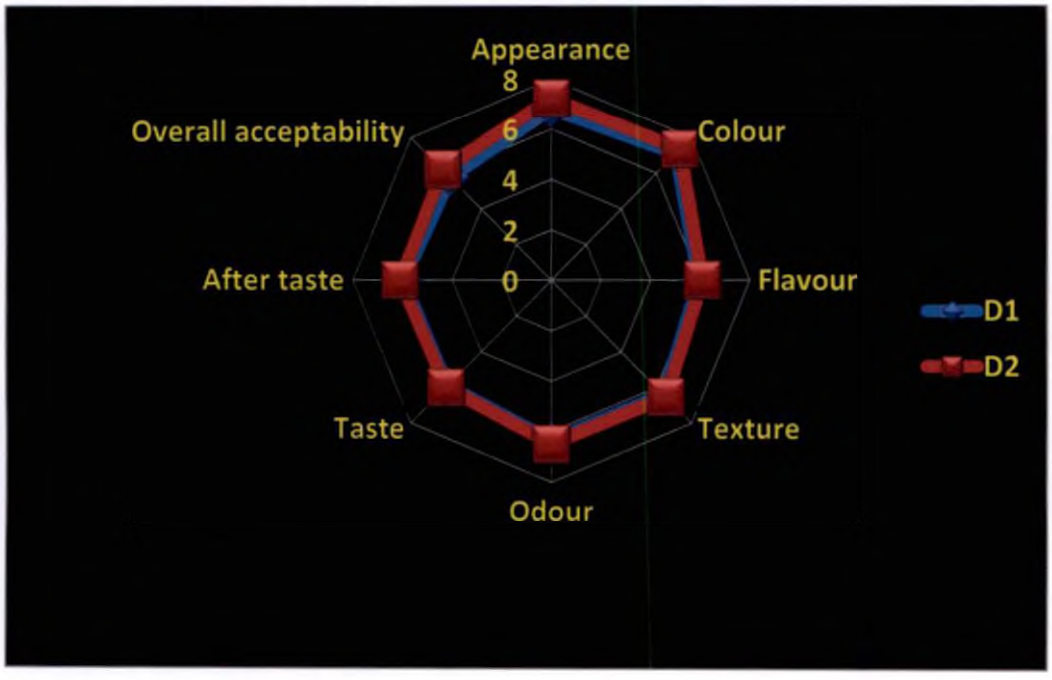


Fig 5. Sensory scores of powder three months after storage



5.3.2. Powder

Drying and powdering is one of the widely used methods of preservation. It assures microbial stability of the product and reduces physical and chemical changes during storage (Lewicki and Lenart, 1992)

Nutmeg rind powder can be used in confectionaries just like nutmeg seed powder. Callistea *et al.* (2010) has reported the use of nutmeg powder in desserts like fruit cakes, muffins, pie and main courses like potato dishes, sauces etc. Nutmeg can be added with beverages like tea and invariably in curry powders (Callistea *et al.*, 2010)

A steady decline in total sugar content in direct solar dried Banarasi aonla at 90 days of storage has also been reported (Tripathi *et al.*, 1988). A similar trend in Desi and Banarasi cultivars of aonla has been found (Ghorai, 1996). The decrease in total sugars might be due to the non-specific hydrolysis of macromolecules, interconversions of sugars and aggregation of monomers during storage (Patter, 1985).

In the present study, nutmeg rind powder was prepared by adopting two methods of drying which includes cabinet drying and sun drying. When dried all the biochemical parameters studied showed an increase when compared to the fresh material. This may be due to the increased concentration of solutes by the removal of water, by convective evaporation, and heat supplied by hot air.

The sun drying was found to be better in quality than cabinet drying with regard to high total sugars, ascorbic acid and low acidity and total phenol. This may be due to the low temperature maintained in cabinet drier and hence reduced the loss of volatile oils.

Sensory qualities are very important from the consumer's point of view. It depends on characters like appearance, colour, texture, flavour, taste, after taste and texture. Overall acceptability of a product is based on all these characters. The sun dried powder was preferred by the panel members based on this evaluation (Fig. 5).

5.3.3. Candy

In Indonesia, the nutmeg fruit is sliced finely, cooked and crystallized to make a fragrant candy called *manisan pala* ("nutmeg sweets"). In this study, candy was prepared in different geometric shapes.

The geometry of sample pieces affects the behaviour of the osmotic concentration due to the variation of the surface area per unit volume or mass and diffusion of water and solutes involved in mass transport (Lerici *et al.,* 1985).

The flakes prepared by slicing nutmeg pieces longitudinally had good appearance when compared to small pieces. Even though the preferential biochemical parameters like total sugars and ascorbic acid was slightly higher for titbits overall acceptability was higher for flakes (Fig. 6). The phenol content which may contribute to the off taste of candy was lower for flakes and it may be the reason for acceptability. Nutritionally flakes can be ranked as a better product, due to high ascorbic acid content (19.32 mg/100g).

The storage of candy in food grade PET bottles, showed an increase in sugar content during the first, second and third month. This may be due to the loss of moisture due to evaporation and also conversion of polysaccharides to reducing sugar. Kumar *et al.* (1992) made similar observation in the case of candy made with ber.

The high sugar content of titbits may be due to the increased osmotic absorption of sugar due to increased surface area. In aonla and blue berry osmo-air drying increase sugar content (Pragathi *et al.*, 2003)

5.3.4. Osmodehydrated chunks

Osmotic dehydration is a complementary treatment in the processing of dehydrated foods, since it presents some advantages such as minimising heat damage to the colour and the flavour, inhibiting enzymatic browning and reducing energy costs (Alakali *et al.*, 2006; Torres *et al.*, 2007). Recently osmotic dehydration process received more attention due to the consumer demand for minimally processed products.

Fig 6. Sensory scores of candy three months after storage

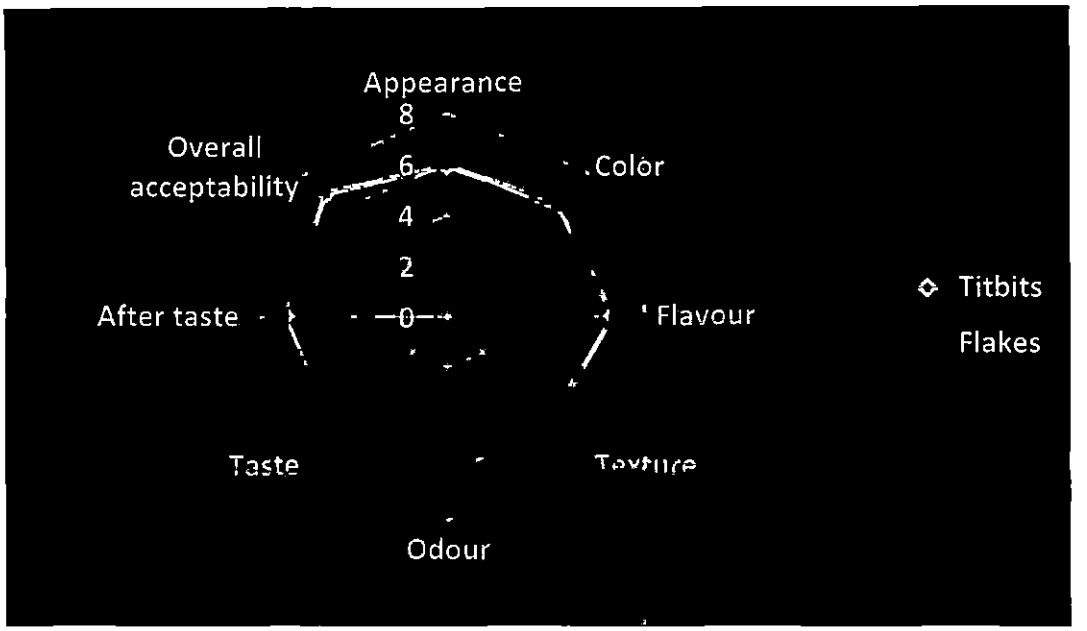
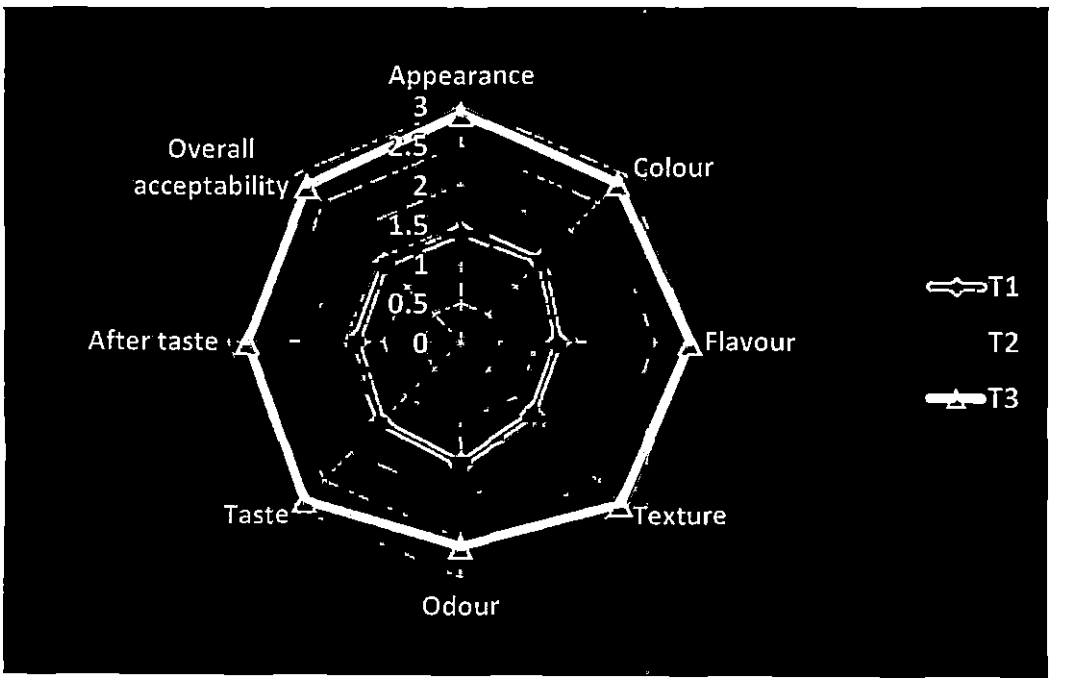


Fig 7. Sensory rank scores of osmodehydrated chunks three months after storage



As a technique for obtaining minimally processed fruits, osmotic dehydration (OD) is adequate, and does possess advantages over other drying techniques, yet it seems that some hydro soluble components may escape into the osmotic solution (OS) during the process. On the other hand, the reuse of the OS in successive OD operations can be a good way of making the process economical and environmentally friendly (Mena *et al.*, 2007).

In the present study, sugar was used as the osmotic agent for the preparation of chunks from nutmeg rind. Vial *et al.* (1991) evaluated the use of inverted sugar as osmotic agent in the osmotic dehydration of kiwi. However, due to its lower cost, sucrose is the most widely used sugar in the majority of studies using this technique.

The immersion of the produce was done in 70° brix sugar syrup in three different durations (12 h, 24 h and 48 h) which resulted in variation in the quality of the product.The chunks immersed in osmotic sugar solution with 70° brix for 48 hours had a better texture and overall acceptability. A study by Markose (2005) also indicated that white watery rose apple osmotically treated in 70° Brix scored the highest overall acceptability. A similar finding was reported by Ramakrishnan (2014) in case of osmodehydrated mango.

The product with high total sugars (98.11 %), ascorbic acid (16.10 mg/100g) and low total phenol content (16.4 mg/100g) was obtained when 48 hours immersion was done. Nutmeg naturally has very low sugar and raw nutmeg has very low TSS 3.38° brix. However immersion in 70° brix for 48 hours increased the total sugar content due to the osmotic gradation, until it reached equilibrium with sugar syrup and it had high overall acceptability after three months of storage (Fig. 7).

The total sugars reduced considerably during the storage period in nutmeg chunks with all the three duration of immersions. The sugar coating over the slices was gradually abridged, there are chances of water absorption and finally dilution of total sugars during storage.

The acidity showed an increasing trend throughout the storage period of nutmeg chunks. Acidity values increased gradually with storage time in an intermediate aonla preserve (Sethi, 1980). Similar trends have also been observed in dehydrated mango pulp (Rao and Roy, 1980) and dates. This increase in acidity might have been due to formation of acids due to interconversion of sugars and other chemical reactions (Clydesdale, 1972) which were accelerated at high ambient temperature (Rao and Roy, 1980). Also, de-esterification of pectin molecules occurs during storage resulting in the loss of jelly grade which leads to a gradual decrease in methoxyl content and increase in titrable acidity (Kertesz, 1951).

The ascorbic acid did not show any significant change during storage. The total phenol content showed a decreasing trend and it may be due to non-enzymatic reactions such as organic acid with sugar and /or oxidation ofphenols, which lead to formation of brown pigments.

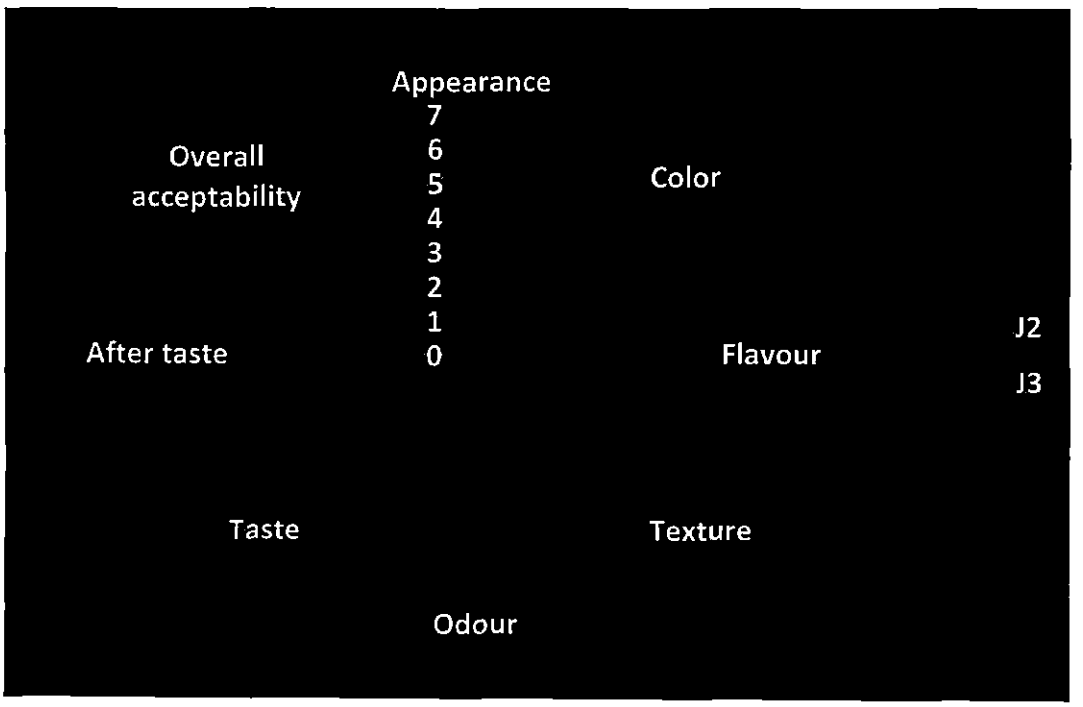
5.3.5. Syrup

Syrup was prepared by taking extract from nutmeg rind by pressure cooking and boiling with water. The quality of the syrup assessed by observing the biochemical parameters showed that syrup prepared from hot water extract had a total sugar content of 61.12 per cent and ascorbic acid 19.32 per cent. The total phenol content was lower (11.8 mg/100g). The organoleptic evaluation showed that the overall acceptability was higher for hot water extract (Fig. 8). This may be due to the presence of high amount of extractives obtained in pressure cooking.

On storage for three months, total sugars increased and there was no change for ascorbic acid. The increase in total sugars might be due to gradual inversion of non-reducing sugars into reducing sugars in acidic medium and hydrolysis of polysaccharides like pectin, cellulose, starch etc. and its conversion into simple sugars simultaneously.

Fig 8. Mean sensory scores of nutmeg rind syrup three months after storage

Fig 9. Mean sensory attributes of nutmeg rind jam three months after storage



The titrable acidity also showed an increasing trend during storage and the pectic substances have been reporfed to increase the acidity in fruit products. Throughout the storage period, the ascorbic acid content decreased and it was proven that the ascorbic acid was easily destroyed by oxidation, especially at high temperature and most easily during processing, storage and cooking.

The total phenol also decreased during the storage period and it may be due to the impact of thermal processing on the nutmeg rinds during the extraction of juices by pressure cooking and hot water extraction method. The high phenol content was considered a desirable factor in syrup unless its acceptance and palatability are affected.

5.3.6. Jam

The rind of the fruit is used in Grenada to make a jam called *morne delice.*

In the present study, jam is prepared by mixing rind with sugar and cooking till the sugar content in the jam reached 68° brix. The standard procedure for making jam was followed. Since nutmeg rind contains high pectin (1.04 %), the proportion of sugar added is varied for better quality of jam. So also the astringent taste due to the presence of tannin (30 g/100g) has to be masked for increasing the palatability. Among the three proportions used, nutmeg rind mixed with double the quantity of sugar was found to be best with regard to biochemical parameters and sensory attributes (Fig. 9).

During storage, total sugars increased gradually in nutmeg rind jam during storage period and the trend in increase was more or less uniform. The increase in total sugars might be due to gradual inversion of non-reducing sugars into reducing sugars in acidic medium and hydrolysis of polysaccharides like pectin, cellulose, starch etc. and its conversion into simple sugars simultaneously.

Acidity value is a measure of stability and shelf life of jam and it is due to the presence of organic acids.In present findings, total acidity of nutmeg rind jam increased gradually during storage period in all the three ratios. An increase in acidity has also been observed in jamun jelly (Ashraf, 1987), aonla jam and papaya jam.

Results of the present studies indicated that the ascorbic acid content of nutmeg rind jam decreased continuously with the storage period in 1:1.5 and 1:2 ratios. The rate of reduction was almost similar in the two ratios. Vitamin C, which is also known as ascorbic acid is easily destroyed by oxidation, especially at high temperature and most easily during processing, storage and cooking (Dauthy, 1995).Reduction in ascorbic acid could be due to oxidation by trapped oxygen in container which results in formation of dehydroascorbic acid. Similar findings were also observed in guava jelly (Singh *et al.*, 2011), jamun jelly (Ashraf, 1987), aonla jam.

In the present study, the phenol content was highest for 1:2 ratio and on storage, a decreasing trend was observed in all the three ratios. The phenolic compounds in fruits and jams are affected by light, pH, pectin and temperature.

It is evident from the present investigation that overall organoleptic and appearance rating based on aroma, taste and appearance of jam decreased during storage period in all the three ratios. Nutmeg rind jam (1:1.5 and 1:2 ratios) was acceptable up to three months. Loss of organoleptic quality and appearance of a jam after certain period is obvious. Temperature plays an important role in inducing certain biochemical changes in the jam which leads to development of off flavour and reduction an organoleptic quality and appearance. Similar results have also been observed in guava jelly (Kalra *et al.*, 1983), aonla jam and candy and papaya products (Kumar, 1990). Colour score of jam declined gradually during storage period in all the three cultivars of aonla. This could be mainly due to non-enzymatic reaction such as organic acid with sugar or oxidation of phenols which leads to the formation of brown pigments.

5.4. Microbial population of nutmeg rind products

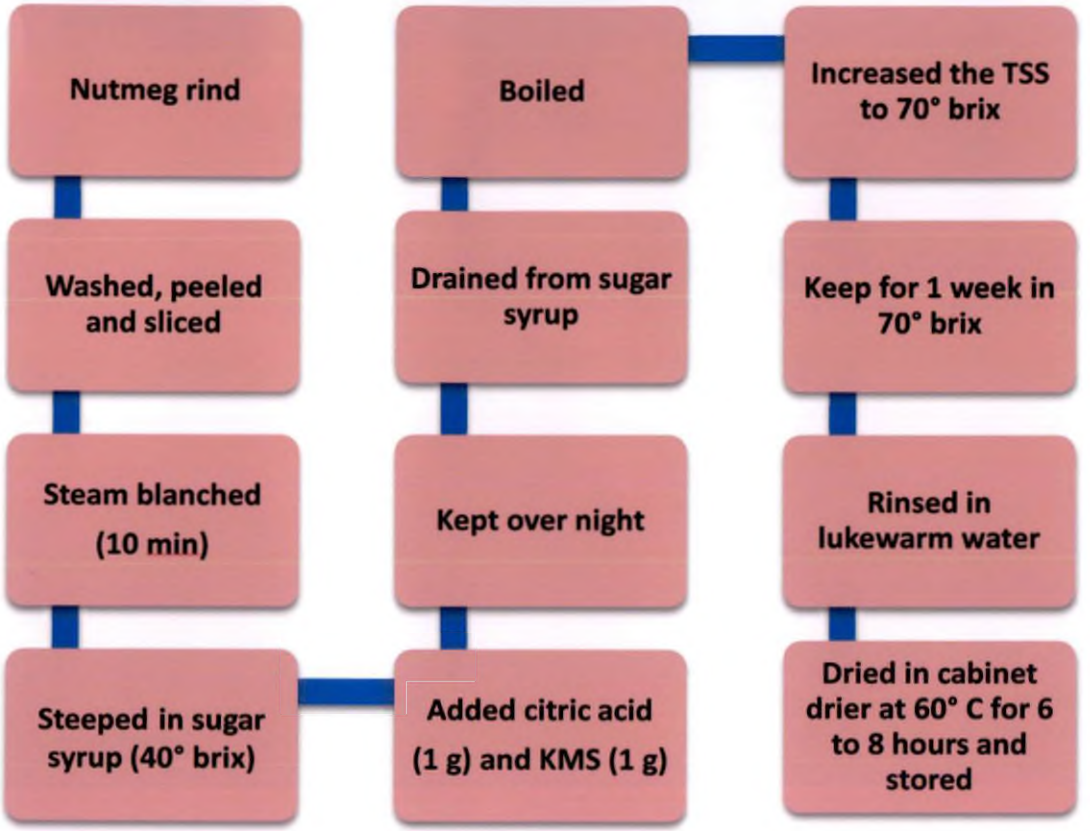
The effect of microbial population on all the products was carried out initially and after three months of storage. The initial and final population in all the products were less and within acceptable limits. The microbial contamination of dehydrated products may be due to the absorption of moisture during storage. After three months, the microbial load observed in jam (Plate 7) and syrup

showed that the products can be stored only for three months under ambient condition. Shivani *et al.* (2010) reported that jam prepared from jamun can be stored for three months at room temperature without spoilage.

5.5. Benefit cost ratio of nutmeg rind products

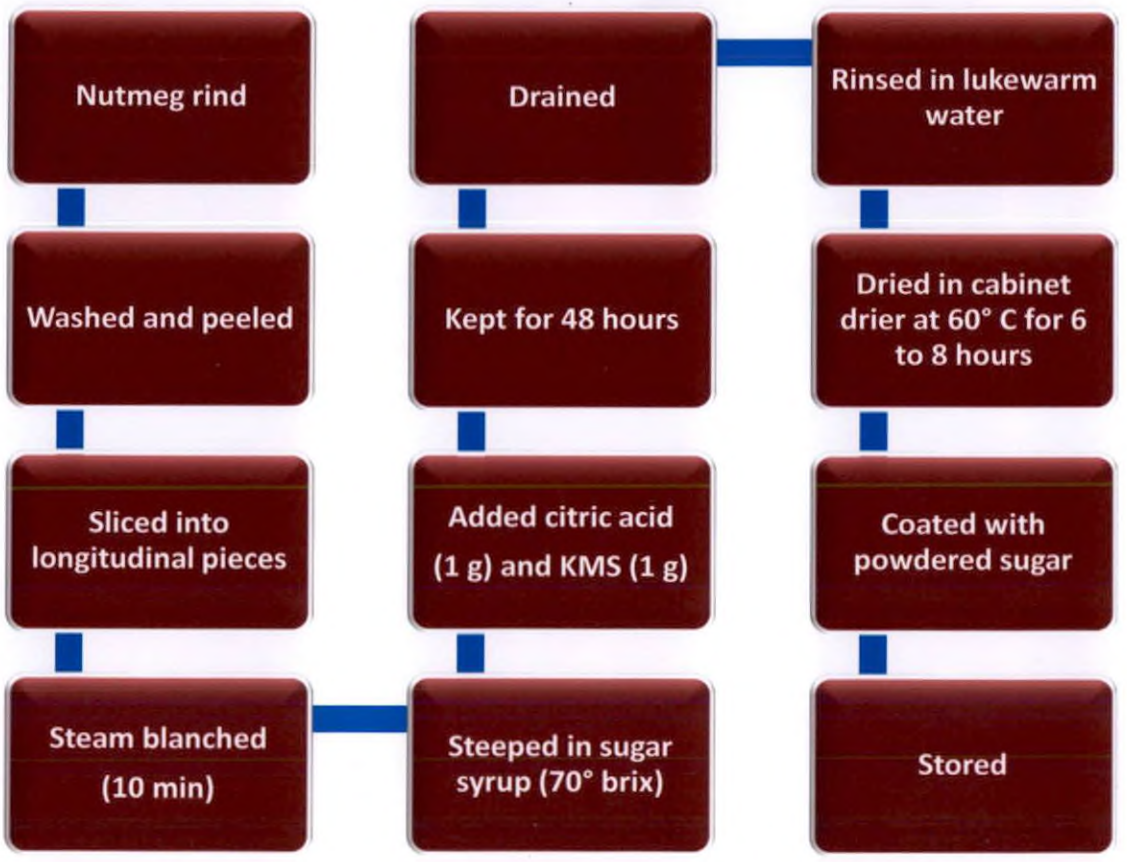
The benefit cost ratio was highest (4.26) when wine was prepared with rind : sugar : water in the ratio 1:1:1. The high value was attributed to the high recovery percentage of wine (66.67 %) in this treatment, whereas when half the quantity of sugar was used the recovery was only 40 per cent. The B:C ratio was low for nutmeg rind powder since the recovery of powder was very less in both types of drying, where it was 12 per cent in sun drying and 8 per cent in cabinet drying. In addition, the electricity cost for cabinet drying made it more expensive. The candy having good customer preference can be prepared with better benefit cost ratio as flakes (Plate 8). The cost of production for titbits was higher due to an increased labour for its preparation. Chunks prepared by standard procedure showed no difference in B:C ratio with difference in duration of immersion in 70° brix sugar solution (Plate 9). This may be due to the fact that no additional cost was incurred by changing the time of immersion. The recovery was 60 per cent in all the three treatments. The high B:C ratio observed in pressure cooking was due to the less energy consumption while cooking. The high B:C ratio for the higher proportion of rind and pulp was due to the high recovery when compared to lower proportion.

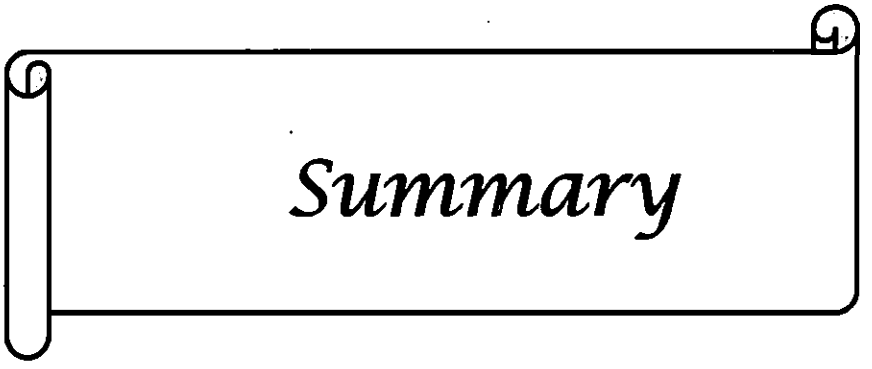
Plate 8. Preparation of nutmeg rind candy



KMS – Potassium metabisulphite

Plate 9. Preparation of osmodehydrated nutmeg chunks




Summary

6. SUMMARY

The project entitled "Proximate analysis and product development in nutmeg (*Myristica fragrans* Houtt.) rind" was carried out in Department of Processing Technology, College of Horticulture, Vellanikkara.

The proximate analysis of the fresh rind, standardization of pre-treatment for reducing the astringency and product development were the topics of interest. The physical and biochemical attributes of nutmeg rind were studied. Thefindings of the study are briefed in this section.

The colour analysis done by visual comparison of rind colour using Universal Colour Language (UCL) showed that the colour was pale greenish yellow was changed to moderate orangish yellow when kept under room temperature. The texture of the nutmeg rind was objectively analysed and it was 1.85 Kg/cm^2.

Nutmeg rind constituting 80 to 85 per cent of whole fruit weight has a moisture content of 88.45 per cent, 1.43 per cent acidity. The astringent nature of the rind may be due to its high total phenol (35.20 mg/100g) and tannin content (33.80 mg/100g). The total soluble solid (TSS) of nutmeg rind is less (3.38°brix) and therefore it has low total sugars (2.69 %). The pericarp showed the presence of 1.25 g/100g protein, 2.55 per cent crude fibre and 0.78 per cent pectin but it is a poor source of ascorbic acid (11.45 mg/100g), starch (0.95 g/100g) and carotene content (37.82 µg/100g).

The important minerals present in the nutmeg pericarp are potassium (0.810 %), calcium (0.413 %), magnesium (0.130 %), copper (1.150 mg/100g), iron (6.078 mg/100g), zinc (2.940 mg/100g), and manganese (0.470 mg/100g) of which the iron content was comparatively high.

The antioxidant activityof nutmeg rind was compared to that of gallic acid and was found that the IC_{50} value of sample was 120 µg/ml while that of standard was 1.25 µg/ml showing moderate antioxidant activity.

The nutmeg rind oil was colourless and the oil recovery percentage in fresh sample was 0.05 per cent and that of dried sample was 0.10 per cent. The GC-MS profiling of the nutmeg rind oil exhibited a six peak chromatogram and the compounds found were myristicin (1.52 %), elemicin (25.67 %), terpenen-4-ol (35.89%), alpha-terpineol (20.49%), methyl (Z)-N-hydroxybenzenecarboximidate (13.45 %) and 1,2–dimethoxy–4[(Z)-1- methoxyprop-1-enyl] benzene (2.98 %). The oleoresin recovery was estimated to be 3.17 per cent. Screening for phytochemicals showed the presence of flavonoids, saponins and terpenoids in petroleum ether, acetone and methanol extracts of nutmeg rind.

The moisture, acidity, total phenol and starch content were higher for peeled sample when compared to that of unpeeled rind, whereas the biochemical constituents like crude fibre, pectin, vitamin C, protein, carotene, reducing sugar, non-reducing and total sugars were relatively higher for the unpeeled nutmeg rind.

Among the pre-treatments given, the highest total sugars was seen in hot water blanched rinds at 80°C for 5 minutes (3.75 %) followed by steam blanching for 5 minutes and the least was observed in salt water 3 per cent for 48 hrs (1.58 %) but it possessed the least titrable acidity of 0.64 per cent followed by lime water treatment (2 % for 2hrs). There was no significant difference in the interaction of pre-treatments.

The highest ascorbic acid (19.04 mg/100g) was observed in rinds treated with 2 per cent lime water for 2 hours followed by rinds treated in 3 per cent salt water for 48 hours. The least phenol content of 0.26 mg/g was noticed in rinds treated in 3 per cent salt water for 48 hrs followed by 0.35 mg/g in lime water treatment.

As far as the texture of the samples is considered, the control samples (T_6) possessed the least firmness (1.86 Kg/cm^2) and among the treatments, 2 per cent lime water treatment for 2 hrs (T_3) showed the maximum firmness (4.83 Kg/cm^2). The salt water treated rind showed medium penetrance (3.70 Kg/cm^2).

Therefore, considering all the biochemical constituents, 3 per cent salt water treatment for 48 hours was found to be the best pre-treatment. The titrable acidity and total phenol content were least and ascorbic acid contentwas comparatively high in this treatment. The texture of the salt water treated rind possessed firmness which was acceptable for product development.

The value added products prepared were wine, powder, candy, chunk, syrup and jam. Wine prepared using unpeeled rind had more TSS ranging from 16.2 - 29°brix and higher alcohol (11.68 %). The visual colour of the wine was yellowish orange with a better clarity. It was concluded that the wine ratio 1:1:1 was selected as the best after biochemical estimation and organoleptic evaluation.

Nutmeg powder was prepared from nutmeg slices by sun drying and dehydration in a cabinet drier at 60°C. The sun dried powder was mostly accepted due to its sensory and biochemical constituents.

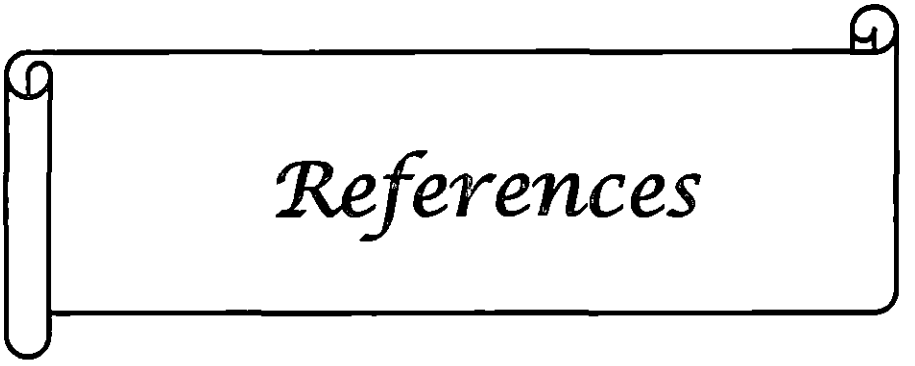
Candy prepared by increasing the brix content of nutmeg pieces into small pieces, titbits and flakes. The biochemical analysis showed that candy titbits ere of better quality while the flakes scored highest in organoleptic evaluation.

Osmodehydration method was used for the preparation of chunks.Chunks prepared in 70° brix with different duration of immersion – 12 hrs, 24 hrs, 48 hrs. After 3 months of storage, the chunks immersed for 48 hrs scored better organoleptic scores and sensory evaluation.

Syrup was prepared with peeled and unpeeled pericarp during preliminary evaluation using two extraction methods. Syrup prepared using unpeeled rind had more flavour and colour compared to peeled and hence gained maximum acceptance. The visual colour of the syrup was creamish yellow with thick consistency. Hence for further study the unpeeled rind was used. The sensory attributes were least for the syrup prepared from the rind pre-treated by immersing in 3 per cent brine for 48 hrs and the juice extracted by hot water method gained the maximum acceptance when compared to the pressure cooked syrup.

The nutmeg rind jam was prepared in three ratios of 1:1, 1:1.5 and 1:2 with varying sugar levels. The ratio of 1:2 gained the maximum score for organoleptic evaluation and for biochemical observations.

The microbial population was least during the initial month and increased on storage, but were within the acceptable limit. The wine prepared with rind : sugar : water in 1:1:1 ratio showed highest B:C ratio (4.26). The B:C ratio was high (1.72) for rind powder prepared by sun drying and it was low (0.92) when powder was prepared by cabinet drying. The candy flakes had a B:C ratio of 1.82 when compared to titbits. Benefit cost ratio for osmodehydrated chunks was 2.52. Syrup prepared by using hot water extract had less B:C ratio (2.45), even though it had good sensory scores. Jam was prepared in three proportions and it was found that, when sugar was used in the ratio 1:2, the recovery percentage was 83.33 per cent and hence it had high B:C ratio of 2.30.


References

REFERENCES

[Anonymous].1999.http://azaleas.org/index.pl/rhsmacfan4.html

AOAC [Association of Official Analytical Chemists].1980. AOAC home page [online]. Available: http://www.aoac.org/iMIS15_Prod/AOAC. [12 Dec. 2014].

Abadio, F. D. B., Domingues, A. M., Borges, S. V., and Oliveira, V. M. 2004. Physical properties of powdered pineapple (*Ananas comosus*) juice effect of maltodextrin concentration and atomization speed. *J. Food. Eng.* 64: 285-287.

Abdullah, M. I. 2009. Physicochemical profiling and detection of phenolic constituents with antioxidant and antibacterial activities of *Myristica fragrans* Houtt. M.Sc. thesis, University Sains Malaysia, 117p.

Akanbi, C. T., Olumese, A. O., Taiwo, K. A., Ojo, A., and Akinwande, B. A. 2003. Effect of blanching medium on drying and storage characteristics of pepper. *Nigerian Drying Symp.* 1: 95 - 107.

Alakali, J. S. and Ariahu, C. C. 2006. Kinetics of osmotic dehydration of mango. *J. Food Processing and Preservation.* 30: 597-607.

Amarowicza, R., Peggb, R. B., Rahimi-Moghaddam, P., Barld, B., and Weilc, J. A. 2004. Free radical scavenging capacity and antioxidant activity of selected plant species from the Canadian prairies. *Food Chem.* 84: 551–562.

Anon, 1999. *Plant resources of South-East Asia, No.13.*

Artes, F., Tudela, J. A., and Villaescusa, R. 2000.Thermal postharvest treatments for improving pomegranate quality and shelf life. *Postharvest Biol. Technol.* 18: 245-251.

Ashraf, S. M. 1987. Studies on postharvest technology of jamun (*Syzygium cumini* Skeels) fruits. Ph.D.(Ag.) thesis, Narendra Dev University of Agriculture and Technology, Faizabad, 148p.

Athmaselvi, K. A. 2009. Effect of pre-treatments and methods of blanching on the quality of turmeric. *J. Plant. Crops* 37(3): 235-238.

Aveno, J. L. and Orden, M. E. M. 2004. Hot water treatment of mango: A study of four export corporations in the Phillipines. *KMITL Sci. Technol. J.* 4 (1): 1685-2044.

Baker, R. A., Berry, N., Hui, Y. H., and Barrett, D. M. 2005. *Fruit Preserves and Jams in Processing Fruits Science and Technology* (2nd Ed.). CRC Press, Boca Ratón, pp. 113–125.

Bamidele, O., Akinnuga, A. M., Alagbonsi, I. A., Ojo, O. A., Olorunfemi, J. O., and Akuyoma, M. A. 2011. Effects of ethanolic extract of *Myristica fragrans* Houtt. Nutmeg on some heamatological in albino rats. *Int. J. Med. Med. Sci.* 3(6): 215–218.

Bhat, C. M., Sehgal, S., and Sharma, R. N. 1982. *A Manual on Food Preservation of Home.* Directorate of Publication, Haryana Agricultural University, Hissar. 231p.

Blasco, M., Perez, J. V. G., Bon, J., Carreres, J. E., and Mulet, A. 2006. Effect of blanching and air flow rate on turmeric drying. *Food Sci. Technol. Int.* 12(4): 315-323.

Blois, M. S. 1956. Antioxidant determinations by the use of a stable free radical. *Nat.* 29: 1199-2000.

Brand-Williams, W., Cuvelier, M., and Berset, C. 1995. Use of a free radical method to evaluate antioxidant activity. *Food Sci. Technol.* 28: 25–30.

Brennan, J. G., Herrera, K., and Jowitt, R. 1991. A study on the factors affecting the spray drying of orange juice. *J. Food Technol.* 26: 314-321.

Brookfield, P. L., Nicoll, S., Gunson, F. A., Harker, F. R., and Wohlers, M. 2011. Sensory evaluation by small postharvest teams and the relationship with instrumental measurements of apple texture. *Postharvest Biol. Technol.* 59: 179–186.

Callistea, M. J., Hennenssey, T. M., Andrew, D and Nelson, D. L. 2010. Spices and condiments. *Int. J. Food Sci. Technol.* 33:215-223

Cano, P., Mann, M. A., and Fuster, C. 1990. Effects of some thermal treatments on polyphenoloxidase and peroxidase activities of banana (*Musa cavendishii*, var. enana). *J. Sci. Food Agric.* 51: 223-231.

Carlsen, M. H., Halvorsen, B. L., Holte, K., Bohn, S. K., Dragland, S., and Blomhoff, R. 2010. The total antioxidant content of more than 3100 foods, beverages, spices, herbs and supplements used worldwide. *Nutr. J.* 9(3): 1–11.

Chand, T., Gehlot, R., Singh, R., Siddiqui, S., and Rana, M. K. 2007. Studies on physico-chemical composition of bael fruit and changes in chemical composition of its pulp and jam during storage. *Haryana J. Hortic. Sci.* 36(1 and 2): 49-51.

Chauhan, O. P., Archana, B. S., Singh, A., Raju, P. S., and Bawa, A. S. 2013. Utilization of tender coconut pulp for jam making and its quality evaluation during storage. *Food Bioprocess Technol.* 6(6): 1444-1449.

Chirathaworn, C., Kongcharoensuntorn, W., Dechdoungchan, T., Lowanitchapat, A., Sanguanmoo, P., and Poovorawan, Y. 2007. *Myristica fragrans* Houtt. methanolic extract induces apoptosis in a human leukemia cell line through SIRT1 mRNA down regulation. *J. Med. Assoc. Thailand* 90(11): 2422–2428.

Chitturi, S., Gopichand, V., Talatam and Vuppu, S. 2013.Studies on protein content, protease activity, antioxidants potential, melanin composition, glucosinolate and pectin constitution with brief statistical analysis in

some medicinally significant fruit peels. *Der Pharmacia Lettre.* 5(1): 13-23.

Chopra, S. L. and Kanwar, S. J. 1978. *Analytical Agricultural Chemistry.* Kalyani Publishers, Ludhiana, 331p.

Clydesdale, F. M., Lin, Y. D., and Francis, F. J. 1972.Formation of 2-pyrrolidone-5-carboxylicacid from glutamine during processing and storage of spinach puree. *J. Food Sci.* 37: 45.

[CODEX STAN] 2009. Codex standard for jam, jellies and marmalades [on line]. Available: http://codexalimentarius.org [07 April 2013].

Costa, F., Cappellin, L., Longhi, S., Guerra, W., Magnago, P., and Porro, D. 2011. Assessment of apple (*Malus domestica* Borkh.) fruit texture by a combined acoustic mechanical profiling strategy. *Postharvest Biol. Technol.* 61: 21–28.

Dabhade, R. S. and Khedkar, D. M. 1980. Studies on drying and dehydration of raw mangoes for preparation of mango powder (*Amchur*). Part–VI. Changes in chemical constituents of raw mango powder during storage. *Indian Food Packer* 34: 48-54.

Das, S. G., Prabhakar, S., and Singh, A. K. 2011. Studies on the physico-chemical changes in jam of three cultivars of aonla during storage. *Haryana J. Hortic. Sci.* 40(1 and 2): 13-18.

Dauthy, M. E. 1995. *Fruit and vegetable processing.* Bulletin No. 119, FAO Agricultural Services, Geneva, 456p.

Deosthale, Y. G. 1982. Food processing and nutritive value of legumes. In: Srivastava, H. C. (ed.), *Pulse production constraints and opportunities* (4thEd.). Oxford and IBH publishing Co, Calcutta, India, pp. 31-68.

Dhas, P. H. A., Zachariah, T. J., Rajesh, P. N., and Subramannian, S. 2004. Effect of blanching and drying on quality of mace (*Myristica fragrans*). *J. Food Sci. Technol.* 41(3): 306-308.

Diaz-Perez, J. C., Mejia, A., Bautista, S., Zavaleta, R., Villanueva, R., and Lopez-Gomez, R. 2001. Response of sapote mamey (*Pouteria sapota* Jacq.) fruit to hot water treatments. *Postharvest Biol. Technol.* 22: 159–167.

Dorman, H. J. D. and Deans, S. J. 2000. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. *J. Appl. Microbiol.* 88: 308–315.

Edoga, H. O., Okwu, D. E., and Mbaebie, B. O. 2005. Phytochemical constituents of some Nigerian medicinal plants. *Afr. J. Biotechnol.* 4(7): 685–688.

Everett, T. H. 1981. Myristica. In: *Illustrated Encyclopaedia of Horticulture,* Vol. 7, Garland Publishing Inc, New York. pp. 2264-2265.

Fallik, E. 2004. Pre-storage hot water treatments (immersion, rinsing and brushing). *Postharvest Biol. Technol.* 32: 125–134.

Ferguson, I. B., Ben-Yehoshua, S., Mitcham, E. J., McDonald, R. E., and Lurie, S. 2000. Postharvest heat treatments: introduction and workshop summary. *Postharvest Biol. Technol.* 21: 1–6.

Ferreira, I. M. P. L. V. O., Pestana, N., Alves, M. R., Mota, F. J. M., Reu, C., and Cunha, S. 2004. Quince jam quality: Microbiological, physicochemical and sensory evaluation. *Food Control* 15: 291–295.

Firoz, B. S., Ahmed, M., and Srivastava, A. K. 2003. Development and quality evaluation of pulse based papaya powder during ambient temperature storage. *Beverage and Food World* 11: 33-35.

Ghorai, K. and Sethi, V. 1996.Varietal suitability of Amla (Desi and Banarasi) fruits for storage and preservation. *Indian Food Packer* 50(1): 11–18.

GITCO [Gujarat Industrial and Technical Consultancy Organisation Limited]. 1999. *Prospective Food Processing Projects*, Gujarat Industrial and Technical Consultancy Organisation Limited, GITCO House, Ahmedabad. 2: 20-25

Gopalakrishnan, M. 1979. Identification of the mace pigments. *J. Food Sci. Technol.* 16: 261-262.

Gopalakrishnan, M. 1992. Chemical composition of nutmeg and mace. *J. Spices Aromat. Crops* 1(1): 49-54.

Gopalan, C., Ramasastri, B. V., and Balasubramanian, S. C. 2000. Proximate principles: Common foods. In: NarasingaRao, B. S., Pant, K. C., and Deosthale. Y. G. (ed.), *Nutritive value of Indian foods (Revised and updated edition).* National Institute of Nutrition, Indian Council of Medicinal Research, Hyderabad, India, pp. 53–55.

Gopalan, C., Sastri, B. V., and Balasubramanian, S. C. 1984. *Nutritive value of Indian Foods.* Indian Council of Medicinal Research, Hyderabad, 156p.

Gul, S. and Safdar, M. 2009. Proximate composition and mineral analysis of Cinnamon. *Pakist. J. Nutr.* 8(9): 1456-1460.

Gupta, A. D., Bansal, V. K., Babu, V., and Maithil, N. 2013. Chemistry, antioxidant and antimicrobial potential of nutmeg (*Myristica fragrans* Houtt.). *J. Genet. Eng. Biotechnol.*11: 25–31.

Hattori, M., Yang, X. W., Miyashiro, H., and Namba, T. 1993. Inhibitory effects of monomeric and dimericphenylpropanoids from mace on lipid peroxidation *in vitro* and *in vivo*. *Phytotherapy Res.* 7: 395-401.

Hong-Guang, Y., When-Hua, Z., Jiang-Hua, C., and Zhi-En, D. 2012. Optimization of the alcoholic fermentation of blueberry juice by AS 2.316 *Saccharomyces cerevisiae* wine yeast. *Afr. J. Biotechnol.* 11(15): 3623-363.

Hooker, J. D. 1973.*Flora of British India.*Periodicals experts, VivekVihar, New Delhi, p.102.

Huang, D., Ou, B., and Prior, R. L. 2005. The chemistry behind antioxidant capacity assays. *J. Agric. Food Chem.* 53: 1841–1856.

Igual, M., Garcia-Martinez, E., Camacho, M. D. M., and Martinez-Navarrete, N. 2013.Physico-chemical and sensorial properties of grapefruit jams as affected by processing. *Food Bioprocess Technol.* 6: 177–185.

ITC [International Trade Centre]. 2003.ITC home page [on line]. Available: http://www.intracen.org/itc/market-info-tools/trade-statistics. [05 Dec. 2014].

Ismail, A. and Wee, Y. L. 2004. Effect of different blanching times on antioxidant properties in selected cruciferous vegetables. *J. Sci. Food Agric.* 85: 2314 – 2320.

Ispir, A., Togrul, T. I. 2009. Osmotic dehydration of apricot: Kinetics and the effect of process parameters. *Chem. Eng. Res. Des.*78: 166- 180.

Izumi, H. and Watada, A. E. 1994. Calcium treatments affect storage quality of shredded carrots. *J. Food Sci.* 59(1): 106-109.

Jarczyk, A. and Wzorek, W. 1977.Fruit and Honey Wines. In: Rose, A.H. (ed.),*Alcoholic Beverages*. Academic Press, London, pp. 387-421.

Jellin,J. M., Gregory, P. J., Batz, F., and Hitchens, K. 2005.Natural Medicines comprehensive Database. In: *Phamacist's Letter/Prescriber's Letter* (7thEd.). Therapeutic Research Faculty, Stockton, pp. 918–919.

Johnson, L. F. and Curl, E. A. 1972. Methods for Research on the Ecology of Soil Borne Plant Pathogens. Burgees Publishing Company, New York, p.247.

John, P. J. 2008. *A Handbook on Postharvest Management of Fruits and Vegetables.*Daya Publishing House, New Delhi. 147p.

Joshi, V. K., Bhutani, V. P., Lal, B. B., and Sharma, R. 1990.A method for preparation of wild apricot (chulli) wine.*Indian Food Packer.*44(5): 50-55.

Joshi, V. K., Sharma, P. C., and Attri, B. L. 1991. Study on deacidification activity of *Schizosaccharomyces pombe* in plum must of variable composition. *J. Appl. Bacteriol.* 70: 386-390.

Jover, A. J. V., Montes, F. J. L., and Fuentes, M. D. M. F. 2004.Measuring perceptions of quality in food products: The case of red wine.*Food Qual. Preference* 15: 453–469.

Jyothi, P. 2006. Value addition and quality evaluation of West Indian Cherry. M.Sc. (Home Science) thesis, Kerala Agricultural University, Thrissur, 85p.

Kalil, U. L. and Sidel, T. P. 1994.Spray drying of mango juice concentrates. *Mesopotamia J. Agric.* **29**(1): 81-89.

Kalra, S. K., Adsule, P. G., Tondon, D. K., Lohani, N. C., and Sankhwar, P. L. 1983. Evaluation of mango-papaya blended beverage. *Indian Food Packer* 45: 33-35.

Kalsi, H. and Dhawan, S.S. 2001. Preparation of guava powder by osmo-air drying and its storage studies. *Beverage and Food World* 28: 33-34.

Kapoor, I. P. S., Singh, B., Singh, G., Carola, S., Heluani, D., Lampasona, M. P. D., and Catalan, C. A. N. 2013. Chemical Composition and Antioxidant Activity of Essential oil and oleoresins of Nutmeg (*Myristica fragrans* Houtt.) fruits. *Int. J. Food Properties*. 16: 1059–1070.

Kays, S. J. 1999. Preharvest factors affecting appearance. *Postharvest Biol. Technol* 15: 233-247.

Kertesz, Z. I. 1951. *The Pectin Substances*. Inter Science Publ Inc., New York, 628p.

Khan, M. R. 2012. Osmotic dehydration technique for fruits preservation - A review. *Pakist. J. Food Sci.* 22(2): 71-85.

Khurdiya, D. S. and Roy, S. K. 1985. Storage studies in jamun (*Syzygium cumini* L.) juice and nectar. *J. Food Sci. Technol.* 22: 217.

Kingsly, R. P., Goyal, R. K., Manikantan, M. R., and Ilyas, S. M. 2007.Effects of pretreatments and drying air temperature on drying behaviour of peach slice.*Int. J. Food Sci. Tech.* 42: 65-69.

Kokate, C. K, Purohit, A. P., and Gokhale, S. B. 2003.Pharmacognosy (42nd Ed.).NiraliPrakashan, Pune, 635p.

Kordylas, J. M. 1991. *Processing and Preservation of Tropical and Subtropical Foods*. Macmillan Education Ltd, London, UK.430p.

Kotecha, T. M., Adsule, R. N., and Kadam, S. S. 1995. Processing of custard apple: preparation of ready-to-serve beverage and wine. *Indian Food Packer*. 49(4): 5-11.

Kotilainen, L., Rajalahti, R., Ragasa, C., and Pehu, E. 2006. Health enhancing foods opportunities for strengthening the sector in developing countries. *Agric. Rural Dev*. 3: 9–12.

Kowalska, H., Marzec, A., and Lenart, A. 2009. Selected mechanical properties of osmotically dehydrated apples impregnated with calcium ions. *J. Fruit Ornamental Plant Res.* 17(2): 163-173.

Krishnamoorthy B., Rema, J., and Mathew, P. A. 2001. Genetic resources and ex situ conservation of nutmeg, a tree of medicinal importance. *J. Med. Aromat. Pl. Sci.* 22: 340-342.

Krishnamoorthy, B. 1987. Nutmeg. *Planters Chronicle* 82(3): 83-84.

Kulkarni, J. H., Singh, H., and Chadha, K. L. 1980. Preliminary screening of mango varieties for wine making. *J. Food Sci. Technol*. 17(5): 218-220.

Kumar, A., Sasikumar, B., Srinivasan, V., John, Z., and Rajeev, P. 2010. Ginger. In: Parthasarathy, V. A. and Rajeev, P. (ed.), Major Spices – Production and Processing. Indian Institute of Spices Research, Calicut, Kerala, pp. 115-151.

Kumar, S. 1990. Studies on postharvest technologyof papaya (*Carica papaya* L.) fruits. Ph.D.(Ag) thesis, N. D. University of Agriculture and Technology, Faizabad, 167p.

Kumar, S., Kumar, A., Baig, M. J., and Chaubey, B. K. 2005. Effect of calcium on physico-chemical changes in aonla (*Emblica officinalis* Gaertn.). *Ind. J. Hort.* 64(4): 324-326.

Kumar, S., Ojha, C. M., Deen, B., Awasthi, O. P., and Nainwal, N. C. 1992. Potentiality of ber (*Ziziphus mauritiana* Lamk.) cultivars for candy making. *Prog. Hort.* 24(1 and2): 74-78.

Larrauri, J. A., Ruperez, P., Borroto, B., and Calixto, S. 1996. Mango peels as a new tropical fibre: Preparation and characterization. *Lebensmittel-Wissenschaft und-Technologie.* 29: 729-733.

Lawless, H. T. and Heymann, H. H. 1998. *Sensory Evaluation of Food: Principles and Practices.* Chapman and Hall, New York, 164p.

Le, K., Chiu, F., and Ng, K. 2007. Identification and quantification of antioxidants in *Fructus lycii. Food Chem.* 105: 353-363.

Lee, M. S., Kim, K.W., Kim, Y.H., and Lee, G.M. 2003. Proteome analysis of antibody-expressing CHO cells in response to hyperosmotic pressure. *Biotech.Prog.* 19: 1734-1741.

Lee, S. R. 1986. *Korean Fermented Foods.* Seoul: Ewha Women's University Press, Seoul, 294p.

Lerici C. R., Rosa D. M., and Bartolucci, L. 1985. Osmotic dehydration of fruits: influence of osmotic agents on drying behaviour and product quality. *J. Food Sci.* 50: 1217–1220.

Lewicki, P. andLenart, A. 1992. Energy consumption during osmo-convection drying of fruits and vegetables, In: Mujumdar, A. S. (ed.), *Drying of Solids.* International Science Publisher, New York, USA.pp. 354-366.

Lindenschmidt, R. C., Trika, A. F., Guard, M. E., and Witschi, H. P. 1986. The effect of dietary butylatedhydroxy toluene on liver and colon tumor development in mice. *Toxicol.* 38: 151–160.

Madhav, A. 2001. Evaluation of fruit wastes as sources of pectin. *J. Food Sci.* 1(6): 52–60.

Madhav, A. and Pushpalatha, P. B. 2002. Quality upgradation of jellies prepared using pectin extracted from fruit wastes. *J. Trop. Agric.* 40: 31-34.

Mao, L., Jeong, J., Que, F., and Huber, D. J. 2006. Physiological properties of fresh-cut watermelon (*Citrullus lanatus*) in response to 1-methylcyclopropene and postprocessing calcium application. *J. Sci. Food Agric.* 86: 46–53.

Markose, A. M. 2005. Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm.) Alston and malay apple (*Syzygium malaccense* (L.) Mernil and Perry. M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur. 100p.

Maya, K. M., Zachariah, T. J, and Krishnamoorthy, B. 2004. Chemical composition of essential oils of nutmeg (*Myristica fragrans* Houtt.) accessions. *J. Spices Aromat. Crops* 13(2): 135–139.

Mena, P. R., Camacho, M. M., and Navarrete, N. M. 2007. Compositional and physicochemical changes associated to successive osmodehydration cycles of pineapple (*Ananas comosus*). *J. Food Eng.* 79(3): 842-849.

Min, B. S., Cuong, T. D., Hung, T. M., Min, B. K., Shin, B. S., and Woo, M. H. 2011. Inhibitory effect of lignans from *Myristica fragrans* on LPS-induced NO Production in RAW264.7 Cells.*Bull. Korean Chem. Soc.* 32(11): 40-59

Mojani, M. S., Ghasemzadeh, A., Rahmat, A., Loh, S. P., and Ramasamy, R. 2014. Assessment of bioactive compounds, nutritional composition and antioxidant activity of Malaysian young ginger (*Zingiber officinale* Rosc.). *Int. Food Res. J.* 21(5): 1931-1935.

Mundada, M., Hathan, S. B., and Maske, S. 2011. Mass transfer kinetics during osmotic dehydration of pomegranate arils. *J. Food Sci.*76: 31-39.

Naknean, P. 2012. Factors affecting mass transfer during osmotic dehydration of fruits. *Int. Food Res. J.* 19:7-18.

Obenland, D. M. and Aung, L. H. 1997. Sodium chloride reduces damage to nectarines caused by hot water treatments. *Postharvest Biol. Technol.* 12: 15-19.

Okiei, W., Ogunlesi, M., Azeez, L., Obakachi, V., Osussanmi, M., and Nkenchor, G. 2009. The voltammetric titrimetric determination of ascorbic acid levels in tropical fruit samples. *Int. J. Electrochemical Sci.* 4(2): 276–287.

Olesen, T., Nacey, L., Wiltshire, N., and O'Brien, S. 2004. Hot water treatments for the control of rots on harvested litchi (*Litchi chinensis* Sonn.) fruit. *Postharvest Biol. Technol.* 32(2): 135–146.

Otunola, G. A., Oloyeda, O. B., Oladiji, A. T., and Afolayan, A. J. 2010.Comparitive analysis of the chemical composition of three spices – *Allium sativum* L., *Zingiber officinale* Rosc. and *Capsicum frutescens* L. commonly consumed in Nigeria. *Afr. J. Biotechnol.* 3: 32-36.

Padmavathy, S. and Mekala, V. 2013. Preliminary phytochemical investigation of some medicinal plants of Western Ghats. *Int. J. Res. Pharma Biomedical Sci.* 4(1): 251-259.

Pal, R. K. and Sharma, R. R. 2010. Enjoy fruits and vegetables for a longer time. *Indian Hort.* 55(6): 49-53.

Pandharipande, S. L., Saurav, P., and Ankit, S. S. 2012. Modeling of osmotic dehydration kinetics of banana slices using artificial neural network. *Int. J. Comput. Appl.* 48(3): 26- 31.

Park, K. J., Bin, A., Brod F. P. R., and Park, T. H. K. B. 2002. Osmotic dehydration kinetics of pear D'anjou (*Pyrus communis* L). *J. Food Eng.* 52: 293-298.

Parthasarathy, V. A. and Madan, M. S. 2010. Spices Research and Development – an Overview. In: Parthasarathy, V. A. and Rajeev, P. A. (Eds.). *Major*

Spices – Production and Processing. Indian Institute of Spices Research, Calicut, pp. 1-14.

Patras, A., Brunton, N. P., Tiwari, B. K., and Butler, F. 2011. Stability and degradation kinetics of bioactive compounds and colour in strawberry jam during storage. *Food Bioprocess Technol.* 4: 1245–1252.

Patter, H. E. 1985. *Evaluation of Quality of Fruits and Vegetables.* AVI Publishing Co., Inc. Westport, 89p.

Paul, S. K., Dutta, H., Mahanta, C. L., and Kumar, P. G. V. 2014. Process standardization, characterization and storage study of a sweet potato (*Ipomoea batatas* L.) wine. *Int. Food Res. J.* 21(3): 1113-1120.

Ponting, J. D. 1973. Osmotic dehydration of fruits- recent modifications and applications. *Processing Biochem.* 8: 18-20.

Pradeep, K. U., Geervani, P., and Eggum, B. O. 1993. Common Indian spices: nutrient composition, consumption and contributions to dietary value. *Plant Foods Hum. Nutr.* 44(2): 137-148.

Pragati, K., Dahiya, S., and Dhawan, S. S. 2003. Effect of drying method on nutrition composition of dehydrated aonla fruit. *Plant Food Hum. Nutr.* 58: 921–928.

Pruthi, J. S. 1992. Simple innovations in mango processing technologies. *Indian Food Packer.* 46(5): 45-54.

Pruthi, J. S. and Krishnankutty, S. A. 1985. A study of factors governing the recovery and quality of pectin from nutmeg waste (rind). *J. Ind. Cocoa, Arecanut and Spices.* 8(3): 75-89.

Preethi, J. S. and Krishnankutty, S. A. 1986. A study of factors governing the recovery and quality of pectin from nutmeg waste (rind). *J. Ind. Cocoa, Arecanut and Spices.* 8: 75-79

Ramakrishnan, R. 2014. Process standardization and varietal screening for osmodehydration in mango (*Mangifera indica*. L). MSc. (Hort.) thesis, Kerala Agricultural University, Thrissur. 65p.

Ramdas, S. 1988. Passion fruit. *Kissan Wld.* 15: 24-27.

Ranganna, S. 1986. *Handbook of Analysis and Quality Control for Fruits and Vegetable Products.* Tata McGraw Hill Publishing Company, New Delhi, pp.98-103.

Ranganna, S. 1997. *Handbook of Analysis and Quality Control for Fruits and Vegetable Products* (3rd Ed.). Tata McGraw and Hill Publication Co. Ltd., New Delhi, 634p.

Rao, V. K., Shivasankara, K. S., and Prakash, G. S. 2006. Antioxidant properties of some under exploited fruits [abstract]. In: *Abstracts, National Symposium on Underutilized Horticultural Crops;* 8-9, June, 2006, Bangalore. Indian Institute of Horticultural Research, Bangalore, p.54. Abstract No. 5.4.2.

Rao, V. S. and Roy, S. K. 1980. Studies on dehydration of mango pulp: Standardization for making mango sheet/leather. *Indian Food Packer* 34: 72-73.

Raoult-Wack, A. L., Guiltbert, S., and Le Maguer, M. 1991. Simultaneous water and solute transport in shrinking media. Application to dewatering and impregnation soaking process analysis (osmotic dehydration). *Drying Technol.* 9: 589-612.

Rathore, N. S., Mathur, G. K., and Chasta, S. S. 2012. *Post-harvest Management and Processing of Fruits and Vegetables.* Indian Council of Agricultural Research, New Delhi, 250p.

Reddy, L.V. A. and Reddy, O.V. S. 2005. Production and characterization of wine from mango fruit (*Mangifera indica* L). *World J. Microbiol. Biotechnol.* 21: 1345-1350.

Sadasivam, S. and Manickam, A. 1996. *Biochemical Methods* (92nd Ed.). New Age International Publishers, 256p.

Sagar, V. R., Khundiya, D. S., and Maini, S. B. 2000. Quality of ripe mango powder as affected by storage temperature and period. *J. Food Sci. Technol*.37: 165-168.

Saima, N. S. 2002. Quality evaluation of Indian gooseberry products. M.Sc. (Home Science) thesis, Kerala Agricultural University, Thrissur, 166p.

Sampathu, S. R. and Krishnamoorthy, N. 1982. Processing and utilization of Kokum (*Garcinia indica*). *Indian Cocoa, Arecanut and Spices J.* 6(1): 12-13.

Sanusi. G., Rasaki, A., Ogunro, P., Yetunde, L., and Sarah, N. 2008. Effect of storage time on ascorbic acid content of some selected 'made in Nigeria' fruit preserves. *Pakist. J. Nutr.* 7(6): 730-732.

Sara T. G., Lila Mathew, K., Leenamol, M. A., and Mridula, K. R. 2000. Kudampuli (*Garcinia gambogia* Desr.) (Malayalam) Kerala Agricultural University, Thrissur, Kerala, India, pp.18.

Satyavathy, G. V., Gupta, A. K., and Tandon, N. 1987. *Myristica* Boehmer (Myristicaceae). *Medicinal Plants of India,* Indian Council of Medical Research, New Delhi, 321p.

Sazada, S., Verma, A., Rather, A. A., Jabeen, F. and Meghavansi, M. K. 2009. Preliminary phytochemical analysis of some important medicinal and aromatic plants. *Adv. In Biol. Res.* 3: 188-195.

Sethi, V. 1980. Studies on preparation and storage of semidry preserve (Murrabha). PhD thesis, IARI, New Delhi, 107p.

Shiva K. N, Prasath, D., Zachariah, T. J., and Parthasarathy V. A. 2010. Chilli and paprika in major spices – production and Processing. In:

Parthasarathy, V. A. and Rajeev, P. A. (Eds.). *Major Spices – Production and Processing.* Indian Institute of Spices Research, Calicut, pp.221-230.

Shivani, P., Kannan, S., and Thirumaran, A. S. 2010. Studies on storage life of jamun (*Syzygium cuminii* Rom.) fruit products. *J. Food Sci. Technol.* 41(2): 186-188

Siljestrom, M., Westerlund, E., Bjorck, I., Holm, J., Asp, N.-G., and Theander, O. 1986. The effects of various thermal processes on dietary fibre and starch content of whole grain wheat and white flour. *J. Cereal Sci.* 4(4): 315–324.

Silva, M. A. P., Placido, G. R., Silva, R. M., Carvalho, B. S., and Caliari, M. 2014.Color and physico-chemical characteristics of passion fruit.*Magistra.* 26: 2036-2040.

Singh, B. P., Pandey, G., Pandey,M. K., and Pathak, R. K. 2005. Shelf life evaluation of aonla cultivars. *Indian J. Hort.* 62(2): 137-140.

Singh, R. P., Murthy, K. N. C., and Jayaprakasha, G. K. 2002. Studies on the antioxidant activity of pomegranate (*Punica granatum*) peel and seed extracts using *in vitro* models. *J. Agric. Food Chem.* 50: 81–86.

Singh, R. S. and Kaur, P. 2009. Evaluation of litchi juice concentration for the production of wine. *Nat. Product Radiance.* 8(4): 386-391.

Singh, S. S. and Gautam, A. 2010. Effect of pretreatment methods on the qualitative and organoleptic attributes of pineapple candy during storage.*Food sci. Res. J.* 1(2): 76-85.

Singh, S., Nautiyal, M. C., and Sharma, S. K. 2011. Studies on shelf-life of osmotically dehydrated wild apricot (chulu) fruits under different packaging materials. *Haryana J. Hortic. Sci.* 40 (1 and 2): 43-45.

Sivakumar, K. P. 2013. Standardization and storage stability of amla sweet candy. *Madras Agric. J.* 100(1 and 3): 248-250.

Smirnoff, N. 2000. Ascorbic Acid: Metabolism and Functions of a Multi-faceted Molecule. *Curr. option plant Biol.* 3: 229-235.

Somani, R., Karve, S., Jain, D., Jain, K., and Singhai, A. K. 2008. Phytochemical and pharmacological potential of *Myristica fragrans* Houtt: A comprehensive review. *Pharmacognosy Rev.* 2(3): 68–76.

Sonavane, G. S., Sarveiya, V. P., Kasture, V. S., and Kasturi, S. P. 2002. Anxiogenic activity of *Myristica fragrans* seeds. *Pharmacol. Biochem. Behav. J.* 71: 239–244.

Su, J. D., Osawa, T., and Namiki, M. 1986. Screening for antioxidative activity of crude drugs. *Agric. Biol. Chem.* 50: 199-203.

Szabo, M. R., Radu, D., Gavrilas, S., Chambre, D., and Iditoiu, C. 2010. Antioxidant and antimicrobial activities of selected spice extracts. *Int. J. Food Properties.* 13(3): 535–545.

Tan, K. P., Khoo, H. E, and Azrina, A. 2013.Comparison of antioxidant components and antioxidant capacity in different parts of nutmeg (*Myristica fragrans*).*Int. Food Res. J.* 20(3): 1049-1052.

Tandon, D. K. and Kumar, S. 2006. Potentiality of underexploited fruits for value additions [abstract]. In: *Abstracts, National Symposium on Underutilized Horticultural Crops;* 8-9, June, 2006, Bangalore. Indian Institute of Horticultural Research, Bangalore, p.35. Abstract No. 1.4.1.

Tijskens, L. M. M., Dos-Santos, N., Jowkar, M. M., Obando-Ulloa, J. M., Moreno, E., and Schouten, R. E. 2009. Postharvest firmness behavior of near-isogenic lines of melon. *Postharvest Biol. Technol.* 51: 320–326.

Tiwari, P., Kumar, B., Kaur, M. Kaur, G., and Kaur, H. 2011. Phytochemical screening and extraction: a review. Internationale pharmaceutica scientia 1(1): 98-106.

Torres, J. D., Talens, P., Carot, J. M., Chiralt, A., and Escriche, I. 2007. Volatile profile of mango (*Mangifera indica L.*), as affected by osmotic dehydration. *Food Chem.* 101(1): 219-228.

Totad, M. 2013. Preparation of sapota (*Manilkara acharus)* candy. *Int. J. Processing Postharvest technol.* 5(1): 82-85.

Touati, N., Tarazona-Diaz, M. P., Aquayo, E., and Louaileche, H. 2014. Effect of storagetime and temperature on the physicochemical and sensory characteristics of commercialapricot jam. *Food chem.* 145: 23-27.

Tripathi, V. K., Singh, M. B., and Singh, S. 1988. Studies on comparative compositional changes in different preserved products of amla (*Emblica officinalis* Gaertn.) var. Banarasi. *Indian Food Packer* 42(4): 60-66.

Verghese, J. 2001. Nutmeg and Mace: IV. Essential oils of *Myristica fragrans* Houtt. and *Myristica argentea* Warb. *Spice India* 14:7-11.

Vial, C., Guilbert, S., and Cuq, J. L. 1991. Osmotic dehydration of kiwi fruit: influence of process variables on the colour and ascorbic acid content. *Sci. des Aliments*. 11(1): 63-84.

Vidhya, R. and Narain, A. 2011. Formulation and evaluation of preserved products utilizing underexploited fruit, wood apple (*Limonia acidissima*). *J. Agric. Environ. Sci.* 10: 112-118.

Vyas, K. K. and Joshi, V. K. 1982. Plum Wine Making: Standardization of Methodology. *Indian Food Packer* 36(6): 82-86.

Weiss, E. A. 2002. *Spice Crops*. CABI Publishing, New York, 190p.

Weng, X. C., Ren, G. P., Duan, S., Dong, X. W., and Jiang, A. L. 1998. Screening of natural antioxidants from Chinese medicines, herbs and spices. *J. Chinese Cereals Oils Assoc.* 13: 46-48.

Westerlund, P. A., Anderson, R. E., and Rahman, S. M. M. 1991.Chemical characterization of water soluble pectin in papaya fruit. *Carbohyd. Res.* 15: 67-78.

Whistler, R. L. and BeMiller, J. N. 1997. *Carbohydrate Chemistry for Food Scientists.* St. Paul Eagan Press, California, 151p.

Wicklund, T., Rosenfeld, H. J., Martinsen, B. K., Sundfor, M. W., Lea, P., and Bruun, T. 2005. Antioxidant capacity and colour of strawberry jam as influenced by cultivar and storage conditions. *Food Sci. Technol.* 38: 387–391.

Woodroof, J. G. 1985. Storage life of canned, dehydrated and preserved fruits. *Commercial Fruit Processing* 7: 595-610.

Yen, I, C., Sookram, R., and McGaw, D. 1996. Yield and chemical composition of essential oils of Grenadian nutmegs. *Trop. Agric.* 73(4): 301.

Ying, L. and Jian-xian, Z. 2009. Antibrowning effects of a compound reagent on fresh cut apples. *Mod.Food. Sci. and Technol.* 16: 212-219

Yoo, B. and Lee, C. M. 1993. Thermoprotective effect of sorbited on proteins during dehydration. *J. Agric. Food Chem.* 41: 190-192.

Zachariah, T. J. and Parthasarathy, V. A. 2006. *Spice Oleoresins – Prospects and Potential.* CAB International, UK., pp. 153-158

Zheng, G., Kinney, P. M., and Lam, L. K. 1992. Myristicin: a potential cancer chemo-preventive agent from parsley leaf oil. *J. Agric. Food Chem.* 40: 107–110.

Appendices

APPENDIX I (a)

Mean rank scores for sensory attributes of wine

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
INITIAL								
W_1	1.05	1.15	1.30	1.45	1.70	1.55	1.40	1.20
W_2	2.10	1.85	1.70	1.95	1.45	1.45	1.70	1.80
W_3	2.85	3.00	3.00	2.60	2.85	3.00	2.90	3.00
Kendall's W	0.861**	0.895**	0.878**	0.578**	0.656**	0.814**	0.787**	0.884**
1 MAS								
W_1	1.00	1.25	1.60	1.30	1.40	1.25	1.45	1.40
W_2	2.10	2.00	1.60	1.85	1.90	1.75	1.65	1.60
W_3	2.90	2.75	2.80	2.85	2.70	3.00	2.90	3.00
Kendall's W	0.958**	0.577**	0.549**	0.748**	0.478**	0.929**	0.748**	0.844**
2 MAS								
W_1	1.25	1.30	1.50	1.45	1.45	1.15	1.25	1.30
W_2	2.05	1.75	1.60	2.05	1.75	1.90	1.75	1.70
W_3	2.70	2.95	2.90	2.50	2.80	2.95	3.00	3.00
Kendall's W	0.681**	0.786**	0.659**	0.427*	0.609**	0.908**	0.878**	0.832**
3 MAS								
W_1	1.30	1.25	1.30	1.45	1.30	1.15	1.45	1.25
W_2	1.90	1.85	1.75	2.15	1.80	1.90	1.65	1.75
W_3	2.80	2.90	2.95	2.40	2.90	2.95	2.90	3.00
Kendall's W	0.671**	0.754**	0.786**	0.422*	0.724**	0.861**	0.706**	0.878**

* Significant at 5% level ** Significant at 1% level

W_1 – 1:0.5:1 W_2 – 1:0.75:1 W_3 – 1:1:1

APPENDIX I (b)

Mean rank scores for sensory attributes of osmodehydrated chunks

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
INITIAL								
T_1	1.5	1.55	1.6	1.55	1.65	1.7	1.65	1.5
T_2	1.6	1.65	1.9	1.7	1.8	1.65	1.7	1.7
T_3	2.9	2.8	2.5	2.75	2.55	2.65	2.65	2.8
Kendall's W	0.718**	0.689**	0.420**	0.611**	0.423*	0.470**	0.454*	0.653**
1 MAS								
T_1	1.35	1.5	1.5	1.4	1.55	1.4	1.45	1.4
T_2	1.75	1.7	2	1.7	1.95	1.7	1.8	1.7
T_3	2.9	2.8	2.5	2.9	2.5	2.9	2.75	2.9
Kendall's W	0.740**	0.632**	0.455**	0.741**	0.364*	0.787**	0.646**	0.741**
2 MAS								
T_1	1.45	1.35	1.5	1.25	1.65	1.35	1.45	1.2
T_2	1.65	1.8	1.9	1.85	1.85	1.7	1.8	1.8
T_3	2.9	2.85	2.6	2.9	2.5	2.95	2.75	3
Kendall's W	0.748**	0.741**	0.517**	0.797**	0.376*	0.832**	0.532**	0.884**
3 MAS								
T_1	1.4	1.45	1.25	1.3	1.55	1.45	1.35	1.4
T_2	1.7	1.7	1.8	1.8	1.85	1.7	1.9	1.8
T_3	2.9	2.85	2.95	2.9	2.6	2.85	2.75	2.8
Kendall's W	0.7**	0.719**	0.836**	0.744**	0.468**	0.619**	0.711**	0.650**

* Significant at 5% level ** Significant at 1% level

T_1 – 12 h T_2 – 24 h T_3 – 48 h

APPENDIX I (c)

Mean rank scores for sensory attributes of nutmeg jam

INITIAL								
Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Odour**	**Taste**	**After taste**	**Overall acceptability**
J_1	1.00	1.25	1.25	1.00	2.05	1.00	1.05	1.00
J_2	2.40	1.90	1.90	2.75	1.55	2.00	2.05	2.00
J_3	2.60	2.85	2.85	2.25	2.40	3.00	2.90	3.00
Kendall's W	0.844**	0.740**	0.740**	0.833**	0.209 (NS)	1.00**	0.879**	1.00**
1 MAS								
J_1	1.00	1.05	1.40	1.00	1.10	1.00	1.05	1.00
J_2	2.25	2.00	2.15	2.60	2.00	2.00	2.05	2.00
J_3	2.75	2.95	2.45	2.40	2.90	3.00	2.90	3.00
Kendall's W	0.878**	0.95**	0.316*	0.760**	0.853**	1.00**	0.879**	1.00**

* Significant at 5% level ** Significant at 1% level

J_1 – 1:1 J_2 – 1:1.5 J_3 – 1:2

APPENDIX - II

Score card for organoleptic evaluation of nutmeg products

Name of the judge:

Date:

Characteristics	Score			
	T_1	T_2	T_3	T4
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

Signature:

APPENDIX III

MEDIA COMPOSITION

1. NUTRIENT AGAR MEDIA (FOR BACTERIA)

Beef extract	: 3 g
Peptone	: 5 g
Sodium chloride	: 5 g
Agar	: 18 g
Distilled water	: 1000 ml
p^H	: 6.8-7.2

2. ROSE BENGAL AGAR MEDIA (FOR FUNGUS)

Papaic digest of soyabean meal	: 5 g
Dextrose	: 10 g
Monopotassium phosphate	: 1 g
Magnesium sulphate	: 0.50 g
Rose bengal	: 0.05 g
Agar	: 15 g
p^H	: 5.6

3. SABAURAUD DEXTROSE AGAR (FOR YEAST)

Mycological peptone	: 10 g
Dextrose	: 40 g
Agar	: 15 g
Distilled water	: 1000 ml
p^H	: 5.6

APPENDIX IV (a)

BENEFIT COST RATIO OF NUTMEG RIND WINE

Ingredients	Quantity	Rate	Amount (Rs.)
Nutmeg rind	1 Kg	Rs.3/Kg	3.00
Sugar	0.50 Kg	Rs.38/Kg	19.00
	0.75 Kg		28.50
	1.00 Kg		38.00
Yeast	3 g	Rs.5/10g	1.50
Fuel (Gas)	15 min	Rs.16/h	4.00
Packaging material	2	Rs.6/bottle	12.00
	3		18.00
	4		24.00
Total cost (W_1)			39.50
Total cost (W_2)			55.00
Total cost (W_3)			70.50

Quantity of product from 1:0.5:1 ratio (W_1) : 1 litre (L)

Quantity of product from 1:0.75:1 ratio (W_2) : 1.5 L

Quantity of product from 1:1:1 ratio (W_3) : 2 L

Number of bottles (500 ml) that can be filled (W_1) : 2

Number of bottles (500 ml) that can be filled (W_2) : 3

Number of bottles (500 ml) that can be filled (W_3) : 4

Cost of one bottle : Rs.75/500ml

B/C ratio (W_1) : 150/ 39.5 = **3.80**

B/C ratio (W_2) : 225/ 55 = **4.10**

B/C ratio (W_3) : 300/ 70.5 = **4.26**

APPENDIX IV (b)

BENEFIT COST RATIO OF NUTMEG RIND POWDER

Total cost of production for 1 Kg product:

Ingredients	Quantity	Rate	Amount (Rs.)
Nutmeg rind (CD)	12.5 Kg	Rs.3/Kg	37.50
Nutmeg rind (SD)	8.5 Kg		25.50
Electricity charge	24 hours (40 units)	Rs.6/unit	240.00
Packaging material	10 Nos	Rs.1.5/ piece	15.00
Labour cost	8 h	Rs.250/8 h	250.00
Total cost (CD)			542.50
Total cost (SD)			290.50

Quantity of product : 1 Kg

Number of packets (100 g) that can be filled : 10

Cost of one packet (CD) : Rs. 50/-

Cost of ten packets of product : Rs. 500/-

B/C ratio (CD) : 500/542.5 = **0.92**

B/C ratio (SD) : 500/290.5 = **1.72**

APPENDIX IV (c)

BENEFIT COST RATIO OF NUTMEG RIND CANDY

Ingredients	Quantity	Rate	Amount (Rs.)
Nutmeg rind	1 Kg	Rs.3/Kg	3.00
Sugar	400 g	Rs.13/Kg	5.20
Citric acid	1 g	Rs.275/500g	0.55
KMS	1 g	Rs.470/500g	0.94
Fuel (Gas)	1.30 h	Rs.16/h	24.00
Electricity charge	6 h (10 units)	Rs.6/unit	60.00
Packaging material (Titbits)	5 piece	Rs.1.5/piece	7.50
Packaging material (Flakes)	6 piece	Rs.1.5/piece	9.00
Labour (Titbits)	3 h	Rs.250/8 h	107.10
Labour (Flakes)	2 h	Rs.250/8 h	62.50
Total cost (Titbits)			208.12
Total cost (Flakes)			165.19

Quantity of product (Titbits) : 500 g

Quantity of product (Flakes) : 600 g

Number of packets (100 g) that can be filled (Titbits) : 5

Number of packets (100 g) that can be filled (Flakes) : 6

Cost of one packet : Rs.50/-

B/C ratio (Titbits) : 250/ 208.12 = **1.20**

B/C ratio (Flakes) : 300/ 165.19 = **1.82**

* Sugar solution can be reused.

APPENDIX IV (d)

BENEFIT COST RATIO OF OSMODEHYDRATED NUTMEG CHUNKS

Ingredients	Quantity	Rate	Amount (Rs.)
Nutmeg rind	1 Kg	Rs.3/Kg	3.00
Sugar	800 g	Rs.13/Kg	10.40
Citric acid	1 g	Rs.275/500g	0.55
KMS	1 g	Rs.470/500g	0.94
Fuel (Gas)	15 min	Rs.16/h	4.00
Electricity charge	6 h (10 units)	Rs.6/unit	60.00
Packaging material	6	Rs.1.5/piece	9.00
Labour	1 h	Rs.250/8 h	31.25
Total cost			119.14

Quantity of product : 600 g

Number of packets (100 g) that can be filled : 6

Cost of one packet : Rs. 50/-

Cost of six packets of product : Rs. 300/-

B/C ratio : 300/ 119.14 = **2.52**

* Sugar solution can be reused.

APPENDIX IV (e)

BENEFIT COST RATIO OF NUTMEG RIND SYRUP

Ingredients	Quantity	Rate	Amount (Rs.)
Nutmeg rind	1 Kg	Rs.3/Kg	3.00
Sugar	650 g	Rs.38/Kg	24.70
Citric acid	1 g	Rs.275/500g	0.55
KMS	1 g	Rs.470/500g	0.94
Fuel (HWE)	1 h	Rs.16/h	16.00
Fuel (PCE)	30 min		8.00
Packaging material	2	Rs.8/bottle	16.00
Total cost (HWE)			61.19
Total cost (PCE)			53.19

Quantity of product : 1 L

Number of bottles (500 ml) that can be filled : 2

Cost of one packet : Rs. 75/-

B/C ratio (HWE) : 150/ 61.19 = **2.45**

B/C ratio (PCE) : 150/ 53.19 = **2.82**

APPENDIX IV (f)

BENEFIT COST RATIO OF NUTMEG RIND JAM

Ingredients	Quantity	Rate	Amount (Rs.)
Nutmeg rind	1 Kg	Rs.3/Kg	3.00
Sugar	1 Kg	Rs.38/Kg	38.00
	1.5 Kg		57.00
	2.0 Kg		76.00
Citric acid	1 g	Rs.275/500g	0.55
KMS	I g	Rs.470/500g	0.94
Fuel (Gas)	15 min	Rs.16/h	4.00
Electricity charge	15 min (0.25 unit)	Rs.6/unit	1.50
Packaging material	3	Rs.7/bottle	21.00
	4		28.00
	5		35.00
Labour	1 h	Rs.250/8h	31.25
Total cost (1:1 ratio)			100.24
Total cost (1:1.5 ratio)			126.24
Total cost (1:2 ratio)			152.24

Quantity of product from 1:1 ratio : 1.5 Kg

Quantity of product from 1:1.5 ratio : 2.0 Kg

Quantity of product from 1:2 ratio : 2.5 Kg

Quantity of jam per bottle : 500 g

Number of bottles from 1:1 ratio : 3

Number of bottles from 1:1.5 ratio : 4

Number of bottles from 1:2 ratio : 5

Cost of one bottle	: Rs. 70/-
B/C ratio (1:1 ratio)	: 210/100.24 = **1.99**
B/C ratio (1:1.5 ratio)	: 280/126.24 = **2.22**
B/C ratio (1:2 ratio)	: 350/152.24 = **2.30**

PROXIMATE ANALYSIS AND PRODUCT DEVELOPMENT IN NUTMEG (*Myristica fragrans* Houtt.) RIND

By

TEENA SIMENTHY

(2012-12-114)

ABSTRACT

Department of Processing Technology

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2015

ABSTRACT

Nutmeg (*Myristica fragrans* Houtt.) belongs to the family Myristicaceae. Nutmeg produces two spices of commerce namely nutmeg, dried kernel of the seed and mace, the dried aril surrounding the seed. Nutmeg rind constitutes 80 to 85 per cent of its whole fruit weight and at ripe stage it has an acidic astringent taste with aromatic flavour. If it can be converted to attractive value added products it will be a boon to nutmeg farmers.

Hence the present study was endeavoured to access the proximate composition of nutmeg pericarp and possible ways to consider it as a value-added commodity, with nutritional and pharmacological benefits.

The color of rind described using Universal Colour Language (UCL) was pale greenish yellow (RHS 164C 71) during harvest and it changed to moderate orangish yellow when kept under room temperature. The texture of the nutmeg rind was 1.85 Kg/cm^2 i.e., 4.1 lbs/sq. inch.

Nutmeg rind constitutes 75 to 80 per cent of whole fruit weight and has a high moisture content of 88.45 per cent. The acidity recorded in rind was 1.43 per cent, total phenol (35.20 mg/100g) and tannin (33.80 mg/100g). The total soluble solid (TSS) of nutmeg rind is less (3.38° brix) and therefore it has low total sugars (2.69 %). In the present study, the pericarp showed the presence of 1.25 g/100g protein, 2.55 per cent of crude fibre and 0.78 per cent pectin. Nutmeg rind is a poor source of ascorbic acid (11.45 mg/100g), starch (0.95 g/100g) and carotene content (37.82 µg/100g).

The nutmeg rind had high iron content (607.800 mg/Kg) and the presence of other minerals like potassium, calcium, magnesium, copper, zinc, and manganese were also observed.

The antioxidant activity of nutmeg rind was compared to that of gallic acid and was found that the IC_{50} value of sample was 120 µg/ml while that of standard was 1.25 µg/ml showing medium antioxidant activity.

The nutmeg rind oil is colourless in nature and the oil recovery percentage in fresh sample is 0.05 per cent and that of dried sample is 0.10 per cent. The GC-MS profiling of the nutmeg rind oil exhibited a seven peak chromatogram and the compounds found were myristicin, elemicin, terpenen-4-ol, alpha-terpineol, methyl (Z)-N-hydroxybenzene carboximidate, 1,2–dimethoxy–4[(Z)-1- methoxyprop-1-enyl] benzene and methyl laurate. The oleoresin recovery was estimated to be 3.17 per cent.

The pericarp was screened for phytochemicals and showed that flavonoids, saponins and terpenoids were present in petroleum ether, acetone and methanol extracts of nutmeg rind.

Considering all the biochemical constituents, 3 per cent salt water treatment for 48 hours was found to be the best pre-treatment for product development. The value added products prepared were wine, powder, candy, chunk, syrup and jam. Wine prepared using rind, sugar and water in the ratio 1:1:1 was selected as the best after biochemical estimation and organoleptic evaluation. The best process for making the nutmeg rind powder is found to be sun drying powder and was mostly accepted due to its sensory and biochemical constituents. Nutmeg rind was also used for the preparation of two types of candy, titbits and flakes. The biochemical analysis showed that candy titbits are of better quality while the flakes scored highest in organoleptic evaluation. The chunks prepared by immersing the pre-treated nutmeg rind in 70° brix sugar solution for 48 hours scored better organoleptic scores and sensory evaluation. The juice extracted from pre-treated nutmeg rind by using pressure cooked and hot water extract had least preference. In the case of jam, the pulp and sugar ratio of 1:2 gained the maximum score for organoleptic evaluation.