DEVELOPMENT OF NOVEL VALUE ADDED PRODUCTS FROM TENDER COCONUT
(*Cocos nucifera* L.)

By

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(2016-12-005)

THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Development of novel value added products from tender coconut (*Cocos nucifera* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not been 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.

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CERTIFICATE

Certified that thesis entitled **"Development of novel value added products from tender coconut (*Cocos nucifera L.*)"** is a bonafide record of research work done independently by Ms. **Archana Unnikrishnan (2016-12-005)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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Dedicated to my Loving Father

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Archana Unnikrishnan

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Introduction

1. INTRODUCTION

Coconut *(Cocos nucifera* L.) is the most valuable gift of nature to humankind and is commonly known as Kalpavruksha, which fulfills all vital human needs. It is unique among horticultural crops as a source of food, drink, shelter, fibre, medicine and a variety of raw materials for producing an array of products with commercial importance. The crop has significant impact on the national economy besides its influence on economic, social and cultural lives of the people in the country. India is the largest coconut producing country in the world with an annual production of 15304 million nuts from an area of 20.95 lakh hectares (Ministry of Agriculture and Farmers Welfare, GOI 2016- 2017). The crop contributes 7,000 crores of rupees to the GDP and earns about Rs.313 crores as foreign exchange by way of export of coconut products and the crop sustains about 10 million people in the country through cultivation, processing, marketing and trade related activities. The contribution of the crop to the vegetable oil pool in India is 6 per cent.

The major portion of the coconut production is from the four South Indian states of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh which comes to 88.87 per cent of the total area and to 90.18 per cent of the total production of coconut. Kerala occupies the premier position, with an area of 7.72 lakh ha (36.85%) and a production of 5137 million nuts (33.3%) (Ministry of Agriculture and Farmers Welfare, GOI 2016- 2017).

In India, as much as 48 per cent of the coconut production is used for edible and religious purposes, then 30 per cent as milling copra, 8 per cent as edible copra and the rest for kernel based products such as desiccated coconut, virgin coconut oil, coconut chips, coconut milk and seed nut (Rethinam and Thampan, 2001). Wide fluctuation in coconut prices had a negative impact on coconut based industries like desiccated coconut, coconut cream etc. Product diversification with a wider raw material base is, therefore, essential for sustainable development of coconut sector. Popularization of the tender coconut consumption can be a justifiable strategy to ensure regular and assured income from coconut farming.

The immature nut known as tender coconut, contains a sterile liquid which is the endosperm. It is used to treat dehydration, especially for people suffering from diarrhoea. It reduces blood pressure and is hepatoprotective in nature. This refreshing drink is filled with many healthy natural nutrients which can enhance the body's metabolism and immunity and is used more as a health supplement (Poduval, 2012). It is consumed by thousands of inhabitants in tropical regions and its demand is increasing rapidly as people are realizing the health benefits it offers. Based on the compositional and functional properties, it is also considered as a sports drink and therefore, has drawn the attention of manufacturers and industries.

The major issues in popularization of tender coconut products are its high perishability as it looses natural freshness within 24 to 36 h unless treated scientifically, the bulky nature and the resultant difficulties in handling, transportation as well as the large quantity of waste collected at the sales points after consumption of tender coconut water always causing some sort of disposal problems.

Even though the information on value addition and product diversification of tender coconut is scanty, popularization of tender coconut consumption has great scope in India especially the four south Indian states contributing to the lion share in production. Along with this, low cost processing technology can offer excellent opportunities in the production of processed foods in rural sector. It will eliminate the problem of garbage disposal and subsequent environmental problem in urban areas where tender coconut finds its major markets. Women groups can also engage in food processing industries to produce diverse convenient foods from tender coconut and market them through different channels both in domestic and external markets. Tender coconut water has a strong tendency to undergo rapid biochemical changes after harvest (Srivatsa *et al.,* 1998). When stored under open conditions, the quality of nut water is found to spoil within 24 hours. Obviously, in such situation consumer satisfaction is not to the desired level. With this background, the present study was conceived and implemented. Through this research work an attempt is being made to convert fresh tender coconut into some novel value added products and also to evaluate their quality and shelf life during storage with the following objective

Objective

To develop novel value added products from tender coconut and to evaluate their quality and shelf life

Review of literature

2. REVIEW OF LITERATURE

Coconut palm (*Cocos nucifera* L.) is one of the most useful tropical trees valued for its economic and social importance. Almost every part of the palm is utilised in several ways. The immature nut with its liquid endosperm is known as tender coconut. Its most common use is to occurring from diarrhoea. It reduces blood pressure and is hepatoprotective in nature. The high mineral content especially K has made it a good sport drink and had drawn the attention of manufacturers and industries. However, perishability of coconut water is very high. When exposed to air, it develops a sour and unpleasant flavour. Its natural freshness is lost within 24 to 36 h unless treated scientifically (Thampan, 1984).

Information on value addition and product diversification of tender coconut is scanty. Moreover, a major chunk of tender coconut is its inedible portion (Thampan, 1984). If these inedible parts can be removed in the production centres itself, it can eliminate the problem of garbage disposal and subsequent environmental problem in urban areas where tender coconut finds its major markets to a certain extent. Low cost food processing technology can offer excellent opportunities in the production of processed foods in the rural sector. Tender coconut water owing to its inherent characteristics, undergoes rapid biochemical and microbial changes, resulting in an unpleasant and non-palatable drink. Efforts to process tender coconut water in the bottled or packaged form has not met with much success, owing to considerable loss in its natural flavour (Thampan, 1984). Therefore, an attempt is being made to convert fresh tender coconut into some novel value added products and also to evaluate their quality and shelf life during storage.

The available literature pertaining to the present study has been reviewed under the following heads:

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2.1 Physico- morphological parameters

2.1.1 Weight of nut

Gangully and Nambiar (1953) reported that the weight of the nut was highest during the eighth month (2205.13 g) which subsequently declined steadily till maturity (1418.5 g). The husk reached its maximum weight in the eighth month (1771 g) and declined to 938 g at twelfth month. However, the pattern of development of the meat was different from most of the other components of the nut. The meat started appearing during the sixth month and steadily increased in content and reached the maximum weight of 223 g in the twelfth month. But the maximum thickness for the kernel was recorded in the tenth month (1.76 cm) which reduced to 1.20 cm during the twelfth month.

Apshara *et al.* (2007) studied physio chemical characteristics of different coconut cultivars. Among all the cultivars, the control cultivar Chowghat Orange Dwarf performed the best for all the characters and also observed that the mean nut weight among the hybrids ranged from 1551.7 g to 1667.0 g and between months it was from 1580.3 g to 1621.5 g and also among the hybrids WCT x MYD recorded the highest nut weight during all the three developmental stages. Nut weight was maximum in 6-months and declined during 7 and 8 months.

2.1.2 Volume of water

Subramanian and Vasudevan (1997) reported that the variety, season and age of nuts influenced the water content. They observed that the amount of water ranged from 400 to 590 millilitre per nut as a varietal character.

Attri *et al.* (1999) evaluated the physico-chemical characteristics of tender nut of 7 – 8 months maturity. The volume of water varied significantly and it was recorded maximum (649.0 ml) in dwarf × tall cultivars. The variety COD had maximum nut water during seven month maturity and also determined that increase in nut weight is due to an increase in volume of water during sixth month, whereas it

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was reduced towards maturity (Ratnambal, 1999), and also reported that weight of tender endosperm was high in 7 months old nuts compared to 5 and 6 months old nuts.

Jackson *et al.* (2004) recorded that volume of water varied with age of the coconuts, it increases from seventh to ninth month but later it decreased as the water begins to form a jelly.

In tender coconut, volume of water is an important economic character determining consumer's acceptability and cultivator's preference and it should not be less than 250 ml per nut. The volume of water ranged from 265.5 ml to 359.1 ml among the hybrids and 302.95 ml to 319.29 ml between developmental stages. The mean volume of nut water was higher in the 6-month-old nuts and lesser in 7 and 8 months. Large quantity of nut water was recorded in COD followed by COD x WCT in almost all the stages of development (Apshara *et al.,* 2007)

2.2 Composition, functional and nutritional benefits of tender coconut

Tender coconut (*Cocos nucifera* L.) is one of the highest sources of electrolytes known to man. It contains sugar, vitamins, minerals like potassium, magnesium, fibre, proteins and antioxidants. Tender coconut flesh is sweet and contains less sugar, more protein than many popular fruits. It has less fat, and these have a high proportion of saturated fat, and it is relatively high in minerals such as iron, phosphorus and zinc. Both tender coconut water and coconut flesh are used as food and medicine. Recently, modern medicinal research has confirmed many health benefits traditionally attributed to tender coconut water and flesh.

Pandalai (1958) determined the chemical composition of tender coconut water and stated that tender coconut had nitrogen (0.5 %), potassium (6.6 %), total soluble solids (4.71^{o} brix), reducing sugars (0.8 g/100 ml), non reducing sugars (1.28 g/100 ml), total sugars (2.08 g/100 ml) and ascorbic acid (2.2 – 3.7 mg/ 100 ml) and the calorific value of tender coconut water was 17.40 per cent with nutritive ratio of 1:42.25.

Fresh coconut kernel contains minerals like potassium (436 mg), calcium (13 mg), magnesium (52 mg), iron (2.08 mg), copper (0.32 mg), phosphorus (94 mg), sulphur (33 mg) and chlorine (114 mg) per 100 grammes of meat. The pH of water was 5.9, titratable acidity was 78 to 234 mg of KoH/litre and the chloride content varied from 32 to 46 milli equivalents per litre (Subramanian and Swaminathan, 1959).

Rosario *et al.* (1979) studied the chemical changes in developing coconut fruit. Sugars, phospholipids and enzyme activities increased with maturity. Decrease in moisture, carbohydrate and ash with subsequent increase in fat content and highest invertase activity was also observed. Reducing sugar concentration at around sixth month stage were glucose in meat and glucose and xylose in water. Predominance of albumin in the younger stages and globulin in the more mature nuts with both fractions comprising 80-91 per cent of the total proteins at all stages of nut development was noted. Positive activity of esterases, phosphates, catalase, invertase and peroxidise was also reported.

According to Thampan (1984), tender coconut water has calorific value of 17.4 per cent, moisture (95.5 %), protein (0.1 %), fat (0.1%), mineral matter (0.41 %), carbohydrate (4 %) and mineral with sodium (105 mg/100 ml), potassium (312 mg/100 ml), calcium (29.0 mg/100 ml), magnesium (30.0 mg/100 ml), iron (0.10 mg/100 ml), copper (0.04 mg/100 ml), phosphorus (37.0 mg/100 ml), sulphur (24.0 mg/100 ml) and chlorine (183.0 mg/100 ml).

Chikkasubbanna *et al.* (1990) reported that for obtaining the adequate amounts of nutrients and sugars in the coconut liquid endosperm, the nuts should be harvested between the seventh and eighth months of maturity.

Dhamodaran *et al.* (1993) evaluated 12 coconut cultivars to find out a suitable tender coconut cultivar. Biochemical evaluation indicated that COD had the maximum amount of total sugars (7.0 g ml^{-1}) and reducing sugars (4.7 g ml^{-1}) and low sodium and potassium content (20 and 2003 ppm respectively) with maximum score of 73 following Anderson's method was given to COD. Organoleptic test conducted also confirmed the superior tender coconut quality of COD.

The studies conducted by Silva and Bamunuarachchi (2009) showed that, thick albuminous endosperm, white in colour and edible, softer and more like gelatine than a mature coconut called kernel or coconut jelly. It is containing less sugar, more protein than many popular fruits, less fat with a high amount of saturated fat and relatively high in minerals such as iron, phosphorus and zinc.

Yong *et al.* (2009) opined that coconut water from the young green coconuts of dwarf palms at 7 months maturity have approximately 5 per cent sugar with fructose, glucose, sucrose, sugar alcohols and 1 per cent ash mainly containing potassium, calcium, magnesium, phosphorus and sodium. Vitamain B namely nicotinic acid (0.64 μg/ml), pantothenic acid (0.003 μg/ml), biotin (0.02 μg/ml), riboflavin (<0.01 μg/ml), folic acid (0.003 μg/ml) lipids, amino acids nitrogenous compounds, organic acids, enzymes and phytohormones (auxin, 1, 3-diphenylurea, cytokinin), enzymes were also present, but in low concentrations.

Evaluation of ten cultivars of coconut namely, B.S. Island, East Coast Tall, FMS Big, Gonthembilli, Hazari, Jamaican Tall, Java, San Ramon, St. Vincent and Zanzibar by Chattopadhyay *et al.* (2013) (5th, 6th, 7th and 8th months after inflorescence emergence) showed that highest volume of water (268.0 ml) with highest reducing sugar (4.26 g/100 ml) and potassium (353.90 mg/ 100 ml) concentrations and least acidity were observed at the 7th month stage but highest pH, TSS, total sugars, non-reducing sugars, nitrogen and phosphorus were all observed at the 8th month of maturity. The cultivars Jamaican Tall, East Coast Tall and Zanzibar were found to have appreciable amounts of water, sugar and minerals at 7 months. These three cultivars were recommended for cultivation as tender nuts should be harvested at 7 months to obtain the highest nutritional benefits.

2.3 Health benefits of tender coconut

Carpenter *et al.* (1964) stated that coconut water has been called the "fluid of life" due to its medicinal benefits such as oral rehydration, treatment of childhood diarrhoea, gastroenteritis and tract infections, and sterility. Whenever someone is sick, coconut water is usually part of the treatment to nourish the patient back to health. Interestingly, modern medical science is now confirming the effectiveness of coconut water for many of these conditions. Coconut water improves blood circulation, helps dilate blood vessels, improves blood flow, and reduces plaque formation. Coconut water also contains certain forms of dietary fiber and amino acids that help moderate sugar absorption and improve insulin sensitivity.

The sugar content and mineral composition of tender coconut water makes it an ideal rehydrating and refreshing drink and useful in preventing and relieving many health problems, including dehydration, constipation, digestive problems, fatigue, heatstroke, diarrhoea, kidney stones and urinary tract infections. Tender coconut water contains a variety of inorganic ions and it can replenish the electrolyte of the human body excreted through sweat such as sodium, potassium, magnesium, and calcium (Campbell *et al.,* 2000).

Matsuyama *et al.* (2001) analyzed different compounds of the coconut water from green and yellow varieties and identified eight compounds were identified in green variety and were characterized as esters (58.3 %), ketones (33.5 %), and diols (8.0 %), representing 99.8 per cent of the total extract. For the specimen of the yellow variety, five components were identified and characterized as diols (74.3 %), esters (16.7 %), and ketones (6.2 %), representing 97. 2 per cent of total extract.

Dolezal (2006) stated that coconut water is the richest natural dietary source of cytokinins which may produce an anti-aging effect on the body, reducing risk of developing degenerative and age related diseases. The presence of L- arginine (300 mg/l) in coconut water could have a cardioprotective effect through its production of nitric oxide, which favours vasorelaxation (Anurag *et al.*, 2007).

2.4 Biochemical parameters

2.4.1 TSS

Jayalekshmy *et al.* (1986) reported that the TSS content increased with 3.4 g/100 g in 6 months old nuts, 3.7 g/100 g in 8 months old nuts and 4.3 g/ 100 g in 10 months old nuts. After 10 months, steep decline was observed in TSS content in coconut water towards maturation.

Chikkasubbanna *et al.* (1990) revealed that the nut with high volume of water contained abundant amounts of sugars and minerals and high amount of TSS.

The specific gravity of water and TSS were found to vary among different cultivars and the highest brix:acid ratio (20.73) was observed in the coconut cultivar Malayan Orange Dwarf (Attri *et al.,* 1999).

Apshara *et al.* (2007) recorded high TSS in the hybrids COD x WCT (6.58 %) and LCT x COD (6.51 %) and also found that TSS increased from 6^{th} month to 8^{th} month of development.

2.4.2 Titratable acidity

Acidity of coconut water at 6^{th}, 8^{th} and 10 th month of development old nuts increased marginally with maturity i.e., 0.4 g/100 g, 0.3 g/100 g and 0.4 g/100 g respectively.

Purkayastha *et al.* (2012) found that fresh tender coconut water contains a titratable acidity content of about 0.06 mg citric acid 100 ml^{-1}.

2.4.3 pH

Jackson *et al.* (2004) stated that pH is a factor that is important in the stability of coconut beverages and also found that pH of fresh tender coconut increased from 4.7 to 5.5 during the age of seventh to the tenth month.

Jose *et al.* (2004) determined that the pH of coconut water at 6^{th}, 8^{th} and 10^{th} month of development and found that it was almost similar i.e., 4.5, 5.1 and 5.2.

The pH of tender nut water was high (5.37) in the hybrid COD x WCT and it slowly increased from 4.87 to 5.97 towards maturity and also stated that the slow increase of pH value towards maturity indicated the gradual loss of acidity and added sugariness in water (Apshara *et al.*, 2007).

2.4.4 Sugars

Child and Nathanael (1950) observed the presence of reducing sugars in the immature to seven month old nuts, subsequently non reducing sugars showed increasing trend. Thereafter, the total sugars decreased to 2 per cent in fully ripe nuts of 12 months age.

Pandalai (1958) reported that in the early stages of nut development when the endosperm formation occurs, invert sugars and amino acids accumulated in the water and reached a maximum concentration during fifth or sixth month. Sucrose appeared thereafter and concentration of total sugars reduced. TSS increase gradually as the nut matured reaching maximum at the seventh month just before the kernel begins to form and declined further.

When the tender nut is about 7-8 months old, the nut water gives the appropriate balance between reducing sugars and sucrose. The concentration of sugars steadily increase from 1.5 per cent to about 5.5 per cent in the early months of maturation and then slowly falls reaching about 2 per cent at 12 months stage. In the early stage, sugars are in the form of glucose and fructose and non reducing sugars, sucrose appears only in later stages which increases with the maturity while the reducing sugars fall (Santoso *et al.*, 1996).

The total sugar content in coconut water remained almost similar with maturity showing 4.2 g/100 g, 3.9 g/100 g and 4.6 g/100 g at 6^{th}, 8^{th} and 10^{th} months respectively (Campos *et al.*, 1996).

Poduval *et al.* (1998) observed that the reducing sugar content was highest in the cultivar COD and among the hybrids it was highest in LCT x COD (3.74 g/100 ml) followed by COD x WCT (3.70 g/100 ml) and the 7 month old nuts showed more reducing sugars.

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In sixth, seventh and eightth month of nut development total sugar content of tender coconut water was high in COD and among the hybrids COD x WCT recorded the highest (5.99 g/100 ml) followed by LCT x COD (5.72 g/100 ml) (Apshara *et al.*, 2007).

Jean *et al.* (2009) observed that the total sugar concentration varied with age of coconut. The 6 months old green nuts contained high total sugars (5.23 g/100 g) than 12 months old nuts (3.24 g/100 g).

2.4.5 Ascorbic acid

Jean *et al.* (2009) found that there was no significant change in ascorbic acid concentration with the maturity of coconut. The maximum ascorbic acid was observed in 6 months age of nuts (7.41 mg/100 g) and it slightly reduced to 7.08 mg/100 g towards maturity (12 months age).

Investigations conducted by Priya and Ramaswamy (2014) showed that tender coconut water containing both ascorbic acid and vitamins of B group with ascorbic acid ranging from 2.2 to 3.7 mg per 100 ml, which gradually diminishes as the kernel surrounding the water begins to harden.

2.4.6 Protein

During fourth month of development, coconut water contained 0.049 per cent protein which changed to 0.088 and 0.123 per cent respectively in the seventh and eighth month and recorded a maximum of 0.2 per cent in the twelflth month (Subramanyam and Swaminathan, 1959).

The protein content of nut water increased from 0.13 per cent to 0.29 per cent while it decreased in the kernel from 8.3 per cent at the eighth month to 6.2 per cent at maturity. In the immature nut water, about 70 per cent of the free amino acids are made of glutamine, arginine, aspargine, alanine and aspartic acid while alanine, aminobutyric acid and glutamic acid constitute about 75 per cent of the free amino acids of mature nut water (Shivasankar, 1991). In a study conducted by Poduval *et al.*

(1998) it was found that in most of the cultivars maximum free amino acid content was in the water of seven month old nut.

The protein concentration varied with the maturity stage of coconut. A protein concentration of 0.12 g/100 g and 0.52 g/100 g was observed at six months and 12 months old nuts respectively (Jean *et al.*, 2009)

2.4.7 Sensory quality

Sensory quality of tender coconut of 7 months maturity was found to be very promising and it was characterized as very fresh, tender, crystalline, and having pulp induced flavour and jelly type endosperm (Hahn, 2012).

2.5 Value addition and processing of tender coconut

2.5.1 Value added products from tender coconut water

Campos *et al.* (1996) suggested addition of ascorbic acid for inhibiting the activity of Polyphenol oxidase and Peroxidase in coconut water, which did not affect the sensory properties when incorporated up to an optimum level. 25 mg L-ascorbic acid addition per 100 ml coconut water was found to act efficiently in reducing the activities of Polyphenol oxidase and Peroxidase enzymes, and the overall acceptability was very good under storage condition of 4° C.

Srivatsa *et al.* (1998) suggested that tender coconut water can be preserved in pouches and cans following the preservation methods like acidification, use of chemical preservatives and sterilization and during high temperature sterilization, flavour is adversely affected by heat treatment. Bio-preservatives consisting of beneficial microorganisms were found to reduce thermal severity on foods during processing and hence, use of bio-preservatives can be initialized for processing the tender coconut water.

Attri *et al.* (1999) reported that tender coconut water can be kept fresh without any adverse effect for two months at low temperature (3-4° C) whereas at ambient temperature of 25 -30° C it was found to ferment after 8 to 10 hours. Further it can be preserved with the help of KMS @ 600 ppm but for consumption the preserved water has to be heated upto boiling point to remove excess sulfur dioxide present in water.

Illiaskutty *et al.* (2004) conducted studies on value added products from tender coconut and observed that 25-33 per cent pineapple juice could be incorporated in the tender coconut water without affecting the quality and acceptability of the tender coconut water beverages. Sensory and storage study was done and concluded that Candy prepared from tender coconut kernel can be stored for 3 months, tuity-fruty for 15 days and tender kernel in syrup for two months in clean dry glass or glazed container or polythene covers.

Microfiltration has been found to be an alternative to thermal sterilization to obtain processed tender coconut water, which can be as good as fresh coconut water and also determined that the storage temperature for processed coconut water should not exceed 4 °C.

Mao *et al.* (2007) studied the effect of ascorbic acid addition on the clarity of coconut water, which is one of the important attribute, contributing to the quality. The turbidity of the micro-filtered coconut water samples, when stored at 4° C, increased when ascorbic acid was not added, as measured by the transmittance. The transmittance of coconut water with ascorbic acid was 33. One percentage higher than untreated sample on 28th day of storage.

Investigations carried out by Reddy *et al.* (2007) showed that the tender coconut water is extracted aseptically on exposure to air initiates some reactions such as oxidation promoted by enzymes polyphenol oxidase and peroxidase, which are naturally present in the coconut water. Coconut water is rich in minerals and electrolytes, catalyze lipid resulting in formation of volatile compounds, producing negative effect on sensorial and nutritional.

Commercial production of canned coconut water employing high temperature/short-time preservation process, eliminates the entire delicate flavour along with the microbes severely limitng the marketability of the product (Jayanti *et al.*, 2008).

Silva and Bamunuarachchi (2009) standardized a procedure for preparing carbonated tender coconut water and the final pasteurized product contained 0.0118 per cent protein, 21.05 per cent reducing sugars, 46.79 per cent total sugars, 0.0525 per cent vitamin C and no fat content.

Yong *et al.* (2009) reported that shelf life of extracted tender coconut water was very less due to the presence of enzymes Polyphenol oxidase and Peroxidase on coming in contact with atmospheric oxygen. The oxidative enzymes have high thermal resistance and their activity leads to yellow, brown or even pink colouration during storage, even under refrigeration.

Yuliana *et al.* (2010) studied the effect of lactic acid bacteria on tender coconut water composition product fermented coco milk drink, and evaluated the product stability and lactic acid bacteria viability during storage at 5°C. *Lactobacillus acidophilus*, *L. bulgaricus* and *Streptococcus thermophilus* could grow well in all of the coco milk drink prepared from mixture of coconut water and coconut milk combination with the ratio of 3:1, 3:2 and 4:1.

Muralidharan and Jayashree (2011) standardized the procedure for the preparation of blended juice with tender coconut water using juice of pomegranate, blue grapes, pineapple, mango and lemon juice. The storage studies indicated that the beverages were safe for consumption for a period of six months.

Browning reactions in tender coconut can be overcome by immersing the fresh cut tender coconut in a solution of anti – browning agent such as potassium metabisulphite at a concentration of about 2g/l for 5 to 10 minutes (Prades *et al.*, 2011).

Priya and Ramaswamy (2014) developed a technology for preservation and packing of tender coconut water in pouches and aluminum cans. The work done by Coconut Development Board (CDB) in collaboration with Defence Food Research

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Laboratory (DFRL) Mysore has revealed in retention of its flavour when packed in pouches/aluminum cans for a period of three months under ambient conditions and six months under refrigerated conditions.

Mahnot *et al.* (2014) observed that the coconut water can be sterilized by non thermal microfiltration technique and can be stored for 46 days in glass and plastic bottles in refrigerated condition with acceptable sensory results on addition of L-ascorbic acid, citric acid and L-cysteine and it remained sterile for 180 days in glass bottles. The pH and TSS did not change significantly but there was an increase in total titratable acidity and simple sugars and quality is not dependent on packaging material.

2.5.2 Value added products from tender coconut kernel

The residual kernel left after the removal of water from the tender coconut can be converted in to value added products like jam. Jam can be prepared from tender coconut pulp alone or in combination with other fruits such as papaya and pineapple (Manay and Shadaksharaswamy, 2005). Haseena *et al.* (2010) studied the post harvest quality and shelf-life of seven to eight months old tender coconut from local tall cultivar, WCT. The nuts with husk and intact perianth were stored at room temperature (27±2°C) and the minimally processed nuts with 60 per cent husk removed when stored both at room temperature and refrigerated conditions (13±2°C) to evaluate the changes in physical and chemical constituents of coconut water during storage. It was observed that, to increase the shelf life of the coconuts the nuts have to be harvested carefully with intact perianth and without any breakage of nuts and the quality of minimally processed nuts deteriorates earlier than non-dehusked nuts during storage.

Snow ball tender coconut is tender coconut without husk, shell and testa, which is ball in shape and white in containing tender coconut water inside. It has got a more prolonged shelf life under refrigerated conditions than ambient (Madhavan and Arumuganathan, 2010).

Muralidharan and Jayashree (2011) described the technology for minimal processing of tender coconut to retain the flavour and prevent discolouration of tender coconut and making tender coconut kernel candy with a shelf life of 3 months.

Gaikwad *et al.* (2012) evaluated the acceptability of ice cream by using coconut powder at different levels (5 %, 7 %, 9 % and 11 %) and concluded that the sample with 7 per cent coconut powder was accepted and appreciated due to its smooth and uniform texture with pleasant mouth feel and also reported that addition of coconut powder not only enhanced the flavour but also helped to increase melting resistance power of ice cream.

Tender coconut pulp was used as an ingredient of pineapple jam to increase the acceptability of the jam. An increase in the level of coconut pulp was found to significantly increase the fat content as well as Na, K, and Ca contents in the jam. Texture profile analysis revealed a significant decrease in hardness whereas adhesiveness, springiness, cohesiveness, gumminess and chewiness increased significantly with increase in tender coconut pulp (Chouhan *et al.,* 2012).

2.5.3 Biochemical characteristics of value added and processed products from tender coconut

2.5.3.1 TSS

The TSS content was highest in lemon blended tender coconut water RTS beverage (14.64 %), followed by pineapple blended (12.45 %) and acidulant blended (6.43 %) (Illiaskutty, 2004).

Shahanas (2012) found out that there was no significant difference in TSS observed initially and at the end of first month of storage between different treatments of blended tender coconut jam. During storage, the maximum TSS was recorded in jam prepared using 25 per cent tender coconut pulp and 75 per cent pineapple pulp (73° brix).

Kathiravan *et al.* (2014) reported that the TSS of thermally pasteurized tender coconut water-nannari blended beverage was 8.90 and it was higher than the tender coconut water beverage (8.00) and there was no significant change in the TSS of tender coconut water- nannari blended beverage with pulsed electric field processing and storage period was found to be 120 days.

Thermally processed tender coconut water had TSS in the range of 4.6 to 5.6° brix whereas TSS of raw tender coconut water was 5.2 ± 0.16 and the thermal treatment had significant effect on TSS of tender coconut water. Thermal treatment at different temperature and time intervals showed slight difference in TSS values (Sanganamoni and Pavuluri, 2017).

2.5.3.2 pH

Jackson *et al.* (2004) recorded a pH of 5.5 for bottled coconut water in Sri Lanka which is called Penipol or candied coconut with an extended shelf life.

Kathiravan *et al.* (2014) observed that the pH of tender coconut water-nannari blended beverage and found that it increased from 4.90 to 4.94 during the storage up to 70 days, and it was attributed to the ascorbic acid degradation by thermal pasteurization.

Mahnot *et al.* (2014) stated that the unfiltered coconut water (without additives) packed in glass bottles showed a reduction in pH from 6.5 on just day 6.3 on 46^{th} day and pH of microfiltered coconut water was lower than that of the control.

2.5.3.3 Titratable acidity

Investigations carried out by Illaiskutty (2004) showed that tender coconut water blended RTS beverage recorded the lowest acidity (0.16 %), followed by acidulant blended (0.17 %) and lemon blended RTS beverage (0.20 %).

Shahanas (2012) observed acidity in various preparation of jam using tender coconut pulp. Least acidity (4.34) was observed in jam with 100 per cent tender coconut pulp and highest was in jam with 25 per cent tender coconut pulp and 75 per cent guava pulp.

The total titratable acidity of tender coconut water-nannari blended beverage decreased slightly after thermal pasteurization and did not change throughout the storage. The decrease in total titratable acidity is related to the increase found in pH after thermal treatment (Kathiravan *et al.,* 2014).

Titratable acidity expressed as malic acid percent of thermally processed coconut water was in the range of 0.072 to 0.076. The thermal treatment conditions had significant effect on titratable acidity of tender coconut water and there was a slight decrease in titratable acidity after thermal treatment (Sanganamoni and Pavuluri, 2017).

2.5.3.4 Sugars

The total sugar content was highest in RTS beverage prepared from tender coconut water added with pineapple juice, (14.42 %) followed by lemon blended RTS (12.16 %). Reducing sugar content of highest (9.16 %) in the beverage blended with lemon and lowest (4.69 %) for tender coconut water (Illiaskutty, 2004)

Purkayastha *et al.* (2012) reported that total sugars in microfiltered tender coconut water increased from first day to seventh day of its storage and decreased thereafter. After 28 days, a loss of 22.03 per cent and 21.67 per cent total sugar was observed in sample treated with ascorbic acid and the sample without ascorbic acid respectively.

Total and reducing sugar content of tender coconut jam blends were studied by Shahanas (2012). It was reported that total sugar content of blended tender coconut jam decreased during storage. Highest total sugars and reducing sugar from the end of 1st month to 3rd month of storage was recorded for jam prepared using 5 per cent tender coconut pulp and 50 per cent mango pulp. Lowest total and sugar was for jam prepared using 25 per cent tender coconut pulp and 75 per cent guava pulp.

2.5.3.5 Ascorbic acid

Highest vitamin C content was observed in lemon blended tender coconut RTS beverage (10.63 %) though the level was not appreciable (Illiaskutty, 2004).

Sanganamoni *et al.* (2017) studied the loss of ascorbic acid from tender coconut beverage which underwent thermal treatment at varying temperature of 80° C, 85° C, 90° C and 95° C for 2.5 min, 5 min, 7.5 min and 10.0 min time. The loss of ascorbic acid increased from 2 per cent to 12 per cent with increasing temperature and time duration.The highest amount was lost at 95° C and at 10 minutes of thermal treatment.

Unpasteurized tender coconut water of the variety Malayan Green Dwarf had the highest ascorbic acid content of 30.18 μg/ml decreasing to 1.65 μg/ml after it was pasteurized for 90° C for 5 minutes. Similarly, ascorbic acid content of tender coconut water of the variety Malayan Yellow Dwarf reduced from 19.10 to 3.59 μg/ml. The reduction in vitamin C content could be attributed to its degradation during heat treatment (Adubofuor *et al.*, 2016).

2.5.3.6 Protein

Kulkarni and Aradhya (2005) reported that the protein concentration showed a gradual decrease in all the microfiltered samples of tender coconut water added with ascorbic acid packed in glass bottles and also stated that the decrease may be due to formation of complexes with other compounds like phenols forming phenol-protein complex and also due to break down of proteins, which occurs normally in beverages during storage.

Dandin (2013) analyzed the protein content of tender coconut processed products such as tender coconut bun, tender coconut dough nut, tender coconut ice cream, tender coconut pudding, tender coconut tuty fruity and found that it was 5.63 g/100 g, 7.24g/100 g, 4..90 g/100 g, 2.65 g/100 g and 1.43 g/100 g respectively.

2.5.3.7 Sensory quality

The mean score for appearance of different tender coconut blended jam ranged from 7.3 to 8.9. The appearance score recorded highest for jam prepared with 25 per cent tender coconut pulp and 75 per cent pineapple pulp, jam prepared with 25 per cent tender coconut pulp and 75 per cent guava pulp, jam prepared with 25 per cent tender coconut pulp and 75 per cent papaya pulp, and also for jam with 25 per cent tender coconut pulp and 75 per cent pineapple pulp, mango pulp, guava pulp and papaya pulp in equal proportions among the different treatments tried for the tender coconut blended jam and the lowest mean score for appearance was for jam prepared with 75 per cent tender coconut pulp and 25 per cent guava pulp (Shahanas, 2012).

The jam containing 75 per cent tender coconut pulp and 25 per cent pineapple pulp showed a maximum sensory acceptability for the mixed jam. The jam prepared at optimum conditions of coconut and pineapple pulp showed a good sensory acceptability after 6 months of storage at 28 ± 2 and 37° C storage conditions on the basis of physicochemical and sensory attributes (Chouhan *et al.,* 2012).

Spiced tender coconut water stored in glass bottle at room and refrigerated temperature had an overall acceptability score of 9.00. The product was acceptable upto 12 months at refrigerated temperature and up to 10 months at room temperature (Sindhumathi and Amutha, 2013).

Adubofuor *et al.* (2016) studied sensory properties of pasteurized and unpasteurized tender coconut water of different coconut cultivars and found that panellists preferred fresh unpasteurized coconut water over the other samples in terms of all the evaluated properties. Heating causes caramelization of the sugars which induces a cloudy appearance of the coconut water. Also Maillard reactions are initiated during the heating process which also contributed to the cloudy or opaque nature of the pasteurized samples. These reactions also altered the aroma, aftertaste and mouthfeel of the coconut water.

2.6 Microbiological characters of tender coconut

Leite *et al.* (2000) stated that the shortest lag-time of the bacteria (*L. monocytogenes)* for establishing in fresh coconut water at 4° C was 12.7 days, at 10° C was 4.2 days and at 35° C was 3 hours. The reduction of the storage temperature from 35° C to 4° C resulted in approximately a 100 times increase in lag-time, showing that storage temperature is an effective way of controlling *L. monocytogenes* in fresh coconut water. Reducing temperature from 35° C to 10° C and then to 4° C, led to a reduction in growth rate around 15 and 70 times, respectively, and these data can be used to estimate the shelf-life of fresh coconut water. It should always be considered that refrigeration prolongs the lag-time but does not inhibit growth of the bacteria, and temperature abuse can considerably increase the level of potential hazards. Melo *et al.* (2003) opined that *Escherichia coli* and *Salmonella* spp. were detected in fresh coconut water stored under refrigeration and populations of up to 1.6×10^5 cfu/ml of *Bacillus cereus* and 8.0×10^4 cfu/ml of *Staphylococcus aureus* were also found.

The tender coconut water when taken out from the nut spoils within a day because of external contamination by microorganisms, which may be in the order of 10^6 cfu/ml in the traditional way of collection (Reddy *et al.*, 2005).

Fortes *et al.* (2006) analyzed 20 samples of refrigerated coconut water packaged in plastic bottles and noted the samples had a pH between 5.0 and 5.2, and were positive for *Escherichia coli.* It imply that fresh coconut water might be a possible vehicle for foodborne diseases.

Control of foodborne pathogens in fresh coconut water can be attained by a combination of surface contact hygiene and time/temperature control and the strategy follows the principles of hurdle technology, where two or more preservation technologies are used to prevent growth of microorganisms. Shelf-life of 4 weeks for micro-filtered coconut water, total microbial counts exceeding the acceptable limit of ≤5000 cfu/ml was observed on 35th day of storage (Rolle, 2007).

Unpasteurized tender coconut water of the cultivar Malayan Yellow Dwarf recorded a yeast and mould count of 840 cfu/ml which reduced to 60 cfu/ml and also recorded 960 cfu/ml which reduced to 70 cfu/ml in the sample which was pasteurized at 80° C and 90° C (5 min) respectively. Microbiological analyses showed that pasteurization provided safe products with yeast and moulds count of less than 1.0 x 10^3 cfu/ml (Adubofuor *et al.,* 2016).

Materials and Methods

3. MATERIALS AND METHODS

MATERIALS

The present investigation on the "Development of novel value added products from tender coconut (*Cocos nucifera* L.)" was carried out with tender coconut collected from different locations in Thrissur district. The investigation was carried out in the Dept. of Post Harvest Technology, College of Horticulture, Vellanikkara, Thrissur during 2016- 2018.

METHODS

The whole research programme was divided into three major experiments

3.1 Effect of food additives on quality of tender coconut RTS beverage

3.2 Effect of blending fruit juice on quality of tender coconut based RTS beverage

3.3 Effect of jellifying agents on the quality of tender coconut jelly

3.1 EFFECT OF FOOD ADDITIVES ON QUALITY OF TENDER COCONUT RTS BEVERAGE

3.1.1 Collection of tender coconut

Fresh tender coconut of about 7 months maturity (cv. COD) was procured without breakage/ damaging of nuts and transported to Department of Post Harvest Technology.

3.1.2 Processing of tender coconut

The collected tender coconut was washed in plain tap water, followed by surface sanitization with chlorine (100 ppm) for 15 minutes. The liquid endosperm along with the soft kernel was extracted from the nuts, followed by grinding to obtain a smooth and fine liquid. The TSS of this liquid was raised to 12^{o} brix. After adjustment of TSS, the liquid was added with 100 ppm ascorbic or malic acid in combination with one of the three preservatives, potassium metabisulphite, sodium benzoate and potassium sorbate at a concentration of 100 ppm and filled in 200 ml bottles, followed by crown corking. The RTS beverage thus prepared was finally pasteurized at a temperature of 85°C for 15 minutes. The pasteurized tender coconut RTS beverage was stored for 3 months under ambient and refrigerated conditions. The two acids such as ascorbic and malic acid were selected as food additive because of its antioxidant activity and flavour enhancement property along with food preservation respectively.

3.1.3 Treatments

T_1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T_2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T_3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T_4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T_5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T_6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T_7- Tender coconut RTS beverage without food additives (control)

Storage conditions: ambient and low temperature (5-7°C)

3.1.4 Design and Layout

The experiment was laid out in a Completely Randomized Design (CRD) with three replications of seven treatments each.

3.1.5 Observations

Observations on shelf life and quality parameters were recorded at 15 days intervals for the tender coconut RTS beverage and at one month intervals for tender coconut jelly.

3.1.5.1 Physical parameters

3.1.5.1.1 *Shelf life (days)*

Shelf life was noted on the basis of edibility, sensory qualities, visual changes and also the incidence of spoilage or microbial contamination.

3.1.5.2 Biochemical parameters

3.1.5.2.1 *Total soluble solids (TSS)*

TSS of tender coconut RTS beverage was measured directly using a hand refractometer (Erma) with a range 0-32° brix and expressed in degree brix (AOAC, 1980).

3.1.5.2.2 *Titratable acidity*

The titratable acidity was estimated by titrating a known volume of the sample against 0.1 N sodium hydroxide solution using phenolphthalein as an indicator for all the samples. The acidity was calculated and expressed as per cent of malic acid (AOAC, 1998).

$$\text{Acidity} = \frac{\text{Normality} \times \text{titre value} \times \text{equivalent weight} \times \text{volume made up} \times 100}{\text{Weight of sample} \times \text{aliquot of sample} \times 1000}$$

3.1.5.2.3 ***pH***

A known weight (10g) was taken and it was macerated with 100ml of water. The mixture was allowed to stand for 30 minutes, followed by decanting the supernatatant in a beaker. The pH of the sample was recorded by using a pH meter.

3.1.5.2.4 ***Reducing sugars***

A known weight of filtered juice sample was first neutralized with 1N NaOH by using phenolphthalein as an indicator and transferred to a 250 ml volumetric flask. About 100 ml of distilled water was added followed by 2 ml pre standardized 45 per cent neutral lead acetate for clarification. Excess lead acetate was neutralized by addition of 2 ml pre standardized 22 per cent potassium oxalate solution. The clarified solution was made up to the mark with distilled water. This was filtered through Whatman's No.1 filter paper. In the clarified filtrate, the reducing sugar was determined by titrating against standard Fehling's solution using methylene blue as an indicator (Ranganna, 1997). The quantity of reducing sugar was calculated by the formula as given below.

$$\text{Reducing sugars (\%)} = \frac{\text{Fehling's Factor x dilution x 100}}{\text{Titre value x weight of sample}}$$

3.1.5.2.5 ***Non reducing sugars***

Non reducing sugar was estimated by deducting reducing sugars from total sugars (% total sugars - % reducing sugars)

3.1.5.2.6 ***Total sugars***

Filtrate (50 ml) used in the estimation of reducing sugars was taken into a 250ml conical flask. After that, 5 g of citric acid and 50 ml of water was added to that solution. Then it was boiled for 10 minutes to complete the inversion of sucrose, followed by cooling. The solution was transferred to a 250 ml volumetric flask and neutralized with 1N NaOH using phenolphthalein as indicator. The neutralized solution was made up to the mark with distilled water. An aliquot was taken from this and titrated against standard Fehling's solution using methylene blue indicator (Ranganna, 1997). The total sugars were calculated as given below.

$$\text{Total sugars (\%)} = \frac{\text{Fehling's Factor x 250 x dilution x 100}}{\text{Titre value x 50 x weight of sample}}$$

3.1.5.2.7 ***Vitamin C/Ascorbic acid***

Five grams of the sample 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 $100g^{-1}$ of fruit (Sadasivam and Manickam, 1996).

3.1.5.2.8 ***Protein***

The protein content of tender coconut RTS beverage was determined by Lowry's method (Lowry, 1951). 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 needed 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 1ml water served as blank. To each test tube including blank, alkaline copper solution (5 ml) was added. It was mixed well and allowed to stand for 10 minutes. To all test tubes Folin-ciocalteau reagent (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.

3.1.5.2.9 *Non enzymatic browning*

To a known weight/volume of sample (10 g), 100 ml of 60 per cent alcohol was added and mixed thoroughly. After keeping overnight, the contents were filtered through Whatman's No.1 filter paper. The colour was measured at 440 nm in a spectrophotometer using 60 per cent alcohol as blank. The results were reported as absorbance/optical density value (Ranganna, 1997).

3.1.5.3 *Organoleptic quality*

Quality of tender coconut RTS was judged by a panel of judges of different age groups for appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability, based on a 9 hedonic scale rating (Amerine *et al.*, 1965). For organoleptic test, Kendall's co-efficient of concordance was performed and the mean rank scores were taken to differentiate the best product. A score of 5.5 was considered acceptable.

3.1.5.4 *Microbial load*

The estimation of microbial population present in the tender coconut RTS samples was carried out by serial dilution plate count method as described by Agarwal and Hasija (1986).

The samples were subjected to microbiological analysis initially and also at specific intervals during their storage. The samples were analysed for the population of bacteria, fungi, and mould in standard plate count Nutrient Agar (NA), Martin Rose Bengal Agar and Sabouraud Dextrose Agar (SDA) media, respectively and the results were expressed in cfu g^{-1} of sample.

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 one 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

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

3.2 EFFECT OF BLENDING FRUIT JUICE ON QUALITY OF TENDER COCONUT BASED RTS BEVERAGE

Tender coconut was blended with fruit juice of guava, pineapple and sweet orange in different proportions (90:10, 80:20, 70:30, 60:40, 50:50 v/v), followed by raising the total soluble solids to 12°Brix. The RTS beverage thus developed was added with 100 ppm of the preservative found best from Experiment 1, filled into 200 ml glass bottles, followed by crown corking and pasteurization at 85°C for 15 minutes. Best proportion of blend from each type of fruit juice and tender coconut was selected based on the organoleptic score. The pasteurized bottles were stored under ambient and refrigerated conditions for 3 months.

3.2.1 Treatments

T_1: Tender coconut RTS beverage blended with guava

T_2: Tender coconut RTS beverage blended with pineapple

T_3: Tender coconut RTS beverage blended with sweet orange

T_4: Tender coconut RTS beverage without fruit juice (control)

3.2.2 Design and Layout

The experiment was laid out in a Completely Randomized Design (CRD) with three replications of four treatments each.

3.2.3 Standardisation of best type of blend from each type of fruit juice and tender coconut

Every blend from each type of fruit juice and tender coconut was subjected to organoleptic evaluation. Based on the organoleptic score of each blend, the best type was standardized and the blend with highest organoleptic score was stored for 3 months.

Storage conditions: ambient and low temperature (5-7°C)

3.2.4 Physical parameters

3.2.4.1 *Shelf life (days)*

Shelf life was noted as in 3.1.5.1.1

3.2.5 Biochemical parameters

3.2.5.1 *Total soluble solids (TSS)*

TSS were estimated as in 3.1.5.2.1

3.2.5.2 *Titratable acidity*

Titratable acidity was estimated as in 3.1.5.2.2

3.2.5.3 *pH*

pH was estimated as in 3.1.5.2.3

3.2.5.4 *Reducing sugars*

Reducing sugars were estimated as in 3.1.5.2.4

3.2.5.5 *Non reducing sugars*

Non reducing sugars were estimated as in 3.1.5.2.5

3.2.5.6 *Total sugars*

Total sugars were estimated as in 3.1.5.2.6

3.2.5.7 *Vitamin C/ Ascorbic acid*

Ascorbic acid was estimated as in 3.1.5.2.7

3.2.5.8 *Protein*

Protein was estimated as in 3.1.5.2.8

3.2.5.9 *Non enzymatic browning*

Non enzymatic browning was estimated as in 3.1.5.2.9

3.2.6 Organoleptic quality

Organoleptic quality was estimated as in 3.1.5.3

3.2.7 Microbial load

Microbial load was estimated as in 3.1.5.4

3.3 EFFECT OF JELLIFYING AGENTS ON THE QUALITY OF TENDER COCONUT JELLY

Tender coconut jelly was prepared from tender coconut water by incorporating jellifying agents at concentrations ranging from 0.5- 2.0 per cent. The quality of jelly thus developed was evaluated based on organoleptic properties. The best type of jelly based on organoleptic score from the various concentrations of each jellifying agent was selected and stored for three months under ambient and refrigerated conditions, after packing in glass jars.

Storage conditions: ambient and low temperature (5-7°C)

3.3.1 Treatments

T_1: Tender coconut jelly from agaropectin

T_2: Tender coconut jelly from banana peel pectin

T_3: Tender coconut jelly from guava pectin

T_4: Tender coconut jelly from nutmeg rind pectin

3.3.2 Design and Layout

The experiment was laid out in a Completely Randomized Design (CRD) with three replications of four treatments each.

3.3.3 Standardisation of best concentration of different jellifying agents

Tender coconut jelly was prepared with varying concentrations (0.5 per cent, 1 per cent, 1.5 per cent and 2 per cent) of different jellifying agents (agaropectin, banana peel pectin, guava pectin, nutmeg rind pectin). The best concentration of each jellifying agent was selected based on the organoleptic score.

3.3.4 Physical parameters

3.3.4.1 *shelf life (Days)*

Shelf life was noted as same as in 3.1.5.1.1

3.3.4.2 *Water activity*

Water activity (A_w) is defined as the ratio of the partial pressure of water in the atmosphere in equilibrium with the substrate to that of the atmosphere in equilibrium with pure water at the same temperature, and is expressed on a scale of 0 to 1. It is measured by using a water activity measuring instrument.

3.3.5 Biochemical parameters

3.3.5.1 *Total soluble solids (TSS)*

TSS were estimated as in 3.1.5.2.1

3.3.5.2 *Titratable acidity*

Titratable acidity was estimated as in 3.1.5.2.2

3.3.5.3 *pH*

pH was estimated as in 3.1.5.2.3

3.3.5.4 *Reducing sugars*

Reducing sugars were estimated as in 3.1.5.2.4

3.3.5.5 *Non reducing sugars*

Non-reducing sugars were estimated as in 3.1.5.2.5

3.3.5.6 *Total sugars*

Total sugars were estimated as in 3.1.5.2.6

3.3.5.7 *Vitamin C/ Ascorbic acid*

Ascorbic acid was estimated as in 3.1.5.2.7

3.3.5.8 *Protein*

Protein was estimated as in 3.1.5.2.8

3.3.5.9 ***Non enzymatic browning***

Non enzymatic browning was estimated as in 3.1.5.2.9

3.3.5.10 ***Organoleptic quality***

Organoleptic quality was estimated as in 3.1.5.3

3.3.6 Microbial load

Microbial load was estimated as in 3.1.5.4

3.4 STATISTICAL ANALYSIS

The data obtained were analysed statistically using analysis of variance (ANOVA) technique. The critical difference value at five per cent level was used for making comparison among different treatments. The scores of sensory evaluation were analysed by Kendall's coefficient of concordance.

Results

4. RESULTS

The results of the present study titled "Development of novel value added products from tender coconut (*Cocos nucifera* L.) are presented in this chapter under the following sections.

4.1 Effect of food additives on quality of tender coconut RTS beverage

4.2 Effect of blending fruit juice on quality of tender coconut based RTS beverage

4.3 Effect of jellifying agents on the quality of tender coconut jelly

4.1 EFFECT OF FOOD ADDITIVES ON QUALITY OF TENDER COCONUT RTS BEVERAGE

Tender coconut water owing to its inherent characteristics, undergoes rapid biochemical and microbial changes, resulting in an unpleasant and non-palatable drink. Efforts to process tender coconut water in the bottled or packaged form has not met with much success, owing to considerable loss in its natural flavour. Therefore, an attempt was made to prepare fresh tender coconut RTS beverage added with a combination of food additives and also to evaluate its quality and shelf life during storage. Observations on the physical and biochemical parameters of tender coconut RTS beverage was recorded and presented below.

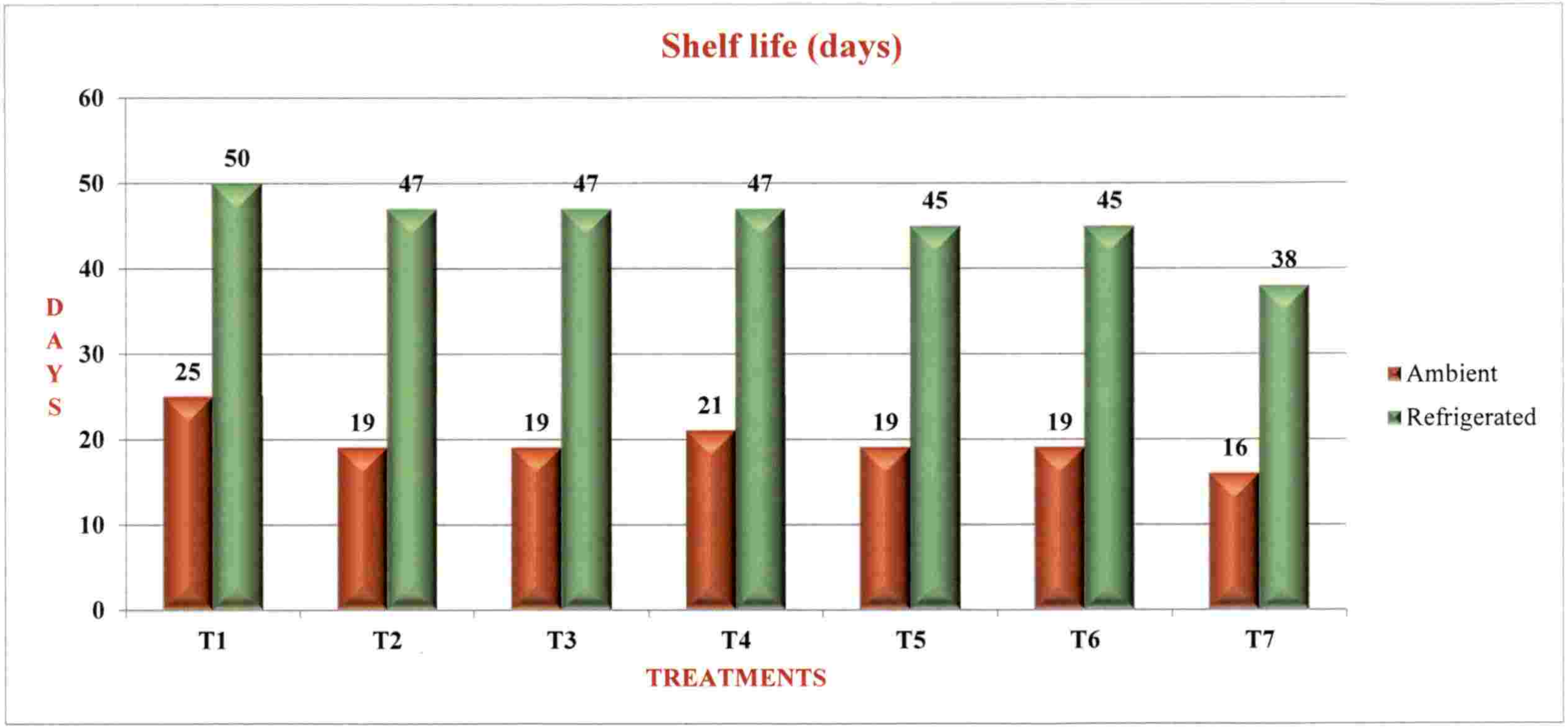
4.1.1 Physical parameters

Three replications of each sample of prepared tender coconut RTS beverage were used for determining the shelf life (days) under both ambient and refrigerated conditions.

4.1.1.1 *Shelf life (days)*

The shelf life of tender coconut RTS beverage stored under ambient and refrigerated conditions varied significantly as shown in (Figure 1). The RTS beverage stored under refrigerated condition gave significantly longer shelf life as compared to samples stored under ambient condition. Tender coconut RTS without any additives (T_7) gave a minimum shelf life of 16 days and 38 days at ambient and refrigerated condition respectively where as tender coconut RTS beverage added with ppm ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1) gave the maximum shelf life of 25 days and 50 days both under ambient and refrigerated condition respectively.

Figure 1. Effect of food additives and storage temperature on shelf life (days) of tender coconut RTS beverage



T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3. Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

4.1.2 Biochemical parameters

4.1.2.1 *Total soluble solids (TSS) (°Brix)*

TSS in all the treatments of tender coconut RTS bevaerage increased throughout the storage period, irrespective of storage conditions (Table 1). Tender coconut RTS beverage stored under ambient condition showed higher variation in TSS compared to those stored under refrigerated condition. Significant increase in TSS of tender coconut RTS beverage was not observed throughout the storage period.

4.1.2.2 *Titratable acidity (%)*

Titratable acidity of tender coconut RTS beverage decreased during storage. Non significant variation of titratable acidity was observed in all the treatments of tender coconut RTS beverage (Table 1). Lowest (0.310 %) titratable acidity was observed in T_7 (control) 15 days after storage under ambient condition whereas under refrigerated condition, titratable acidity of all the treatments of tender coconut RTS beverage declined to 0.27 per cent, 45 days after storage.

4.1.2.3 *pH*

An increasing trend in pH was observed in all the treatments of tender coconut RTS beverage as shown in Table 2. Under ambient condition, the treatment T_3 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium sorbate (100 ppm) showed highest pH (4.66) whereas the treatment without any additives (T_7) showed the lowest pH (4.47), 15 days after storage. After 45 days of storage, tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1) showed the highest pH (4.87) and lowest pH (4.52) was observed in treatment where malic acid (100 ppm) and sodium benzoate (100 ppm) was added to tender coconut RTS beverage.

4.1.2.4 *Vitamin- C (mg 100g^{-1})*

Ascorbic acid content in all the treatments of tender coconut RTS beverage decreased significantly throughout the storage period, irrespective of storage conditions (Table 2). Tender coconut RTS beverage stored under refrigerated condition retained higher amount of ascorbic acid as compared to those stored under ambient condition. After 15 days of storage, T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) stored under refrigerated condition showed highest ascorbic acid (53.00 mg 100g^{-1}) while the lowest (2.00 mg 100g^{-1}) was observed in T_7 (control) under ambient condition. After 45 days of storage under refrigerated condition, tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1) retained the highest (52.98 mg 100 g^{-1}) ascorbic acid.

4.1.2.5 *Reducing sugars (%)*

An increasing trend in reducing sugar content was observed in all the treatments of tender coconut RTS beverage, irrespective of storage conditions (Table 3). The increase was significantly higher under ambient temperature compared to low temperature (5-7° C) throughout the storage period. Under ambient condition, highest reducing sugar content (7.96 %) was observed in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm)) and the lowest (7.43 %) was in T_7 (control), 15 days after storage. Under refrigerated condition, T_7 (control) showed highest (7.56 %) and T_2 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and sodium benzoate (100 ppm)) showed the lowest (7.23 %) reducing sugar content after 45 days of storage.

4.1.2.6 *Non reducing sugars (%)*

Similar to reducing sugars non-reducing sugars also showed an increasing trend under both the storage conditions. Under ambient condition, the change was non significant. The highest (6.40 %) non reducing sugar content was observed in T_4

(tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm)) and T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm)) and the lowest (5.96 %) was observed in T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate(100 ppm)), 15 days after storage under ambient condition. Tender coconut added with malic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_4) showed highest (6.66 %) non-reduing sugars and the lowest (6.36 %) was observed in T_2 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and sodium benzoate (100 ppm)), 45 days after storage under refrigerated storage.

4.1.2.6 ***Total sugars (%)***

Total sugar content in all the treatments of tender coconut RTS beverage also showed an increasing trend throughout the storage period, irrespective of storage conditions (Table 3). The increase was more under ambient condition compared to refrigerated storage. Under ambient condition, when tender coconut RTS beverage was added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1) showed highest (13.95 %) total sugars, the lowest total sugar content (13.50 %) was observed in T_3 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium sorbate (100 ppm) and T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm), 15 days after storage. At 45 days after storage under refrigerated condition, the highest total sugar content (13.66 %) was observed in T_4 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm) and the lowest (13.24 %) in T_2 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and sodium benzoate (100 ppm).

4.1.2.8 ***Protein (%)***

A decreasing trend in protein content was observed in all the treatments of tender coconut RTS beverage, irrespective of storage condition (Table 4). The loss of

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protein during storage period was higher under ambient condition. The treatment T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) showed the highest (0.071 %) and the treatment T_7 (control) showed lowest (0.030 %) protein content 15 days after storage under ambient condition. Under refrigerated condition, the protein content varied significantly and the highest (0.053 %) protein content was observed in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and the lowest (0.012 %) in T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm), after 45 days of storage period.

4.1.2.9 ***Non-enzymatic browning***

Non-enzymatic browning of tender coconut RTS beverage increased during the storage period (Table 4). Under ambient condition, same non-enzymatic browning (0.01) was observed in four treatments such as T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm), T_2 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and sodium benzoate (100 ppm), T_3 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium sorbate (100 ppm) and T_4 (tender coconut added with malic acid (100 ppm) and potassium metabisulphite (100 ppm) and the highest (0.05) non-enzymatic browning was observed in T_7 (control), 15 days after storage. After 45 days of storage under refrigerated condition, tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm) (T_6) showed highest (0.07) non-enymatic browning and the lowest (0.03) was observed in treatments T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and T_4 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm).

Table 1. Effect of storage conditions on total soluble solids (TSS) and titratable acidity of tender coconut RTS beverage

Treatments	Total Soluble Solids (° Brix)						Titratable acidity (%)			
	Initial	Ambient	Refrigeration (5-7° C)			Initial	Ambient	Refrigeration (5- 7° C)		
		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS
T1	12.00	13.33	13.16	13.53	14.33	0.334	0.311	0.310	0.307	0.271
T2		13.33	13.32	13.83	14.50	0.333	0.314	0.312	0.307	0.271
T3		13.16	13.00	13.50	14.00	0.332	0.313	0.311	0.307	0.272
T4		13.16	13.10	13.66	14.00	0.335	0.312	0.310	0.306	0.274
T5		13.33	13.20	13.66	14.00	0.334	0.313	0.310	0.306	0.273
T6		13.06	13.03	13.33	13.83	0.332	0.311	0.310	0.307	0.273
T7		13.83	13.33	13.63	-	0.330	0.310	0.316	0.304	-
CD		NS	NS	NS	NS	NS	NS	NS	NS	NS

DAS: Days after storage

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 2. Effect of storage conditions on pH and Vitamin- C content of tender coconut RTS beverage

Treatments	pH					Vitamin C (mg $100g^{-1}$)				
	Initial	Ambient	Refrigeration (5-7° C)			Initial	Ambient	Refrigeration (5-7° C)		
		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS
T1	4.47	4.66	4.65	4.72	4.87	54.16	53.00	53.15	53.07	52.98
T2		4.52	4.51	4.60	4.77	54.16	52.98	53.00	52.92	52.73
T3		4.66	4.63	4.66	4.67	54.16	52.89	52.98	52.77	52.01
T4		4.52	4.48	4.56	4.57	3.27	3.00	3.12	3.00	2.98
T5		4.48	4.42	4.46	4.52	3.23	2.91	3.16	2.33	1.87
T6		4.50	4.48	4.49	4.55	3.27	2.21	2.45	2.32	1.34
T7		4.47	4.46	4.50	-	2.83	2.00	2.23	1.90	-
CD	-	0.05	0.02	0.01	0.02	1.78	1.96	2.90	1.90	1.94

DAS: Days after storage

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 3. Effect of storage conditions on reducing, non-reducing and total sugar content of tender coconut RTS beverage

Treatments	Reducing sugars (%)					Non-reducing sugars (%)					Total sugars (%)				
	Initial	Ambient	Refrigeration (5-7° C)			Initial	Ambient	Refrigeration (5-7° C)			Initial	Ambient	Refrigeration (5-7° C)		
		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS
T1	6.83	7.96	7.25	7.32	7.55	5.62	5.99	6.16	6.30	6.55	12.45	13.95	13.24	13.32	13.55
T2		7.68	7.15	7.20	7.23		5.97	5.81	6.54	6.36		13.67	13.00	13.20	13.24
T3		7.52	7.01	7.37	7.48		6.16	5.80	6.23	6.44		13.50	12.85	13.37	13.48
T4		7.76	7.22	7.36	7.54		6.40	6.00	6.01	6.66		13.75	13.24	13.34	13.66
T5		7.57	7.08	7.17	7.55		5.96	5.91	6.43	6.65		13.54	13.00	13.17	13.65
T6		7.53	7.03	7.19	7.33		6.40	6.22	6.46	6.47		13.50	13.16	13.19	13.34
T7		7.43	6.95	7.13	-		6.30	6.05	6.34	-		13.70	13.00	13.13	-
CD		0.03	0.06	0.04	0.04		NS	0.12	0.26	0.19		0.06	0.09	NS	0.15

DAS: Days after storage

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3. Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 4. Effect of storage conditions on protein content and non-enzymatic browning of tender coconut RTS beverage

Treatments	Protein (%)					Initial	Non-enzymatic browning (absorbance)			
	Initial	Ambient	Refrigeration (5-7° C)				Ambient	Refrigeration (5-7° C)		
		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS
T1	0.09	0.071	0.082	0.076	0.053	0.01	0.01	0.01	0.03	0.03
T2		0.051	0.071	0.062	0.042	0.01	0.01	0.01	0.03	0.04
T3		0.051	0.071	0.061	0.056	0.01	0.01	0.01	0.03	0.05
T4		0.062	0.064	0.042	0.037	0.01	0.01	0.01	0.02	0.03
T5		0.052	0.054	0.054	0.038	0.01	0.02	0.01	0.05	0.06
T6		0.051	0.053	0.030	0.012	0.01	0.02	0.01	0.05	0.07
T7		0.030	0.032	0.020	-	0.04	0.05	0.03	0.06	-
CD		0.01	0.008	0.009	0.008	NS	NS	NS	0.008	0.01

DAS: Days after storage

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3. Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

4.1.2.10 *Organoleptic quality*

Data on mean sensory scores of tender coconut RTS beverage initialy, 15 days after storge under both ambient and refrigerated conditions, 30 days and 45 days after storage under refrigerated condition are presented in Tables 5, 6, 7, 8 and 9 respectively. Sensory quality of tender coconut RTS beverage declined during storage in all the treatments. The loss of sensory quality was higher under ambient condition. Tender coconut RTS added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1) showed highest over all acceptability score of 7.00, 15 days after storage under ambient condition whereas overall acceptability score was highest (7.4) in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and lowest (4.9) in T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate (100 ppm) and T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm) 45 days after storage under refrigerated condition.

4.1.3 *Microbial load*

Enumeration of microbial population (bacteria, fungi and yeast) in freshly prepared tender coconut RTS beverage was done immediately after pasteurization. Bacteria was predominant among the micro organisms and the microbial load was higher in all the treatments under ambient condition compared to those under refrigerated condition (Table 10). Under ambient condition, bacteria and yeast population was observed in all the treatments of tender coconut RTS beverage and the fungi were absent in the treatments T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate (100 ppm) 15 days after storage. Highest bacterial load (19.66×10^5 cfu g^{-1}) was observed in T_7 (control) and lowest (9.33×10^5 cfu g^{-1}) in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm). Highest (1.66×10^3 cfu g^{-1}) fungal load was observed in T_7 (control) and lowest

($0.33x10^3$ cfu g^{-1}) was in T_4 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm), 15 days after storage under ambient ondition.

All the treatments of tender coconut RTS beverage except T_1(tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) showed bacterial population from 15 days to 45 days after storage. Fungi were observed in T_2 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and sodium benzoate (100 ppm), T_4 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm) and T_7 (control), 45 days after storage and yeast population was observed in the treatments T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate (100 ppm) and T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm) after 45 days of storage under refrigerated condition (Table 10).

Table 5. Effect of storage on organoleptic quality of tender coconut RTS beverage (Initial)

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
T1	8.2	8.8	7.5	8.8	9.0	9.0	7.1	8.0
T2	9.0	7.4	8.0	7.8	8.9	7.0	7.4	7.4
T3	8.2	8.3	7.8	7.0	9.0	7.8	7.0	7.0
T4	8.2	7.1	5.9	7.1	7.4	6.8	7.0	7.2
T5	6.0	7.8	8.6	6.7	8.1	8.8	7.5	7.7
T6	6.0	7.1	7.7	7.0	8.2	8.5	7.6	6.3
T7	5.5	6.3	6.6	8.0	7.7	7.5	6.6	6.0
Kendal's W test	0.356	0.321	0.332	0.314	0.318	0.321	0.293	0.245

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 6. Effect of storage on organoleptic quality of tender coconut RTS (15 DAS) under ambient condition

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
T1	9.0	8.0	7.0	7.0	7.5	7.0	6.5	7.0
T2	7.5	7.0	6.7	6.0	6.5	6.5	6.0	5.0
T3	8.0	7.9	7.9	6.0	7.2	6.9	6.0	6.0
T4	7.4	7.8	6.5	6.3	6.8	6.9	6.4	7.0
T5	5.9	7.5	8.4	6.0	7.5	6.0	6.3	5.0
T6	5.1	6.0	5.9	5.6	5.0	5.4	5.3	5.0
T7	5.1	5.0	4.9	4.6	4.0	4.5	4.3	4.0
Kendal's W test	0.231	0.264	0.201	0.163	0.238	0.174	0.125	0.237

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 7. Effect of storage on organoleptic quality of tender coconut RTS (15 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
T1	9.0	8.0	8.6	7.4	8.7	9.8	7.1	8.0
T2	7.6	6.9	7.3	7.9	7.7	8.7	7.0	7.5
T3	8.3	8.2	8.0	7.8	7.9	7.7	7.0	7.0
T4	7.4	8.0	7.0	5.8	7.0	7.0	6.8	7.0
T5	6.0	6.9	8.0	6.4	7.9	8.4	7.3	7.5
T6	6.0	6.9	7.6	6.9	7.9	8.0	7.4	6.0
T7	5.3	6.4	6.0	7.6	7.4	7.3	6.0	5.7
Kendel's W test	0.421	0.411	0.420	0.431	0.395	0.402	0.399	0.410

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 8. Effect of storage on organoleptic quality of tender coconut RTS (30 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
T1	8.9	7.8	8.4	7.0	8.5	9.5	6.9	7.6
T2	7.4	6.5	7.0	7.5	7.4	8.6	6.7	7.2
T3	8.0	7.3	7.7	7.6	7.7	7.4	6.8	6.5
T4	7.0	7.9	6.8	5.6	6.8	6.8	6.6	6.8
T5	5.9	6.5	7.7	6.0	7.5	5.0	7.1	5.0
T6	5.8	6.6	7.5	6.3	7.4	5.0	7.0	4.9
T7	5.0	5.7	7.0	7.0	7.0	4.9	5.9	4.5
Kendal's W test	0.561	0.498	0.497	0.501	0.396	0.401	0.498	0.467

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 9. Effect of storage on organoleptic quality of tender coconut RTS (45 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
T1	8.6	7.6	8.3	7.0	8.4	9.3	6.7	7.4
T2	7.2	6.2	6.7	7.3	7.3	8.4	6.5	7.0
T3	7.8	7.0	7.5	7.4	7.4	7.0	6.5	6.2
T4	6.8	7.4	6.6	5.4	6.4	6.4	6.2	6.5
T5	5.3	6.4	7.3	5.5	7.0	4.9	6.8	4.9
T6	5.3	6.2	7.0	6.0	7.0	4.9	6.8	4.9
T7	-	-	-	-	-	-	-	-
Kendal's W test	0.567	0.532	0.530	0.523	0.517	0.511	0.497	0.504

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Plate 1. Tender coconut RTS beverage under different storage conditions

Initial

15 DAS (Ambient)

45DAS (Refrigerated)

DAS : Days after storage

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

Table 10. Effect of storage on microbial population of tender coconut RTS beverage

Treatments	Bacterial load (10^5 cfu g^{-1})					Fungal load (10^3 cfu g^{-1})					Yeast load (10^3 cfu g^{-1})				
	Initial	Ambient	Refrigerated (5-7° C)			Initial	Ambient	Refrigerated (5-7° C)			Initial	Ambient	Refrigerated (5-7° C)		
		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS		15 DAS	15 DAS	30 DAS	45 DAS
T1	ND	9.33	ND	4.33	4.33	ND	ND	ND	ND	ND	ND	4.00	ND	ND	ND
T2		9.66	5.33	5.33	7.33		1.00	ND	ND	0.33		5.66	ND	ND	ND
T3		11.66	5.33	5.33	7.33		1.33	ND	ND	ND		4.66	ND	ND	ND
T4		9.33	5.33	5.33	7.54		0.33	ND	ND	0.33		4.33	ND	ND	ND
T5		11.66	5.33	5.33	7.55		ND	ND	ND	ND		4.33	ND	ND	0.67
T6		11.66	5.33	5.33	7.33		1.33	ND	ND	ND		4.33	ND	ND	0.62
T7		19.66	7.33	7.33	-		1.66	0.66	0.66	-		7.00	ND	ND	-
CD	-	1.02	1.02	1.02	1.02		NS	NS	NS	0.38		1.09	NS	NS	NS

DAS: Days after storage

T1- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium metabisulphite)

T2- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm sodium benzoate)

T3- Tender coconut RTS beverage (100 ppm ascorbic acid and 100 ppm potassium sorbate)

T4- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium metabisulphite)

T5- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm sodium benzoate)

T6- Tender coconut RTS beverage (100 ppm malic acid and 100 ppm potassium sorbate)

T7- Tender coconut RTS beverage without food additives (control)

4.2 EFFECT OF BLENDING FRUIT JUICE ON QUALITY OF TENDER COCONUT BASED RTS BEVERAGE

4.2.1 Standardisation of best type of blend from each type of fruit juice and tender coconut

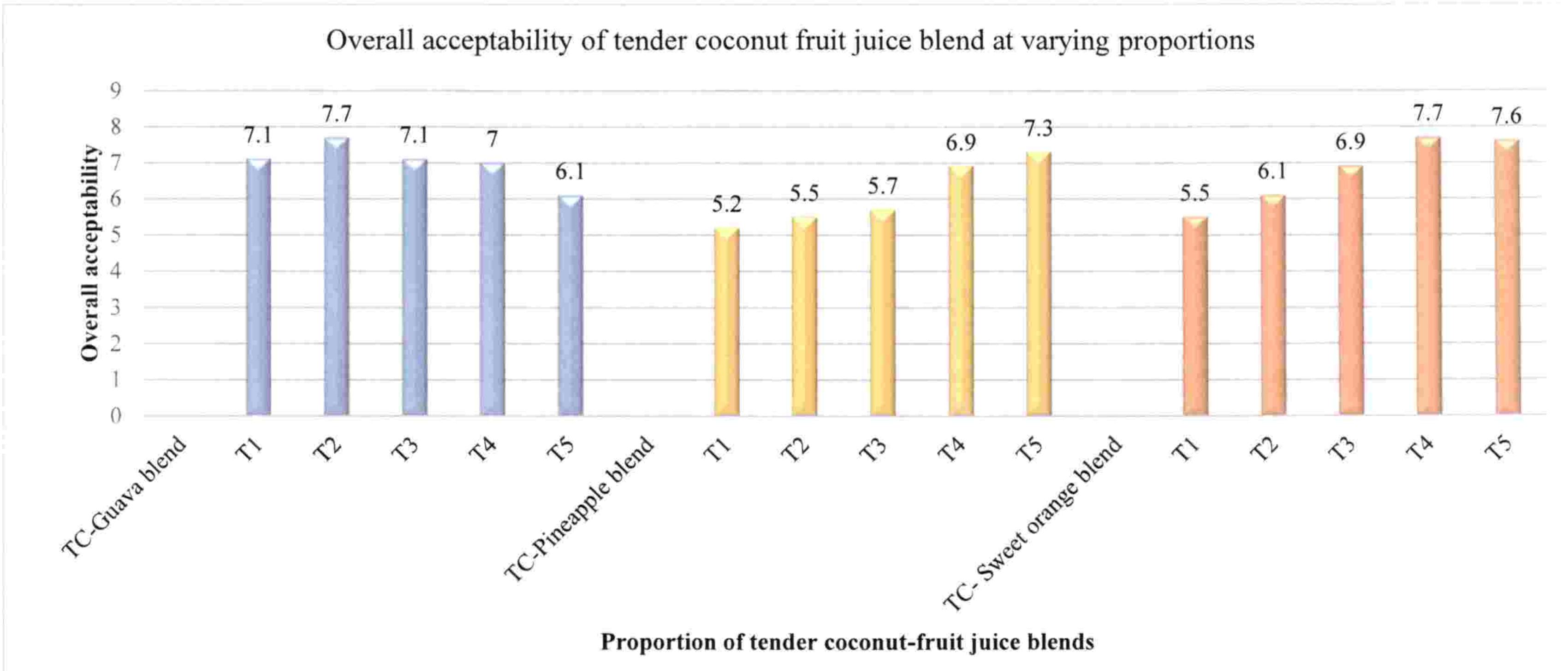
Tender coconut was blended with fruit juice/pulp of guava, pineapple and sweet orange in different proportions (90:10, 80:20, 70:30, 60:40, 50:50 v/v), followed by raising the total soluble solids to 12° brix. Every blend from each type of fruit juice and tender coconut was subjected to organoleptic evaluation. Organoleptic score of different proportions of tender coconut and fruit juice of guava, pineapple and sweet orange is given in figure 2. Based on the organoleptic score obtained for each blend, best type of tender coconut-fruit juice blend was identified. The RTS beverage thus developed by blending tender coconut and fruit juice/ pulp added with the combination of ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) was found as the best additive from experiment 1 and it was stored for 3 months and observations on shelf life and quality parameters were noted. Tender coconut blended with guava pulp in 80:20, tender coconut and pineapple in 50:50 and tender coconut with sweet orange in 60:40 proportion was selected for storage studies.

4.2.2 Physical parameters

4.2.2.1 *Shelf life (days)*

Storage of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange under refrigerated condition prolonged the shelf life significantly (figure 3). Tender coconut RTS beverage blended with pineapple (T_2) gave significantly longer shelf life under both the storage conditions. Maximum shelf life of 40 days and 73 days was observed in T_2 (tender coconut RTS beverage blended with pineapple) under ambient and refrigerated condition respectively. The treatment T_4 (tender coconut RTS beverage without fruit juice) gave minimum shelf life of 32 days under ambient condition and 38 days under refrigerated condition.

Figure 2. Overall acceptability score of tender coconut-fruit juice blend at varying proportions



T1: 90:10

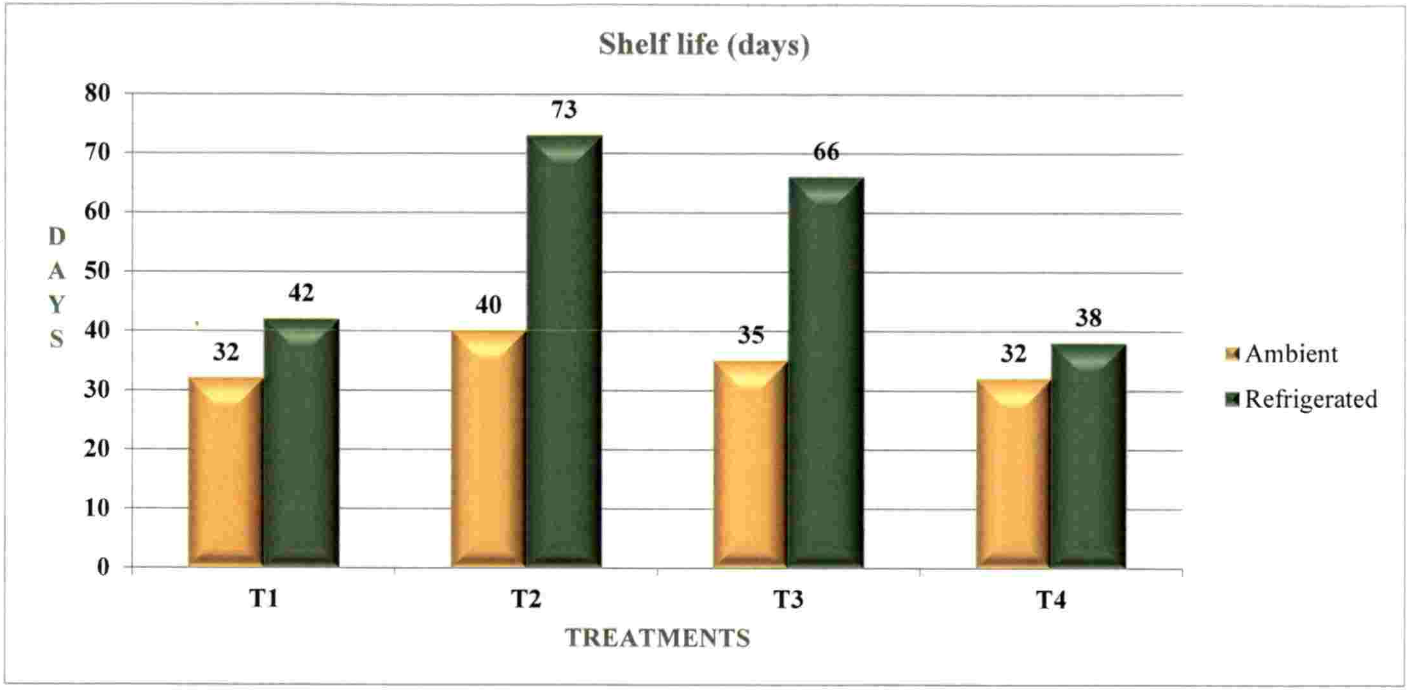
T2: 80:20

T3: 70:30

T4: 60:40

T5: 50:50

Figure 3. Effect of storage conditions on shelf life of tender coconut- fruit juice blend



T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

4.2.3 Biochemical parameters

4.2.3.1 *Total soluble solids (TSS) (°Brix)*

TSS in all four treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange increased throughout the storage period, irrespective of storage conditions (Table 11). The rate of increase in TSS was higher in all the treatments stored under ambient condition than those stored under refrigerated condition. TSS increased from 12° brix to 14.73° brix during the storage period. The highest TSS (14.63° brix) was observed in T_3 (tender coconut RTS beverage blended with sweet orange) and lowest (14.00° brix) was observed in T_1 (tender coconut RTS beverage blended with guava) 30 days after storage under ambient condition. Under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) showed highest TSS (14.23° brix) and T_1 (tender coconut RTS beverage blended with guava) and T4 (control) showed lowest TSS (13.50° brix) after 30 days of storage period. After 60 days of storage under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) showed highest (14.73° brix) under refrigerated condition.

4.2.3.2 *Titratable acidity (%)*

Titratable acidity of all treatments of tender coconut RTS beverage blended with fuit juice decreased significantly during storage period (Table 12). Tender coconut RTS beverage without fruit juice (T_4) showed lowest titratable acidity of 0.26 per cent and 0.28 per cent, 30 days after storage under ambient and refrigerated condition respectively. Highest titratable acidity (0.60 %) was observed in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage under both the storage conditions. After 60 days of storage under refrigerated condition, tender coconut RTS beverage blended with pineapple (T_2) showed lowest (0.38 %) titratable acidity.

Table 11. Effect of storage conditions on TSS (^{o} brix) of tender coconut RTS blended with fruit juice

Treatments	Initial	TSS (^{o} brix)					
		Ambient		Refrigeration (5-7^o C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	12.00	13.50	14.00	12.73	13.50	-	-
T2		14.23	14.63	12.33	14.23	14.63	14.73
T3		13.86	14.16	12.46	13.86	14.30	14.55
T4		13.51	14.10	13.33	13.50	-	-
CD		0.12	0.22	NS	NS	0.10	0.11

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 12. Effect of storage conditions on titratable acidity (%) of tender coconut RTS blended with fruit juice

Treatments	Initial	Titratable acidity (%)					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	0.52	0.48	0.40	0.49	0.47	-	-
T2	0.56	0.50	0.46	0.54	0.48	0.41	0.38
T3	0.64	0.62	0.60	0.63	0.60	0.58	0.50
T4	0.33	0.29	0.26	0.30	0.28	-	-
CD	-	0.008	0.011	0.010	0.019	0.009	0.009

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

4.2.3.3 *pH*

The pH of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange increased during the storage period irrespective of storage conditions (Table 13). The increase was significantly higher under ambient condition compared to refrigerated condition. Among the treatments, T_4 (control) showed highest pH (4.58) and T_3 (tender coconut RTS beverage blended with sweet orange) showed lowest pH (3.45) after 30 days of storage under ambient condition. Under refrigerated condition, the highest pH (4.51) was observed in T_4 (control) and lowest pH (3.44) was observed in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage. At the end of the storage (60 days after storage) under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) showed highest pH (3.74).

4.2.3.4 ***Reducing sugars (%)***

Reducing sugars in all the four treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange showed an increasing trend throughout the storage period, irrespective of storage conditions (Table 14). A highest reducing sugar content of 7.47 per cent was observed in T_3 (tender coconut RTS beverage blended with sweet orange) under ambient storage condition and tender coconut RTS beverage blended with pineapple (T_2) showed the lowest reducing sugar content of 6.31 per cent 30 days after storage under refrigerated condition. Sixty days after storage, T_3 (tender coconut RTS beverage blended with sweet orange) showed highest (7.36 %) reducing sugars under refrigerated condition.

4.2.3.5 *Non-Reducing sugars (%)*

Non reducing sugars increased during storage in all the treatments of tender coconut RTS blended with fruit juice/pulp, irrespective of storage conditions (Table

15). Highest non-reducing sugars (8.24 %) were observed in T_2 (tender coconut RTS beverage blended with pineapple) under ambient condition and lowest (6.13 %) was observed in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage under refrigerated condition. Under refrigerated condition, T_2 ((tender coconut RTS beverage blended with pineapple) showed highest (8.41 %) showed highest non-reducing sugars, 60 days after storage.

4.2.3.6 *Total sugars (%)*

Total sugars showed an increasing trend in all the treatments of tender coconut RTS beverage blended with fruit juice/ pulp of guava, pineapple and sweet orange throughout the storage period irrespective of storage conditions (Table 16). Thirty days after storage, tender coconut RTS beverage blended with pineapple (T_2) showed highest (14.58 %) total sugars under ambient condition and T_1 (tender coconut RTS beverage blended with guava) showed lowest (13.34 %) total sugars under refrigerated condition. Tender coconut RTS beverage blended with pineapple showed highest (14.58 %) total sugars, 60 days after storage under refrigerated condition.

4.2.3.7 *Vitamin C (mg 100 g^{-1})*

All the treatments of tender coconut RTS blended with fruit juice/pulp of guava, pineapple and sweet orange showed decreasing trend in vitamin C content throughout the storage period. The treatments stored under refrigerated condition showed higher amount of vitamin C compared to ambient condition (Table 17). Highest vitamin C content (47.66 mg 100 g^{-1}) was retained in T_3 (tender coconut RTS beverage blended with sweet orange), under refrigerated condition and the lowest (1.27 mg 100 g^{-1}) was retained in T_4 (control), under ambient condition, 30 days after storage. Tender coconut RTS beverage blended with sweet orange (T_3) retained highest (45.21 mg 100 g^{-1}) vitamin C content, 60 days after storage under refrigerated condition.

Table 13. Effect of storage conditions on pH of tender coconut RTS blended with fruit juice

Treatments	Initial	pH					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	3.76	3.87	3.95	3.82	3.88	-	-
T2	3.64	3.74	3.75	3.67	3.71	3.73	3.74
T3	3.37	3.41	3.45	3.40	3.44	3.48	3.51
T4	4.45	4.51	4.58	4.48	4.51	-	-
CD	-	0.025	0.039	0.032	0.025	0.032	0.058

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 14. Effect of storage conditions on reducing sugars (%) of tender coconut RTS blended with fruit juice

Treatments	Initial	Reducing sugars (%)					
		Ambient		Refrigeration (5-7^{o} C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	6.85	7.16	7.36	6.92	7.06	-	-
T2	6.28	6.42	6.55	6.29	6.31	6.32	6.37
T3	7.23	7.32	7.47	7.27	7.31	7.32	7.36
T4	6.73	6.98	7.29	6.84	6.85	-	-
CD	-	0.059	0.081	0.080	0.058	0.030	0.048

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 15. Effect of storage conditions on non-reducing sugars (%) of tender coconut RTS blended with fruit juice

Treatments	Initial	Non-reducing sugars (%)					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	6.04	6.13	6.27	6.04	6.22	-	-
T2	7.43	7.64	8.24	7.57	7.99	8.26	8.41
T3	5.87	6.03	6.27	5.97	6.13	6.24	6.30
T4	5.63	6.25	6.25	6.09	7.09	-	-
CD	-	0.139	0.175	0.077	0.147	0.308	0.069

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 16. Effect of storage conditions on total sugars (%) of tender coconut RTS blended with fruit juice

Treatments	Initial	Total sugars (%)					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	12.89	13.30	13.59	13.00	13.34	-	-
T2	13.71	14.06	14.58	13.88	14.55	14.57	14.58
T3	13.10	13.35	13.74	13.19	13.41	13.55	13.62
T4	12.36	13.23	13.54	12.95	13.90	-	-
CD	-	0.142	0.170	0.031	0.140	0.075	0.032

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 17. Effect of storage on vitamin C content (mg 100 g^{-1}) of tender coconut RTS blended with fruit juice

Treatments	Initial	Vitamin C (mg 100 g^{-1})					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	47.86	47.35	47.22	47.43	47.37	-	-
T2	44.23	44.00	43.98	44.09	43.98	42.52	40.00
T3	47.88	47.81	47.64	47.88	47.66	46.29	45.21
T4	12.83	2.00	1.27	2.23	2.00	-	-
CD	-	0.958	0.161	0.103	0.530	0.176	0.381

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

4.2.3.8 *Protein (%)*

Protein percentage significantly varied among all the treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange. The treatments of tender coconut blended with fruit juice/pulp of guava, pineapple and sweet orange stored under refrigerated condition retained higher amount of protein compared to those treatments stored under ambient condition. Tender coconut RTS beverage without any fruit juice (T_4) showed highest amount of protein (0.02 %) under refrigerated condition and lowest protein (0.001 %) content was observed in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage under ambient condition. After 60 days of storage under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) retained highest (0.004 %) protein content (Table 18).

4.2.3.9 *Non-enzymatic browning*

All the treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange showed increasing trend in non-enzymatic browning. The non-enzymatic browning varied significantly among all the treatments thoughout the storage irrespective of storage conditions (Table 19). Lowest (0.03) non-enzymatic browning was observed in T_2 (tender coconut RTS beverage blended with pineapple) under refrigerated condition and highest (0.12) in T_1 (tender coconut RTS beverage blended with guava), under ambient condition, 30 days after storage. Under refrigerated condition, both T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) showed the same non-enzymatic browing value of 0.07 at the end of the storage.

Table 18. Effect of storage conditions on protein (%) of tender coconut RTS blended with fruit juice

Treatments	Initial	Protein (%)					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	0.01	0.007	0.005	0.008	0.006	-	-
T2	0.009	0.007	0.003	0.008	0.007	0.007	0.004
T3	0.004	0.002	0.001	0.003	0.002	0.0008	0.0007
T4	0.09	0.003	0.002	0.05	0.02	-	-
CD	-	0.008	0.006	0.003	0.014	0.010	0.021

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 19. Effect of storage conditions on non-enzymatic browning of tender coconut RTS blended with fruit juice

Treatments	Initial	Non-enzymatic browning (absorbance)					
		Ambient		Refrigeration (5-7° C)			
		15 DAS	30 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	0.05	0.07	0.12	0.06	0.10	-	-
T2	0.01	0.04	0.06	0.02	0.03	0.05	0.07
T3	0.03	0.05	0.07	0.04	0.05	0.06	0.07
T4	0.07	0.09	0.11	0.08	0.09	-	-
CD	-	0.008	0.008	0.008	0.008	0.013	NS

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

4.2.3.10 *Organoleptic quality*

Organoleptic quality of all the treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange varied significantly under both the storage conditions (Table 20-26). Organoleptic quality of the tender coconut juice blend which consists of higher percentage of tender coconut decreased rapidly than those treatments containing low percentage of tender coconut. Tender coconut RTS beverage blended with pineapple (T_2) retained highest overall acceptability (7.3) after 30 days of storage under refrigerated condition and the lowest (4.0) was observed in T_4 (control) under ambient condition. After 60 days of storage under refrigerated condition, tender coconut RTS beverage blended with pineapple showed highest (7.0) over all acceptability score.

4.2.3.11 *Microbial quality*

Microbial load including bacteria, fungi and yeast) increased significantly among the treatments of tender coconut RTS blended with fruit juice/pulp of guava, pineapple and sweet orange throughout the storage period irrespective of storage conditions (Table 27-28). It was higher under ambient condition than under refrigerated condition. Bacterial load was observed in all the treatments within 15 days of storage under ambient condition. But in refrigerated condition, no microbial load was observed up to 15 days of storage. After 15 days, bacteria, fungi and yeast load was observed in all the treatments under refrigerated condition. Highest (9.33×10^5 cfu g^{-1}) bacterial load was observed in T_4 (control), 30 days after storage under ambient condition. Under refrigerated condition, bacterial load was not detected in T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) up to 30 days. After 45 days of storage period, the treatments T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) showed a bacterial load of 3.23×10^5 cfu g^{-1} and 4.21×10^5 cfu g^{-1} respectively.

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After 15 days of storage period, fungal load was observed only in T_1 (tender coconut RTS beverage blended with guava) and T_4 (control) under ambient condition. Under refrigerated condition, none of the treatments supported fungal population up to 15 days of storage. Highest (2.32×10^3 cfu g^{-1}) fungal load was observed in T_4 (control), 30 days after storage under ambient condition.

Yeast population was not observed in any of the treatments up to 15 days of storage under ambient condition. After 30 days of storage, highest yeast load (6.23×10 cfu g^{-1}) was observed in T_4 (control) under ambient condition and lowest (0.66×10 cfu g^{-1}) was in the treatments T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) under refrigerated condition

Table 20. Organoleptic quality of tender coconut RTS blended with fruit juice (Initial)

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.7	7.5	7.6	7.6	7.4	7.7	7.5	7.7
T2	7.2	7.5	7.6	7.8	5.5	6.8	7.5	7.9
T3	7.2	7.2	7.2	6.2	6.7	7.8	7.7	7.6
T4	5.5	6.6	6.3	8.0	7.7	7.5	6.6	6.0
Kendal's W test	0.569	0.306	0.394	0.248	0.532	0.478	0.333	0.731

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 21. Organoleptic quality of tender coconut RTS blended with fruit juice (15DAS) under ambient condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.5	7.3	7.4	7.4	7.2	7.5	7.4	7.3
T2	7.3	7.6	7.7	7.8	5.6	6.9	6.5	7.4
T3	7.0	7.0	7.0	6.0	6.5	7.6	7.5	7.4
T4	5.3	6.4	6.0	7.9	7.6	7.3	6.4	5.8
Kendal's W test	0.567	0.303	0.384	0.238	0.530	0.428	0.323	0.701

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 22. Organoleptic quality of tender coconut RTS blended with fruit juice (15 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.6	7.4	7.3	7.3	7.2	7.6	7.5	7.6
T2	7.4	7.7	7.8	5.9	7.0	6.6	7.2	7.4
T3	7.1	7.2	7.1	6.1	6.6	7.7	7.6	7.5
T4	5.4	6.6	6.1	8.0	7.7	7.4	6.5	5.9
Kendal's W test	0.566	0.304	0.392	0.243	0.529	0.476	0.331	0.729

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 23. Organoleptic quality of tender coconut RTS blended with fruit juice (30 DAS) under ambient condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	6.3	6.0	6.1	5.1	6.0	4.9	4.2	4.8
T2	7.3	7.4	7.6	7.8	5.6	6.9	6.5	7.3
T3	6.8	6.9	6.7	5.8	6.4	7.4	7.3	7.2
T4	5.0	6.3	5.7	5.7	6.6	4.9	4.0	4.6
Kendal's W test	0.549	0.302	0.374	0.238	0.530	0.475	0.330	0.729

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 24. Organoleptic quality of tender coconut RTS blended with fruit juice (30 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.0	7.0	7.0	6.8	6.6	4.9	7.0	4.8
T2	7.5	7.8	7.8	6.0	7.1	6.8	7.3	7.4
T3	6.9	6.9	6.8	6.0	6.5	7.5	7.5	7.4
T4	5.0	6.0	5.6	5.5	5.0	5.0	6.0	4.7
Kendal's W test	0.549	0.296	0.374	0.228	0.502	0.454	0.301	0.711

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Table 25. Organoleptic quality of tender coconut RTS blended with fruit juice (45 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T2	7.6	7.9	7.9	6.1	7.2	6.9	7.4	7.2
T3	6.7	6.7	6.5	5.5	6.0	7.0	7.0	7.0
Kendal's W test	0.306	0.307	0.307	0.312	0.331	0.347	0.333	0.331

Table 26. Organoleptic quality of tender coconut RTS blended with fruit juice (60 DAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T2	7.5	7.2	7.0	6.0	7.0	6.7	6.2	7.0
T3	6.0	6.0	6.3	5.3	5.7	6.6	6.4	6.1
Kendal's W test	0.306	0.306	0.307	0.307	0.309	0.313	0.294	0.287

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

Table 27. Microbial quality of tender coconut RTS blended with fruit juice under ambient condition

Treatments	Bcterial load(10^5 cfu g^{-1})			Fungal load (10^3 cfu g^{-1})			Yeast load (10^3 cfu g^{-1})		
	Initial	15 DAS	30 DAS	Initial	15 DAS	30 DAS	Initial	15 DAS	30 DAS
T1	ND	3.33	8.33	ND	0.33	0.33	ND	ND	4.33
T2	ND	2.66	7.33	ND	0.33	ND	ND	ND	1.33
T3	ND	2.66	7.33	ND	0.33	ND	ND	ND	2.31
T4	ND	3.66	9.33	ND	0.66	2.32	ND	ND	6.23
CD	-	NS	1.10	-	NS	0.781	-	-	1.101

DAS: Days after storage **ND**: Not detected

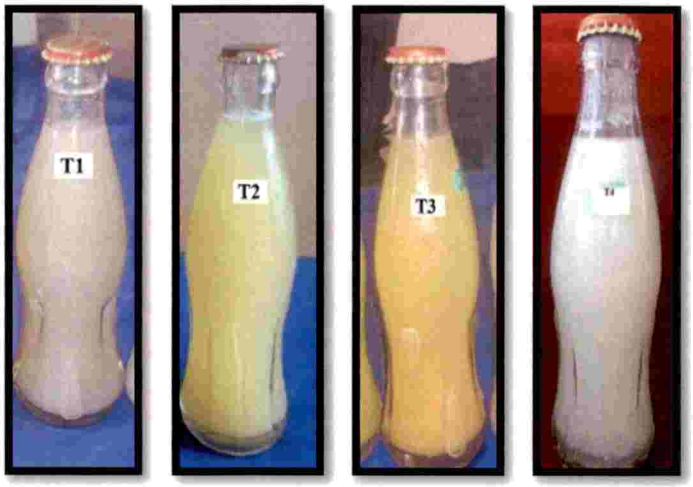
T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

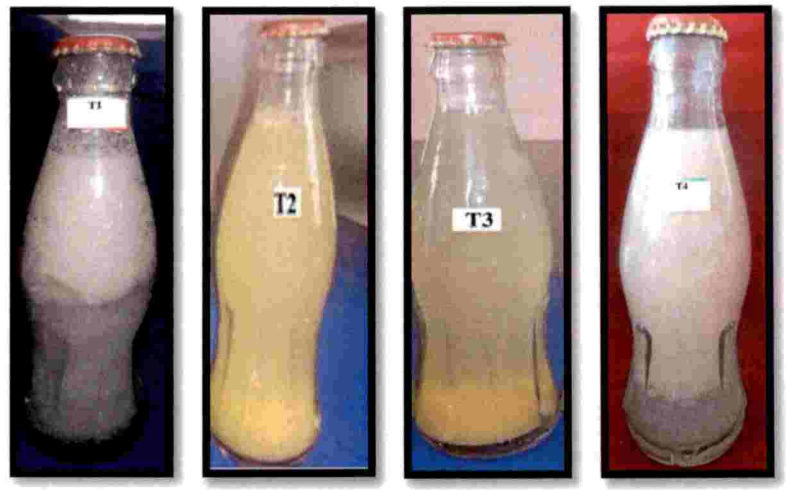
T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Plate 2. Tender coconut RTS beverage blended with fruit juice/pulp under ambient storage condition



Initial



30 DAS

DAS: Days after storage

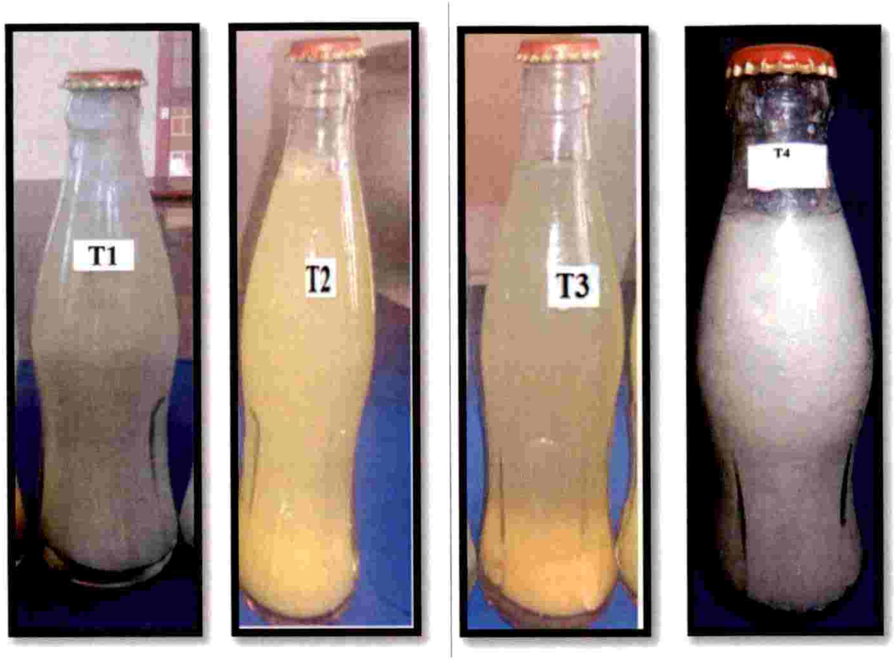
T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

Plate 3. Tender coconut RTS beverage blended with fruit juice/pulp under refrigerated storage condition



30 DAS

60 DAS

DAS: Days after storage

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without any juice blend

Table 28. Microbial quality of tender coconut RTS blended with fruit juice under refrigerated condition

Treatments	Bcterial load(10^5 cfu g^{-1})					Fungal load (10^3 cfu g^{-1})					Yeast load (10^3 cfu g^{-1})				
	Initial	15 DAS	30 DAS	45 DAS	60 DAS	Initial	15 DAS	30 DAS	45 DAS	60 DAS	Initial	15 DAS	30 DAS	45 DAS	60 DAS
T1	ND	ND	0.33	-		ND	ND	0.66	-	-	ND	ND	1.33	-	-
T2	ND	ND	ND	2.32	3.23	ND	ND	ND	0.33	0.33	ND	ND	0.66	0.66	0.66
T3	ND	ND	ND	3.33	4.21	ND	ND	ND	0.33	0.33	ND	ND	0.66	1.00	1.00
T4	ND	ND	1.00	-		ND	ND	0.66	-	-	ND	ND	1.66	-	-
CD	-	NS	NS	NS	NS	-		NS	NS	NS	-	-	NS	NS	NS

DAS: Days after storage **ND:** Not detected

T1: Tender coconut RTS beverage blended with guava

T2: Tender coconut RTS beverage blended with pineapple

T3: Tender coconut RTS beverage blended with sweet orange

T4: Tender coconut RTS beverage without fruit juice (control)

4.3 EFFECT OF JELLIFYING AGENTS ON THE QUALITY OF TENDER COCONUT JELLY

4.3.1 Standardisation of optimum concentration of different jellifying agents for the preparation of tender coconut jelly

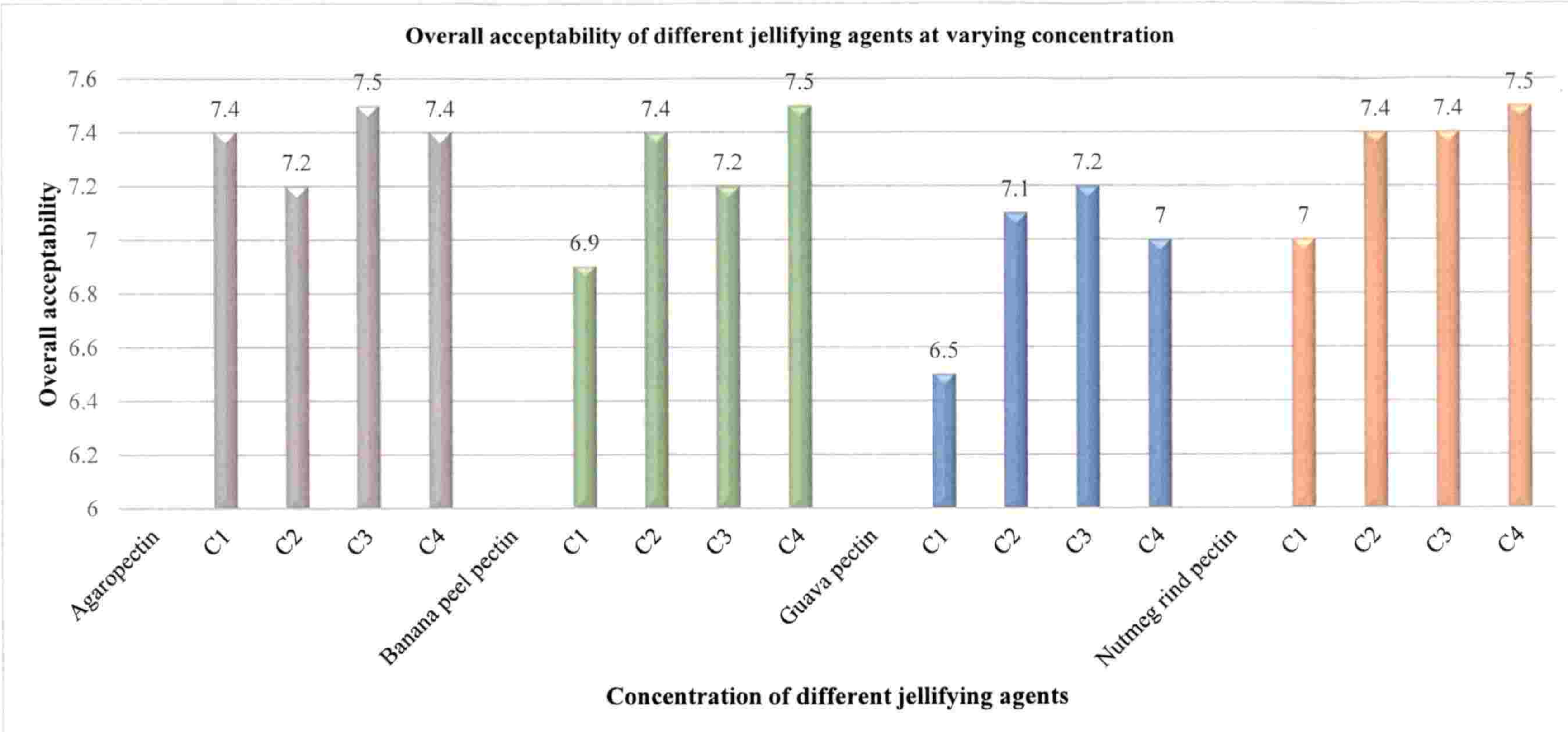
Tender coconut jelly was prepared from tender coconut by incorporating jellifying agents such as agaropectin, banana peel pectin, guava pectin and nutmeg rind pectin at different concentrations (0.5 %, 1.0 %, 1.5 % and 2.0 %). The quality of jelly thus developed was subjected to organoleptic evaluation to select best concentration of the jellifying agents. The organoleptic properties varied significantly in all the treatments of tender coconut jelly. Treatments of different concentration such as C3 (1.5 %), C4 (2.0 %), C3 (1.5 %) and C4 (2.0 %) showed highest over all acceptability score of 7.5, 7.5, 7.2 and 7.5 for the jellifying agents such as agraopectin, banana peel pectin, guava pectin and nutmeg rind pectin respectively as shown in figure 4.

4.3.2 Physical parameters

4.3.2.1 *Shelf life (days)*

Tender coconut jelly stored under refrigerated condition had prolonged shelf life than samples stored under ambient condition. Tender coconut jelly could be stored safely for 90 days under refrigerated condition (Figure 5). Minimum shelf life (70 days) was observed in the treatment where tender coconut jelly is from banana peel pectin (T_2) and maximum (86 days) was observed in T_1 (tender coconut jelly from agaropectin) under ambient condition.

Figure 4. Overall acceptability score of different jellifying agents of varying concentration



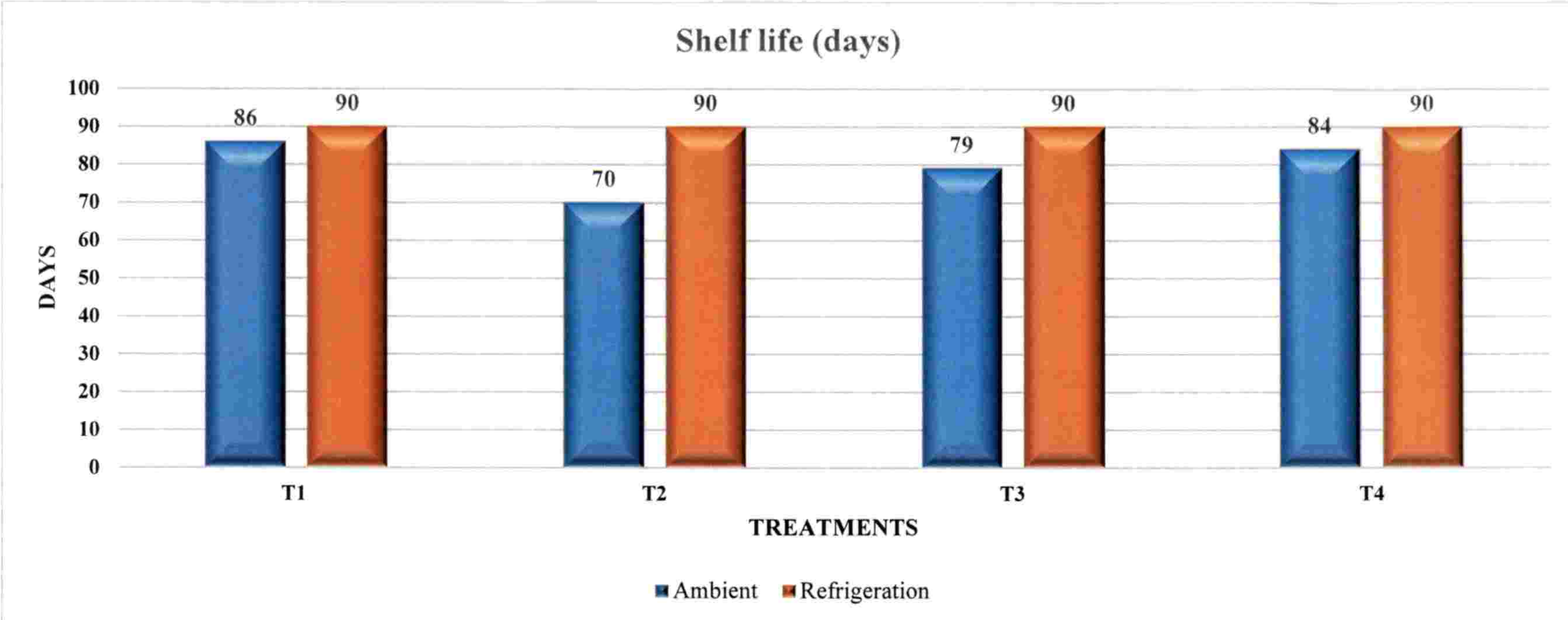
C1: 0.5 per cent

C2: 1.0 per cent

C3: 1.5 per cent

C4: 2.0 per cent

Figure 5. Effect of storage on shelf life of tender coconut jelly



T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

4.3.2.2 *Water activity*

All the samples of tender coconut jelly showed significant variation in water activity (Table 29). Samples stored under refrigerated condition showed higher increase in water activity than those treatments stored under refrigerated condition. Under ambient condition, tender coconut jelly prepared from nutmeg rind pectin (T_4) showed lowest water activity (0.74) and highest (0.78) water activity was observed in T_2 (tender coconut jelly from banana peel pectin), two months after storage. Three months after storage under refrigerated condition, T_4 (tender coconut jelly prepared from nutmeg rind pectin) showed lowest (0.75) water activity and highest was (0.80) observed in T_2 (tender coconut jelly from banana peel pectin).

4.3.3 Biochemical parameters

4.3.3.1 *Total soluble solids (TSS) (°Brix)*

TSS of all four treatments of tender coconut jelly increased significantly throughout the storage period, irrespective of storage conditions (Table 30). TSS varied from 65.41° brix to 67.38° brix. Tender coconut jelly prepared from agaropectin (T_1) showed lowest TSS (65.41° brix) and T_2 (tender coconut jelly prepared from banana peel pectin) showed highest TSS (66.25° brix), two months after storage under ambient condition. Under refrigerated condition, highest TSS (67.38° brix) was observed in T_2 (tender coconut jelly from banan peel pectin) and lowest TSS (66.06° brix) was in T_1 (tender coconut jelly prepared from agaropectin), three months after storage.

4.3.3.2 *Titratable acidity (%)*

Titratable acidity of all the treatments of tender coconut jelly decreased during storage, irrespective of storage conditions (Table 30). But the variation in titratable acidity of tender coconut jelly stored under refrigerated condition was non significant. After two months of storage, treatments T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin) showed lowest titratable acidity (0.58 %) and highest titratable acidity (0.60 %) was observed in T_1 (tender coconut jelly from agaropectin) under ambient condition. The treatments T_1 (tender coconut jelly from agaropectin), T_3 (tender coconut jelly from guava pectin) and T_4 (tender coconut jelly from nutmeg rind pectin) showed highest titratable acidity (0.64 %) and lowest titratable acidity (0.63 %) was observed in T_2 (tender coconut jelly from banana peel pectin), three months after storage under refrigerated condition.

4.3.3.3 *pH*

The pH of all treatments increased significantly throughout storage irrespective of storage condition (Table 31). Highest pH (3.69) was observed in T_1 (tender coconut jelly from agaropectin) and lowest (3.61) was observed in the treatments T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin), two months after storage under ambient condition. Under refrigerated condition, highest pH (3.68) was observed in T_1 (tender coconut jelly from agaropectin) and lowest (3.60) was in T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin), three months after storage.

4.3.3.4 *Vitamin C (mg 100 g^{-1})*

All the samples of tender coconut jelly showed significant variation in vitamin C content during storage and showed a decreasing trend during storage under both the storage conditions (Table 31). The samples stored under refrigerated condition retained higher amount of vitamin C as compared to those stored under ambient condition. Under ambient condition, T_3 (tender coconut jelly from guava pectin) showed highest (11.93 mg 100 g^{-1}) vitamin C and lowest (10.02 mg 100 g^{-1}) was observed in T_4 (control), two months after storage. Under refrigerated condition, highest vitamin C content (11.93 mg 100 g^{-1}) was observed in T_3 (tender coconut jelly from guava pectin) and lowest (10.00 mg 100 g^{-1}) was observed in T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin), three months after storage.

4.3.3.5 *Sugars*

Reducing sugars showed an increasing trend in all the treatments of tender coconut jelly throughout storage under both the storage conditions. The increase in non-reducing sugars was very high in all the treatments stored under ambient condition than refrigerated condition (Table 32). Tender coconut jelly prepared with agaropectin (T_1) showed lowest (13.66 %) reducing sugars and that prepared from guava pectin showed highest (14.54 %) reducing sugars, two months after storage under ambient condition. Under refrigerated condition, three months after storage, T_1 (tender coconut jelly prepared from agaropectin) showed lowest (13.28 %) reducing sugars and the highest (13.96 %) was observed in T_2 (tender coconut jelly from banana peel pectin).

Non-reducing sugars increased significantly in all the samples of tender coconut jelly throughout storage, irrespective of storage conditions (Table 32). Tender coconut jelly prepared from guava pectin (T_3) showed highest non-reducing sugar content (26.50 %) and lowest (25.46 %) was observed in T_4 (tender coconut jelly from nutmeg rind pectin), two months after storage under ambient condition. Under refrigerated condition, tender coconut jelly prepared from guava pectin showed highest non-reducing sugars (26.64 %) and T_2 (tender coconut jelly from banana peel pectin) showed the lowest (25.19 %), three months after storage.

Total sugars in all the treatments of tender coconut jelly increased significantly during storage irrespective of the storage conditions. The increase was high under ambient condition (Table 32). Tender coconut jelly from guava pectin (T_3) showed highest total sugars (39.56 %) and T_2 (tender coconut jelly from banana peel pectin) showed the lowest (38.01 %), two months after storage under ambient

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condition. Under refrigerated condition, lowest (38.23 %) total sugars were observed in T_1 (tender coconut jelly from agaropectin) and highest (39.55 %) was in T_3 (tender coconut jelly from guava pectin), three months after storage.

4.3.3.6 *Protein (%)*

Protein content in all the treatments showed a declining trend during the storage period, irrespective of storage conditions. Tender coconut jelly stored under refrigerated condition retained higher amount of protein compared to those under ambient condition (Table 33). Tender coconut jelly from agaropectin (T_1) retained highest (0.047 %) amount of protein and the lowest (0.040 %) was retained in T_3 (tender coconut jelly from guava pectin), two months after storage under ambient storage condition whereas under refrigerated condition, three months after storage, highest (0.047 %) protein content was observed in T_1 (tender coconut jelly from agaropectin) and lowest (0.039 %) was in T_2 (tender coconut jelly from banana peel pectin).

4.3.3.7 *Non-enzymatic browning*

All the treatments of tender coconut jelly showed an increasing trend in non-enzymatic browning. Under ambient condition, lowest non-enzymatic browning (0.10) was observed in T_1 (tender coconut jelly from agaro pectin) and highest (0.12) was observed in T_2 (tender coconut jelly from banana peel petin) and T_4 (tender coconut jelly from nutmeg rind pectin), two months after storage. Under refrigerated condition, T_1 (tender coconut jelly from agaropectin) showed lowest (0.11) and T_2 (tender coconut jelly from banana peel petin) showed highest (0.14) non-enymatic browning, three months after storage (Table 33).

LH

Table 29. Effect of storage on water activity of tender coconut jelly

Treatments	Initial	Water activity				
		Ambient		Refrigeration (5-7° C)		
		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS
T1	0.75	0.75	0.76	0.75	0.75	0.77
T2	0.76	0.76	0.78	0.76	0.77	0.80
T3	0.75	0.75	0.76	0.75	0.75	0.76
T4	0.74	0.74	0.74	0.74	0.74	0.75
CD	-	0.011	0.012	0.011	0.010	0.015

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 30. Effect of storage conditions on TSS (° brix) and titratable acidity (%) of tender coconut jelly

Treatments	Initial	TSS (° brix)					Initial	Titratable acidity (%)				
		Ambient		Refrigeration (5-7° C)				Ambient		Refrigeration (5-7° C)		
		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS
T1	65.23	65.27	65.41	65.23	65.26	66.06	0.67	0.63	0.60	0.67	0.65	0.64
T2	65.20	65.36	66.25	65.27	65.31	67.38	0.67	0.62	0.58	0.66	0.65	0.63
T3	65.33	65.37	65.85	65.35	65.44	67.23	0.67	0.63	0.59	0.66	0.65	0.64
T4	65.40	65.42	65.65	65.40	65.45	66.53	0.67	0.61	0.58	0.67	0.66	0.64
CD	-	0.021	0.033	1.63	0.112	0.064	-	0.011	0.010	NS	NS	NS

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 31. Effect of storage conditions on pH and vitamin C (mg 100 g^{-1}) of tender coconut jelly

Treatments	pH						Vitamin C (mg 100 g^{-1})					
	Initial	Ambient		Refrigeration (5-7° C)			Initial	Ambient		Refrigeration (5-7° C)		
		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS
T1	3.58	3.67	3.69	3.64	3.65	3.68	10.38	10.26	10.16	10.33	10.30	10.03
T2	3.59	3.61	3.63	3.60	3.61	3.65	10.40	10.38	10.25	10.36	10.36	10.00
T3	3.60	3.63	3.65	3.62	3.64	3.66	12.16	12.00	11.92	12.05	12.03	11.93
T4	3.58	3.61	3.63	3.60	3.62	3.65	10.15	10.08	10.02	10.75	10.02	10.00
CD	-	0.011	0.012	0.015	NS	0.008	-	0.028	0.033	1.107	0.019	0.054

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 32. Effect of storage conditions on reducing, non-reducing and total sugars (%) of tender coconut jelly

Treatments	Initial	Reducing sugars (%)					Initial	Non-reducing sugars (%)					Initial	Total sugars (%)				
		Ambient		Refrigeration (5-7° C)				Ambient		Refrigeration (5-7° C)				Ambient		Refrigeration (5-7° C)		
		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS
T1	12.45	13.46	13.66	12.48	12.68	13.28	25.51	25.61	25.67	25.52	25.55	25.58	37.96	38.27	38.34	37.99	38.03	38.23
T2	12.48	13.97	14.33	13.41	13.66	13.96	25.11	25.65	25.68	25.16	25.17	25.19	37.59	37.29	38.01	37.58	38.24	38.66
T3	12.56	13.98	14.54	13.02	13.25	13.80	26.42	26.47	26.50	26.52	26.61	26.64	38.98	39.25	39.56	38.95	39.16	39.55
T4	12.49	13.47	13.69	12.56	12.74	13.34	25.39	25.44	25.46	25.40	25.44	25.50	37.88	38.01	38.12	37.90	38.14	38.35
CD	-	0.017	0.024	0.046	0.022	0.100	-	0.055	0.045	0.109	0.130	0.184	-	0.090	0.045	0.070	0.122	0.102

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 33. Effect of storage conditions on protein (%) and non-enzymatic browning of tender coconut jelly

Treatments	Initial	Protein (%)					Initial	Non-enzymatic browning (absorbance)				
		Ambient		Refrigeration (5-7° C)				Ambient		Refrigeration (5-7° C)		
		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS
T1	0.056	0.054	0.047	0.055	0.048	0.047	0.05	0.07	0.10	0.06	0.09	0.11
T2	0.054	0.049	0.042	0.051	0.040	0.039	0.07	0.10	0.12	0.08	0.10	0.14
T3	0.054	0.050	0.040	0.050	0.042	0.040	0.06	0.08	0.11	0.07	0.09	0.12
T4	0.055	0.050	0.045	0.054	0.046	0.044	0.06	0.09	0.12	0.08	0.10	0.13
CD	-	0.001	0.002	0.001	0.003	0.003	-	NS	NS	0.006	NS	NS

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

4.3.3.8 *Organoleptic quality*

Organoleptic quality of all the treatments of tender coconut jelly varied significantly under both the storage conditions. Organoleptic quality of all the treatments decreased during storage. The deacrease in organoleptic quality of tender coconut jelly was higher under ambient condition (Table 34-39).Tender coconut jelly from nutmeg rind pectin (T_4) showed highest (7.7) over all acceptability and tender coconut jelly from banana peel pectin showed the lowest score (6.5), two months after storage under ambient condition. Under refrigerated condition, the highest (7.4) overall acceptability score was observed in T_1 (tender coconut jelly from agaropectin) and T_4 (tender coconut jelly from nutmeg rind pectin), and the lowest (6.2) was in T_2 (tender coconut jelly from banana peel pectin), three months after storage.

4.3.3.9 *Microbial load*

Variation in microbial population in all the treatments of tender coconut jelly was non significant. Bacterial population was observed in all the samples of tender coconut jelly 1 month after storage, fungal load was observed in T_2 (tender coconut jelly from banana peel pectin) and no yeast load was observed in the samples under ambient condition throughout the storage period. Under refrigerated condition, microbial load was comparatively lower than ambient storage. Bacterial load was observed in all the samples of tender coconut jelly except T_4 (tender coconut jelly from nutmeg rind pectin). Fungal and yeast load was observed only in T_2 (tender coconut from banana peel pectin). Data regarding microbial load is shown in the Table 40.

Table 34. Effect of storage on oraganoleptic quality of tender coconut jelly (Initial)

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	8.5	8.0	6.8	8.0	7.5	7.8	7.8	8.0
T2	7.7	7.7	7.0	6.2	7.0	7.5	7.1	7.4
T3	7.5	7.5	7.5	6.5	7.0	7.5	7.5	7.5
T4	8.5	7.5	7.8	7.5	7.5	8.0	7.8	8.0
Kendal's W test	0.294	0.196	0.208	0.228	0.120	0.134	0.094	0.232

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 35. Effect of storage on oraganoleptic quality of tender coconut jelly (1 MAS) under ambient condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	8.3	7.8	6.6	7.8	7.3	7.6	7.6	7.8
T2	7.5	7.5	6.8	6.3	6.8	7.3	7.0	7.3
T3	7.3	7.3	7.3	7.3	6.8	7.3	7.3	7.3
T4	8.2	7.3	7.6	7.3	7.3	7.8	7.6	7.8
Kendal's W test	0.294	0.196	0.207	0.228	0.121	0.136	0.093	0.232

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 36. Effect of storage on oraganoleptic quality of tender coconut jelly (1 MAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.9	7.8	7.6	7.5	7.5	7.6	7.2	7.8
T2	7.0	6.5	6.7	7.0	7.0	7.5	6.4	7.0
T3	7.7	8.0	7.9	7.9	7.9	7.5	7.7	7.8
T4	8.3	8.4	7.8	7.7	7.7	6.9	7.6	8.0
Kendal's W test	0.213	0.234	0.215	0.106	0.106	0.113	0.114	0.213

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 37. Effect of storage on oraganoleptic quality of tender coconut jelly (2 MAS) under ambient condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.8	7.5	7.3	7.2	7.5	7.5	7.0	7.6
T2	6.3	6.4	6.4	6.5	6.0	6.0	6.4	6.5
T3	7.2	7.0	7.0	7.1	5.6	7.0	6.6	7.0
T4	8.0	8.0	7.5	7.5	7.5	6.5	7.7	8.0
Kendal's W test	0.264	0.262	0.243	0.243	0.296	0.245	0.248	0.263

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 38. Effect of storage on oraganoleptic quality of tender coconut jelly (2 MAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	8.0	7.7	7.5	7.3	7.6	7.7	7.3	7.7
T2	6.5	6.6	6.6	6.7	6.3	6.2	6.5	6.6
T3	7.2	7.3	7.3	7.1	5.7	7.2	6.8	7.0
T4	8.2	8.2	7.7	7.6	7.6	6.8	7.5	8.0
Kendal's W test	0.265	0.263	0.255	0.253	0.300	0.286	0.294	0.298

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 39. Effect of storage on oraganoleptic quality of tender coconut jelly (3 MAS) under refrigerated condition

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.7	7.0	7.5	6.2	7.0	7.4	7.2	7.4
T2	6.5	6.8	6.5	6.0	6.5	6.4	6.0	6.2
T3	7.2	7.4	7.2	6.7	7.0	7.4	7.4	7.1
T4	7.5	7.8	7.8	6.0	7.1	6.8	7.3	7.4
Kendal's W test	0.236	0.254	0.259	0.132	0.154	0.187	0.205	0.206

MAS: Months after storage

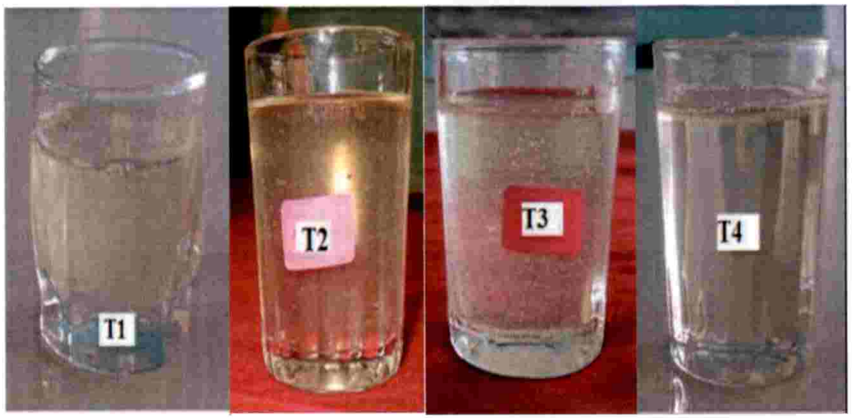
T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

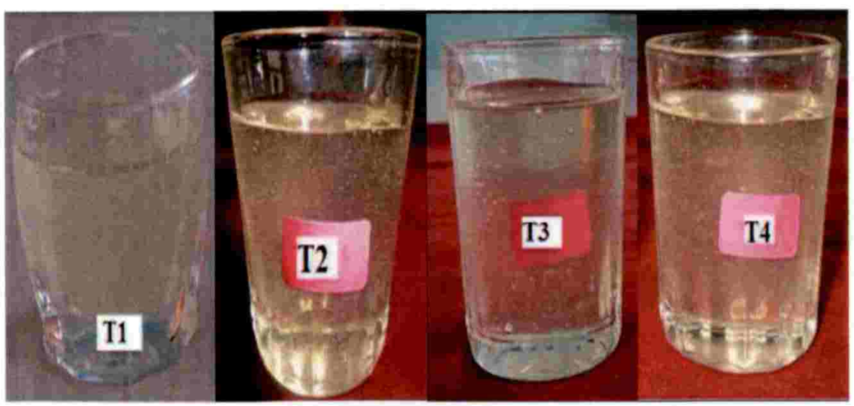
T4: Tender coconut jelly from nutmeg rind pectin

Plate 4. Effect of storage conditions on tender coconut jelly



Initial

2 MAS (Ambient)



3 MAS (Refrigeration)

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Table 40. Effect of storage on microbial quality of tender coconut jelly

Treatments	Initial	Bacterial load (10^5 cfu g^{-1})					Initial	Fungal load (13^5 cfu g^{-1})					Initial	Yeast load (10^3 cfu g^{-1})				
		Ambient		Refrigeration (5-7° C)				Ambient		Refrigeration (5-7° C)				Ambient		Refrigeration (5-7° C)		
		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS		1 MAS	2 MAS	1 MAS	2 MAS	3 MAS
T1	ND	ND	1.31	ND	ND	1.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T2	ND	ND	1.65	ND	ND	1.33	ND	ND	0.67	ND	ND	0.68	ND	ND	ND	ND	ND	0.63
T3	ND	ND	0.66	ND	ND	0.32	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T4	ND	ND	0.32	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CD	-	-	NS	-	-	0.78	-	-	NS	-	-	NS	-	-	-	-	-	-

MAS: Months after storage

T1: Tender coconut jelly from agaropectin

T2: Tender coconut jelly from banana peel pectin

T3: Tender coconut jelly from guava pectin

T4: Tender coconut jelly from nutmeg rind pectin

Discussion

5. DISCUSSION

Coconut palm (*Cocos nucifera* L.) is one of the most useful tropical trees valued for its economic and social importance. The palm provides many raw materials for the production of an array of value added and processed products of commercial importance. The immature nut known as tender coconut, contains a sterile liquid which is the endosperm. It is used to treat dehydration, especially for people suffering from diarrhoea. It reduces blood pressure and is hepatoprotective in nature. Based on the compositional and functional properties, it is also considered as a sports beverage and therefore, has drawn the attention of manufacturers and industries. But high perishability of tender coconut water limits its popularization in the commercial sector. When exposed to air, it develops a sour and unpleasant flavour. Its natural freshness is lost within 24 to 36 h unless treated scientifically.

Eventhough the information on value addition and product diversification of tender coconut is scanty popularization of tender coconut consumption has great scope in India. Hence to popularize tender coconut based value added products by overcoming the limitations associated with its processing, a study on 'Development of novel value added products from tender coconut (*Cocos nucifera* L.)' was carried out in the Dept. of Post Harvest Technology, College of Horticulture, Vellanikkara with the main objective to develop novel value added products from tender coconut and to evaluate their quality and shelf life during storage.

The discussion pertaining to the study is presented under the following heads.

5.1 Effect of food additives on quality of tender coconut RTS beverage

5.2 Effect of blending fruit juice on quality of tender coconut based RTS beverage

5.3 Effect of jellifying agents on the quality of tender coconut jelly

5.1 EFFECT OF FOOD ADDITIVES ON QUALITY OF TENDER COCONUT RTS BEVERAGE

Tender coconut water owing to its inherent characteristics, undergoes rapid biochemical and microbial changes, resulting in an unpleasant and non-palatable drink. Efforts to process tender coconut water in the bottled or packaged form has not met with much success, owing to considerable loss in its natural flavour. Therefore, an attempt is being made to prepare fresh tender coconut RTS beverage added with a combination of food additives and also to evaluate its quality and shelf life during storage. For that, fresh tender coconut of about 7 months maturity (cv.COD) was procured from various localities of Thrissur, Kerala. The collected tender coconut was washed in plain tap water, followed by surface sanitization with chlorine (100 ppm) for 15 minutes. The endosperm (water, along with the soft kernel) was extracted from the nuts, followed by grinding to obtain a smooth and fine liquid. The total soluble solids of this liquid was raised to 12° Brix. After adjustment of TSS, the liquid was added with ascorbic or malic acid (100 ppm) in combination with one of the three preservatives (potassium metabisulphite, sodium benzoate and potassium sorbate) at a concentration of 100 ppm and was filled into 200 ml bottles, followed by crown corking. The RTS beverage thus prepared was finally pasteurized at a temperature of 85°C for 15 minutes. The pasteurized tender coconut RTS beverage was stored for 3 months under ambient and refrigerated conditions. Observations on the physical and biochemical parameters of tender coconut RTS beverage were recorded.

5.1.1 Physical parameters

5.1.1.1 *Shelf life (days)*

The shelf life of tender coconut RTS beverage stored under ambient and refrigerated conditions varied significantly. The RTS beverage stored under refrigerated condition gave significantly longer shelf life as compared to samples under ambient condition. Attri *et al.* (1999) reported that tender coconut water can be kept fresh without any adverse effect for two months at low temperature (3-4° C) and at ambient temperature (25 -30° C) it was found to ferment after 8 to 10 hours. The tender coconut RTS had minimum two months of shelf life period based on physicochemical and microbial parameters (Omeka *et al.,* 2017).

The treatment T_7 (tender coconut RTS without any additives) gave a minimum shelf life of 16 days and 38 days at ambient and refrigerated conditions respectively. The treatment T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) gave the maximum shelf life of 25 days and 50 days under ambient and refrigerated conditions respectively. Attri *et al.* (1999) also confirmed that the shelf life of tender coconut water was increased by preservation with the help of KMS @ 600 ppm but for consumption the preserved water had to be heated upto boiling point to remove excess SO_2 present in water. Mahnot *et al.* (2014) also reported that tender coconut water sterilized by non thermal microfiltration technique could be stored for 46 days in glass and plastic bottles in refrigerated condition with acceptable sensory results on addition of L-ascorbic acid, citric acid and L-cysteine.

5.1.2 Biochemical parameters

5.1.2.1 *Total soluble solids (TSS) (^{0} Brix)*

TSS in all the treatments of tender coconut RTS beverage increased throughout the storage period, irrespective of storage conditions. Increase in TSS of any beverages may be due to the inversion of sugars in the product as reported by Potter (1996). According to Sindhumathi and Amutha (2015), increase in TSS might be due to the solubilization of insoluble portion of the products due to presence of acids.

Tender coconut RTS beverage under ambient condition showed higher rate of increase compared to those stored under refrigerated condition. But the increase in

TSS of tender coconut RTS beverage throughout the storage period was not significant. The increase in TSS of tender coconut RTS beverage under ambient condition may be due to the higher rate of inversion of sugars at higher temperature as compared to refrigerated storage.

5.1.2.2 *Titratable acidity (%)*

Titratable acidity of tender coconut RTS beverage decreased during storage. However, food additives and storage conditions did not have any significant effect on titratable acidity of tender coconut RTS beverage. Decline in acidity may be due to the inversion of complex sugars into simple sugars. Non significant variation of titratable acidity was observed in all the treatments of tender coconut fruit based RTS beverage. Hemalatha *et al.* (2018) also reported that the acidity of RTS beverages decreased with increase in storage duration and observed that the decrease in acidity might be due to the acidic hydrolysis of the polysaccharides, where the acid is utilized for converting non-reducing sugars into reducing sugars.

5.1.2.3 pH

An increasing trend in pH was observed in all the treatments of tender coconut RTS beverage. Under ambient condition, tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium sorbate (100 ppm) (T_3) showed highest pH (4.66) whereas the treatment T_7 (control) showed the lowest pH of 4.47, 15 days after storage. The treatment T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) showed the highest (4.87) and lowest (4.52) pH was observed in T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate (100 ppm), 45 days after storage under refrigerated condition. Increase in pH of tender coconut RTS beverage may be due to decline in titratable acidity of the product, which was higher under ambient condition than under refrigerated storage. Jackson *et al.* (2004) reported that bottled tender coconut water in Sri Lanka which is called Penipol or candied coconut has a pH of 5.5 which extends its shelf life. Omeka *et al.* (2017) reported that after 21 days of storage period, pH of tender coconut based RTS beverage increased from 4.40 to 4.51.

5.1.2.4 *Vitamin- C (mg 100g^{-1})*

Ascorbic acid content in all the treatments of tender coconut RTS beverage decreased significantly throughout the storage period, irrespective of storage conditions. This is due to the fact that ascorbic acid being sensitive to oxygen, light and heat was easily oxidized in presence of oxygen by both enzymatic and non-enzymatic catalyst. RTS beverage stored under refrigerated condition retained higher amount of ascorbic acid as compared to those under ambient condition. Sanganamoni *et al.* (2017) reported that the loss of ascorbic acid in tender coconut RTS bebverage was higher at higher processing temperature and longer duration. After 15 days of storage under ambient condition, T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) showed highest ascorbic acid (53.00 mg 100g^{-1}) and 45 days after storage under refrigerated condition, the same treatment retained highest (52.98 mg 100g^{-1}) amount of vitamin C.

5.1.2.5 *Sugars (%)*

Sugar content in all the treatments of tender coconut RTS beverage increased during storage, irrespective of storage conditions. This is due to the breakdown of complex polysaccharides into monosacharides. Silva and Bamunuarachchi (2009) reported that pasteurized carbonated tender coconut water contained 21.05 per cent reducing sugars and 46.79 per cent total sugars. Purkayastha *et al.* (2012) reported that total sugars in microfiltered tender coconut water increased from first day to seventh day of its storage.

5.1.2.6 *Protein (%)*

A decreasing trend in protein content was observed in all the treatments of tender coconut RTS beverage, irrespective of storage condition. Kulkarni and Aradhya, (2005) reported that the protein concentration showed a gradual decrease in

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all the microfiltered samples of tender coconut water added with ascorbic acid packed in glass bottles and stated that the decrease may be due to formation of complexes with other compounds like phenols forming phenol- protein complex in addition to the break down of proteins, which normally occurs in beverages during storage.

The loss of protein during storage period was higher under ambient condition. The treatment T_1 (Tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) showed the highest (0.071 %) and the treatment T_7 (control) showed lowest (0.030 %) protein content, 15 days after storage under ambient condition. Under refrigerated condition, the highest (0.053 %) protein content was observed in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and the lowest (0.012 %) in T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm), after 45 days of storage period. Silva and Bamunuarachchi (2009) reported that pasteurized carbonated tender coconut water had a protein content of 0.0118 per cent.

5.1.2.7 *Non-enzymatic browning*

Non-enzymatic browning of tender coconut RTS beverage increased during the storage period. Under ambient condition, lowest non-enzymatic browning (0.01) was observed in four treatments where tender coconut RTS beverage was added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm), tender coconut RTS beverage added with ascorbic acid (100 ppm) and sodium benzoate (100 ppm), tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium sorbate (100 ppm) and tender coconut added with malic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1, T_2, T_3 and T_4) and the highest (0.05) non-enzymatic browning was observed in control where tender coconut RTS was stored as such, 15 days after storage. After 45 days of storage under refrigerated condition, tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm) (T_6) showed highest (0.07) non-enymatic browning and the lowest

(0.03) was observed in treatments T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and T_4 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm).

Lowest browning in tender coconut RTS beverage added with ascorbic acid and potassium metabisulphite may be due to the anti-oxidant activity of these additives in preventing the formation of brown pigments. Storage at low temperature may have reduced the rate of browning under refrigerated storage. Prades *et al.* (2011) reported that browning in fresh cut tender coconut could be overcome by immersing in sodium metabisulphite at a concentration of about 2g/l for 5 to 10 minutes. Bhardwaj and Nandal (2014) reported that low temperature lead to a decline in the enzymatic and non-enzymatic browning reaction in blended Kinnow juice in presence of KMS.

5.1.2.8 *Organoleptic quality*

Data on mean sensory scores of tender coconut RTS beverage initialy, 15 days after storge under both ambient and refrigerated conditions, 30 days and 45 days after storage under refrigerated condition are presented in table 5, 6, 7, 8 and 9 respectively. Sensory quality of tender coconut RTS beverage declined during storage in all the treatments. The loss of sensory quality was higher under ambient condition. Tender coconut RTS added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) (T_1) showed highest overall acceptability score of 8.00, 15 days after storage under ambient condition whereas overall acceptability score was highest (7.4) in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and lowest (4.9) in T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate (100 ppm) and T_6 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium sorbate (100 ppm) 45 days after storage under refrigerated condition.

Adubofuor *et al.* (2016) reported that fresh unpasteurized coconut water was preferred over pasteurized samples of tender coconut water. Heating caused caramelization of the sugars which induced a cloudy appearance of the coconut water. Also, Maillard reactions were initiated during the heating process which also contributed to the cloudy or opaque nature of the pasteurized samples. These reactions also altered the colour, aroma, aftertaste and mouthfeel of coconut water.

5.1.2.9 *Microbial load*

Bacteria was predominant among the microbial population and the microbial load was higher in all the treatments under ambient condition compared to those under refrigerated condition. Leite *et al.* (2000) reported that refrigeration prolonged the lag-time but did not inhibit growth of bacteria in fresh tender coconut water and temperature abuse could considerably increase the level of potential hazards.

Under ambient condition, bacteria and yeast population was observed in all the treatments of tender coconut RTS beverage and fungi were absent in the treatments T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and T_5 (tender coconut RTS beverage added with malic acid (100 ppm) and sodium benzoate (100 ppm) 15 days after storage. Lowest bacterial load was observed in T_1 (tender coconut RTS beverage added with ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) and lowest fungal load (0.33×10^3 cfu g^{-1}) was in T_4 (tender coconut RTS beverage added with malic acid (100 ppm) and potassium metabisulphite (100 ppm), 15 days after storage under ambient condition. Melo *et al.* (2003) detected *Escherichia coli* and *Salmonella* spp. in fresh coconut water stored under refrigeration and populations of up to 1.6×10^5 cfu ml^{-1} of *Bacillus cereus* and 8.0×10^4 cfu ml^{-1} of *Staphylococcus aureus* were also found. Jayanti *et al.* (2008) observed that HT/ST treatment of canned coconut water eliminated the delicate flavour along with the microbes. Akhtar *et al.* (2009) reported lower microbial growth due to KMS treatment.

5.2 EFFECT OF BLENDING FRUIT JUICE ON QUALITY OF TENDER COCONUT BASED RTS BEVERAGE

5.2.1 Standardisation of best type of blend from each type of fruit juice and tender coconut

Every blend from each type of tender coconut-fruit juice at different proportions (90:10, 80:20, 70:30, 60:40, 50:50 v/v) was subjected to organoleptic evaluation and best type was identified based on the organoleptic score obtained for each blend. Then a combination of ascorbic acid (100 ppm) and potassium metabisulphite (100 ppm) which was found as the best additives from experiment 1 was added to the best blend. Tender coconut blended with guava pulp in 80:20, tender coconut and pineapple in 50:50 and tender coconut with sweet orange in 60:40 proportion were identified as best and selected for storage studies.

Illiaskutty *et al.* (2002) reported that 25-33 per cent pineapple juice could be incorporated in the tender coconut water without affecting the quality and acceptability of the tender coconut water beverages. Work done by Islam *et al.* (2014) also showed that fruit juice blend prepared with 50 per cent guava pulp and 50 per cent pineapple juice improved the drink quality.

5.2.2 Physical parameters

5.2.2.1 *Shelf life (days)*

Storage of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange under refrigerated condition prolonged the shelf life significantly. Tender coconut RTS beverage blended with pineapple (T_2) had significantly longer shelf life under both the storage conditions. Longest shelf life of 40 days and 73 days was observed in T_2 (tender coconut RTS beverage blended with pineapple) under ambient and refrigerated conditions respectively. The treatment T_4 (tender coconut RTS beverage without fruit juice) recorded the lowest shelf life of 32 days under ambient condition and 38 days under refrigerated condition. This observation is in confirmation with the result of another study conducted by Illiaskutty (2004) who reported that all the beverages prepared from tender coconut water stayed well in refrigerated conditions than ambient. Among that, pineapple and lemon blended beverages stayed well both in glass and retort pouches throughout the storage period of two months.

5.2.3 Biochemical parameters

5.2.3.1 *Total soluble solids (TSS) (°Brix)*

When the tender coconut RTS beverage was blended with fruit juice/pulp of guava, pineapple and sweet orange, the TSS was found to increase throughout the storage period irrespective of the storage conditions. Increase in TSS may be due to solubilization of complex sugars into simple ones which was higher under ambient condition. The rate of increase in TSS was higher in all the treatments under ambient condition than those stored under refrigerated condition. Deka and Sethi (2001) found an increasing trend in total soluble solids in juice blends during storage at ambient and low temperature in lime-aonla and mango-pineapple spiced RTS beverages. Illiaskutty *et al.* (2004) also reported similar findings in tender coconut water-fruit juice blended beverages.

TSS increased from 12° brix to 14.73° brix during the storage period. The highest TSS (14.63° brix) was observed in T_3 (tender coconut RTS beverage blended with sweet orange) and lowest (14.00° brix) was observed in T_1 (Tender coconut RTS beverage blended with guava), 30 days after storage under ambient condition. Under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) showed highest TSS (14.23° brix) and T_1 (tender coconut RTS beverage blended with guava) and T_4 (control) showed lowest TSS (13.50° brix) after 30 days of storage period. Guava pulp stored at different temperatures showed an increasing trend in total soluble solids within forty-five days of storage (Kalra and Revath, 1981). Citrus

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fruit juice when stored at room temperature showed increase in TSS as reported by Mehta and Bajaj (1983). Illiaskutty (2004) observed that total soluble solids was highest (14.64 %) in lemon blended tender coconut RTS beverage followed by pineapple blended (12.45 %) and acidulant blended tender coconut water RTS beverage (6.43 %). Kathiravan *et al.* (2014) reported that the total soluble solids (°brix) of thermally pasteurized tender coconut water-nannari blended beverage is 8.90 and it was higher than the tender coconut water beverage (8.00) and there was no significant change in the TSS of tender coconut water- nannari blended beverage with pulsed electric field processing and also reported that initial TSS of the spiced tender coconut water RTS beverages had 11.0° brix under both ambient and refrigerated temperatures. Then the brix value increased to 13.00 in room temperature and 12.00 in refrigerated temperature during storage. After 60 days of storage under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) showed highest (14.73 ° brix) under refrigerated condition. Increase in TSS might be due to the solubilization of insoluble portion of the products due to presence of acids (Sindhumathi and Amutha, 2015)

5.2.3.2 *Titratable acidity (%)*

Titratable acidity of all treatments of tender coconut RTS beverage blended with fuit juice decreased significantly during storage period. The decrease in titratable acidity may be due to the conversion of complex sugars into simple ones which was higher under ambient condition. Tender coconut RTS beverage without fruit juice (T_4) showed lowest titratable acidity of 0.26 per cent and 0.28 per cent, 30 days after storage under ambient and refrigerated condition respectively. Highest titratable acidity (0.60 %) was observed in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage under both the storage conditions. After 60 days of storage under refrigerated condition, tender coconut RTS beverage blended with pineapple (T_2) showed lowest (0.38 %) titratable acidity. Kathiravan *et al.* (2014)

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reported that the decrease in titratable acidity of tender coconut water-nannari blended beverage during storage was related to the increase found in pH.

Kalra *et al.* (1991) noticed that beverages made from the blend of commercial mango cultivars and papaya blends showed negligible changes in titrable acidity. Illiaskutty (2004) recorded the lowest acidity (0.16 %) in tender coconut water RTS and highest in lemon blended coconut RTS (0.20 %), 2 months after storage. Akusu *et al.* (2016) reported that the titratable acidity of juices decreased at increased pH value and also reported that orange juice had the highest titratable acidity (1.27 %) and pineapple juice with lowest value of 0.47 per cent. Islam *et al.* (2014) also found in pineapple and orange juice blend gradual decrease in titratable acidity and vitamin-C along the storage period and increment of TSS and progressiveness of pH during storage period.

5.2.3.3 *pH*

The pH of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange increased during the storage period irrespective of storage conditions. The increase was higher under ambient condition compared to refrigerated condition. Among the treatments, T_4 (control) showed highest pH (4.58) and T_3 (tender coconut RTS beverage blended with sweet orange) showed lowest pH (3.45) after 30 days of storage under ambient condition. Under refrigerated condition, the highest pH (4.51) was observed in T_4 (control) and the lowest (3.44) was in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage. At the end of the storage (60 days after storage) under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) showed highest (3.74) pH. Chouhan *et al.* (2012) observed that the pH values of coconut water lemon blended RTS beverage ranged from 4.36 to 4.78 among various experimental conditions and addition of lemon juice significantly decreased the pH of the beverage. Akusu *et al.* (2016) reported that the pH of the juice blend prepared from juice of orange, carrot and pineapple at different proportions ranged between 3.50 and 3.97.

5.2.3.4 *Sugars (%)*

Sugar content (reducing, non-reducing and total sugars) in all the four treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange showed an increasing trend throughout the storage period, irrespective of storage conditions. The increase was higher under ambient condition than refrigerated condition. Sindhumathi and Amutha (2015) found that reducing sugars of spiced tender coconut water RTS increased gradually during storage and the increase in reducing sugar content of the sample stored at refrigeration temperature was slightly lesser than the sample stored at room temperature. Highest reducing sugar content of 7.47 per cent was observed in T_3 (tender coconut RTS beverage blended with sweet orange) under ambient storage condition and tender coconut RTS beverage blended with pineapple (T_2) showed the lowest reducing sugar content of 6.31 per cent, 30 days after storage under refrigerated condition. Sixty days after storage, T_3 (tender coconut RTS beverage blended with sweet orange) showed highest (7.36 %) reducing sugars under refrigerated condition. Illiaskutty (2004) reported that reducing sugar content highest (9.16 %) in the beverage blended with lemon and lowest for tender coconut water (4.69 %). There was continuous increase in the values of reducing sugars (4.8 to 11.5 %) in the RTS beverage prepared from pineapple and guava blends during three months of storage (Oyeleke *et al.,* 2013). The accumulation of reducing sugars was reported to be more in sulphur dioxide or KMS preserved fruit juice which could be attributed to acid induced hydrolysis of polysaccharides and disaccharides into monosaccharides due to formation of sulphurous acid (Pareek *et al.,* 2015).

Highest non-reducing sugars (8.24 %) were observed in T_2 (tender coconut RTS beverage blended with pineapple) under ambient condition and lowest (6.31 %) in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage under refrigerated condition. Under refrigerated condition, T_2 (tender coconut

RTS beverage blended with pineapple) registerd highest value (8.41 %), 60 days after storage.

Tender coconut RTS beverage blended with pineapple (T_2) recorded highest (14.58 %) total sugars under ambient condition, 30 days after storage and T1 (tender coconut RTS beverage blended with guava) showed lowest (13.34 %) total sugars under refrigerated condition 30 days after storage. Tender coconut RTS beverage blended with pineapple showed highest (14.58 %) total sugars, 60 days after storage under refrigerated condition. Illiaskutty (2004) reported that the RTS beverage prepared from tender coconut water added with pineapple juice, lime juice and acidulant in which highest total sugar was recorded in pineapple blended RTS beverage (14.42 %) followed by lemon blended (12.16 %). According to Jain *et al.* (1988), the increase in total sugar could be attributed to the gradual inversion of non reducing sugar. In support of the above findings, Metha and Bajaj (1983) observed an increase in total sugar in the range of 5.89 - 12.11 percent in citrus juices stored for 8 months at ambient temperature. Islam *et al.* (2014) reported that the total sugar content of the guava-pineapple blended RTS beverage increased gradually from 6.47 to 8.88 per cent with increment of pineapple juice from initial stage. Similar results were reported by Sindumathi and Premalatha (2013) in papaya and pineapple juice.

5.2.3.7 *Vitamin C (mg 100 g^{-1})*

All the treatments of tender coconut RTS blended with fruit juice/pulp of guava, pineapple and sweet orange showed significant variation in vitamin C content throughout the storage period. The treatments of tender coconut RTS blended with fruit juice/pulp of guava, pineapple and sweet orange stored under refrigerated condition showed higher amount of vitamin C compared to ambient condition. The vitamin C content of all the treatments decreased during storage. Loss of vitamin C content could be due to thermal degradation during processing and subsequent oxidation during storage period as it is highly sensitive to heat, oxidation and light

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(Brock *et al.,* 1998). In thermally preserved fruit juices anaerobic degradation of ascorbic acid takes place during storage (Solomon *et al.,* 1995).

After 30 days of storage, highest vitamin C (47.66 mg 100 g^{-1}) was retained in T_3 (tender coconut RTS beverage blended with sweet orange), under refrigerated condition and the lowest (1.27 mg 100 g^{-1}) in T_4 (control), under ambient condition. Tender coconut RTS beverage blended with sweet orange (T_3) retained highest (45.21 mg 100 g^{-1}) vitamin C content, 60 days after storage under refrigerated condition. The highest vitamins C content was observed in lemon blended tender coconut RTS (10.63 mg 100 g^{-1}) though the level was not appreciable (Illiaskutty, 2004). These findings are in conformity with those of Singh *et al.* (2007), who reported that there was decrease in ascorbic acid of guava and pineapple beverages during storage period. The changes in ascorbic acid were found to be more in the samples stored at higher temperatures compared to the samples at low temperature, which is in agreement with the studies conducted by Chauhan *et al.* (2008) where pomegranate juice was blended with tender coconut water for making beverage. Sindhumathi and Amutha (2015) observed that the vitamin C content of tender coconut spice blended beverage reduced from an initial value of 1.98 mg 100 g^{-1} to 1.75 mg 100 g^{-1} in room temperature and 1.86 mg 100 g^{-1} in refrigerated temperature, which may be due to the effect of storage temperature and catalytic activity of fructose in the catabolization of vitamin C. Bhardwaj and Mukherjee (2012) reported the maximum retention of ascorbic acid (28.4 mg 100 ml^{-1}) was in kinnow juice blend and also stated that comparatively lower loss of ascorbic acid was observed in juice samples preserved with higher concentration (750 ppm) of KMS since higher concentration of KMS reduced oxidation of ascorbic acid during storage for longer time. Islam *et al.* (2014) also found that in pineapple and orange juice blend, a decrease in titratable acidity and vitamin-C in the storage period and increment of TSS and progressiveness of pH during storage period. Carvalho *et al.* (2007) reported a decreasing trend in vitamin C content in cashew apple juice blended with coconut water during storage.

4.1.2.8 *Protein (%)*

Protein percentage varied among the treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange. The treatments of tender coconut blended with fruit juice/pulp of guava, pineapple and sweet orange stored under refrigerated condition retained higher amount of protein compared to those stored under ambient condition. Tender coconut RTS beverage without any fruit juice (T_4) showed highest amount (0.02 %) of protein under refrigerated condition and lowest (0.002 %) was observed in T_3 (tender coconut RTS beverage blended with sweet orange), 30 days after storage under ambient condition. After 60 days of storage under refrigerated condition, T_2 (tender coconut RTS beverage blended with pineapple) retained highest (0.004 %) protein content. The protein values obtained in the study were comparable to values obtained in orange juice blended RTS beverages (Tasnim, 2010). Owolade and Arueya (2016) reported that protein content of beetroot-pineapple blend was very low (0.12 %) and it was significantly lower than 100 per cent pineapple juice.

4.1.2.9 *Non-enzymatic browning*

All the treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange showed increasing trend in non-enzymatic browning. The non-enzymatic browning varied significantly among all the treatments thoughout the storage irrespective of storage conditions. Browning of fruit juice during storage is the result of non-enzymatic chemical reaction between amino acids and reducing sugars called as Maillard reaction (Lorenzo and Morales, 2010).

Non-enzymatic browning was lowest (0.02) when tender coconut beverage was blended with pineapple (T_2) and stored under refrigerated condition, and it was highest (0.12) when guava was used for blending and stored for 30 days under ambient condition. Under refrigerated condition, both T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) showed the same non-enzymatic browing value of 0.07. Saini *et al.*

(2000) reported that upto 83.33 per cent browning in mango pulp can be reduced by the application of potassium meta-bi-sulphite. Bhardwaj (2013) reported a linear increase in non-enzymatic browning during storage of blended juice of Kinnow for 6 months.

5.2.3.10 *Organoleptic quality*

Organoleptic quality of all the treatments of tender coconut RTS beverage blended with fruit juice/pulp of guava, pineapple and sweet orange varied significantly under both the storage conditions (Table 14-20). Organoleptic quality of the tender coconut juice blend which consists of higher percentage of tender coconut decreased rapidly than those treatments containing low percentage of tender coconut. Tender coconut RTS beverage blended with pineapple (T_2) retained highest overall acceptability (7.3) after 30 days of storage under refrigerated condition and the lowest (4.0) was observed in control (T_4) under ambient condition. After 60 days of storage under refrigerated condition, tender coconut RTS beverage blended with pineapple showed highest (7.0) over all acceptability score. Jan and Masih (2012) reported that the highest sensory score (8.0) was obtained with maximum (60 %) incorporation of pineapple juice in the pineapple-carrot-orange juice blend.

Refrigerated beverages scored better as compared to beverages kept at room temperature. This observation was confirmed with the findings of Raju *et al.* (2003) who reported that beverages kept well at refrigerated condition than room temperature (28-30° C) and colour of the pineapple and lemon blended beverages were more appealing in glass containers stored under refrigerated condition. Illiaskutty (2004) reported that mean score for overall acceptability was highest in pineapple blended tender coconut RTS beverage (4.4), followed by lemon blended beverage (4.3), acidulant blended beverage (3.9) and that the taste attribute scores of tender coconut RTS beverage blended with fruit juice of pineapple and lemon was found to decline during storage bringing undesirable taste towards the end of shelf life. This may be due to the fact that the fruit drinks are inherently susceptible to spoilage by fermentative microorganisms during storage, which bring about deteriorative changes in the taste attribute. Taking into account of the overall acceptability of the beverages, pineapple blended coconut beverage was adjudged to be the best with respect to sensory attributes. Spiced tender coconut water stored in glass bottle at room and refrigerated temperature had an overall acceptability score of 9.00 and the product was acceptable upto 12 months at refrigerated temperature and up to 10 months at room temperature (Sindhumathi and Amutha, 2015).

4.1.2.11 ***Microbial load***

Microbial load including bacteria, fungi and yeast increased in the samples of tender coconut RTS blended with fruit juice/pulp of guava, pineapple and sweet orange throughout the storage period irrespective of storage conditions. It was higher under ambient condition than under refrigerated condition. Bacterial load was observed in all the treatments within 15 days of storage under ambient condition. But in refrigerated condition, no microbial load was observed up to 15 days of storage. After 15 days, bacteria, fungi and yeast population was observed in all the treatments under refrigerated condition. Under refrigerated condition, bacterial population was not detected in T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) up to 30 days. After 45 days of storage period, the treatments T_2 (tender coconut RTS beverage blended with pineapple) and T_3 (tender coconut RTS beverage blended with sweet orange) showed a bacterial load of 3.23×10^5 cfu g^{-1} and 4.21×10^5 cfu g^{-1} respectively.

After 15 days of storage period, fungal load was observed only in T1 (tender coconut RTS beverage blended with guava) and T_4 (control) under ambient condition. Under refrigerated condition, none of the treatments supported fungal population up to 15 days of storage.

Yeast population was not observed in any of the treatments up to 15 days of storage under ambient condition. Under ambient condition, lowest yeast population (0.66×10 cfu g^{-1}) was in the treatment T_2 (tender coconut RTS beverage blended with pineapple) and under refrigerated condition lowest was in T_3 (tender coconut RTS beverage blended with sweet orange).

Hashmi *et al.* (2007) reported that the mango pulp stored at ambient temperature (30° - 36° C) with 0.2 per cent KMS showed negligible microbial growth. Nwachukwu and Ezeigbo (2013) had also reported lower microbial load in sodium benzoate treated and pasteurized soursop juice. Yigeremu *et al.* (2001) and Mutaku *et al.* (2005) concluded that preservatives significantly reduced the microbial growth in comparison to untreated papaya juice. Amin *et al.* (2008) showed reduced microbial growth during storage of fruit juice by using potassium sorbate, sodium benzoate and KMS. Initially no bacterial and fungal population was observed in tender coconut spice blended RTS beverage and at the end of the storage period the bacterial count was 4.00×10^6 cfu g^{-1} in room temperature and 2.00×10^6 cfu g^{-1} in refrigerated temperature. Fungal population was 3.00×10^2 cfu g^{-1} in room temperature and 2.00×10^2 cfu g^{-1} in refrigerated temperature at 120th day of storage period in spiced tender coconut water (Sindhumathi and Amutha, 2015).

5.3 EFFECT OF JELLIFYING AGENTS ON THE QUALITY OF TENDER COCONUT JELLY

5.3.1 Standardisation of optimum concentration of different jellifying agents for the preparation of tender coconut jelly

Jellyfying agents such as agaropectin, banana peel pectin, guava pectin and nutmeg rind pectin at different concentrations (0.5 %, 1 %, 1.5 % and 2.0 %) were incorporated to tender coconut and tender coconut jelly was prepared The quality of jelly thus developed was subjected to organoleptic evaluation to select best concentration of the jellifying agents. The concentration such as 1.5 % 2.0 %, 1.5 % and 2.0 % were standardized for the jellifying agents such as agraopectin, banana peel pectin, guava pectin and nutmeg rind pectin respectively.

Sundar Raj and Ranganathan (2012) reported that fruit jelly prepared with addition of 0.5 per cent of citrus peel pectin extract had scored 8.5 for taste, colour and texture. Raj *et al.* (2012) reported that desirable consistency was obtained for jelly made from pectin extracts of banana peel, nutmeg rind and lime peel. Bhat and Singh (2014) found that guava fruit could be used as a potential source of pectin at optimum condition where extracting temperature of 85° C using hydrochloric acid for extraction for 60 miutes at a pH 2 and it gave a pectin yield of 16.8 per cent.

Israel *et al.* (2015) reported that the sensory qualities such as colour, flavour,texture and mouth feel of strawberry jam prepared from banana peel pectin were same as compared to that of commercial citrus pectin. Panchami *et al.* (2017) observed that 24.5 per cent of pectin could be extracted from citrus peel whereas from apple pomace, mango peel and banana peel 10.8 per cent, 7.5 per cent and 2.5 per cent respectively could be extracted.

5.3.2 Physical parameters

5.3.2.1 *Shelf life (days)*

Tender coconut jelly stored under refrigerated condition had prolonged shelf life than samples stored under ambient condition. Tender coconut jelly could be stored safely for 90 days under refrigerated condition. Under ambient condition, maximum shelf life (86 days) was observed in T1 (tender coconut jelly from agaropectin) and minimum (70 days) was in the treatment with tender coconut jelly from banana peel pectin (T_2) Safdar *et al.* (2012) reported that commercial mango jam stored at ambient temperature (25±3°C) showed a maximum shelf life of 150 days. Chauhan *et al.* (2012) reported similar results in tender coconut jam. Islam *et al.* (2012) reported that all sensory parameters were acceptable up to 4 months and also reported that shelf life of dragon fruit jelly was less than 4 months. Kumar and Deen (2017) reported that wood apple jelly was safe and acceptable up to 6 months.

5.3.2.2 *Water activity*

All the samples of tender coconut jelly showed significant variation in water activity. Samples stored under ambient condition showed higher increase in water activity than those treatments stored under refrigerated condition. Under ambient condition, tender coconut jelly prepared from nutmeg rind pectin (T_4) showed lowest water activity (0.74), 2 months after storage. Three months after storage under refrigerated condition, T_4 (tender coconut jelly prepared from nutmeg rind pectin) showed lowest (0.75) water activity. Astuti and Karseno (2012) observed that the increase of water content in tender coconut jam stored at cool temperature (5.07 %) was higher than room temperature (4.11 %). The increase of water content may be due to the syneresis of coconut jam during storage.

5.3.3 Biochemical parameters

5.3.3.1 *Total soluble solids (TSS) (°Brix)*

TSS of all four treatments of tender coconut jelly increased significantly throughout the storage period, irrespective of storage conditions. TSS varied from 65.41° brix to 67.38° brix. Tender coconut jelly prepared from agaropectin (T1) showed lowest TSS (65.41° brix) and T_2 (tender coconut jelly prepared from banana peel pectin) showed highest TSS (66.25° brix), two months after storage under ambient condition. Under refrigerated condition, highest TSS (67.38° brix) was observed in T_2 (tender coconut jelly from banan peel pectin) and lowest TSS (66.06° brix) was in T1 (tender coconut jelly prepared from agaropectin), three months after storage. Islam *et al.* (2012) reported that TSS of jelly prepared from dragon fruit ranged from 66.67 to 67.00 ° brix during the storage period of 4 months.

The initial TSS content of coconut based jam was 68.50° brix which increased to 72.00 and 73.00° brix when packed in glass bottles and plastic container stored at room temperature and also increased to 70.00 and 71.00° brix stored at refrigeration temperature (Sindhumathi and Amutha, 2014). Shahanas (2012) reported that there was no significant difference in TSS observed initially and at the end of first month of storage between all treatments of blended tender coconut jam. But during storage, the maximum TSS was recorded in jam prepared using 25 per cent tender coconut pulp and 75 per cent pineapple pulp (73° brix).

5.3.3.2 *Titratable acidity (%)*

Titratable acidity of all the treatments of tender coconut jelly decreased during storage, irrespective of storage conditions. But the variation in titratable acidity of tender coconut jelly stored under refrigerated condition was non significant. After 2 months of storage, treatments T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin) showed lowest titratable acidity (0.58 %). Highest titratable acidity (0.60 %) was observed in T1 (tender coconut jelly from agaropectin) under ambient condition. The treatments T1 (tender coconut jelly from agaropectin), T_3 (tender coconut jelly from guava pectin) and T_4 (tender coconut jelly from nutmeg rind pectin) showed highest titratable acidity (0.64 %) and lowest titratable acidity (0.63 %) was observed in T_2 (tender coconut jelly from banana peel pectin), three months after storage under refrigerated condition. Islam *et al.* (2012) reported that titratable acidity of dragon fruit jelly decreased from 0.44 per cent to 0.40 per cent during the storage period of 4 months.

5.3.3.3 *pH*

The pH of all treatments increased significantly throughout storage irrespective of storage condition. Highest pH (3.69) was observed in T1 (tender coconut jelly from agaropectin) and lowest (3.61) was observed in the treatments T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin), two months after storage under ambient condition. Under refrigerated condition, highest pH (3.68) was observed in T1 (tender coconut jelly from agaropectin) and lowest (3.60) in T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin), three months after storage. Singh and Chandra (2012) reported that pH of guava-carrot jelly increased from 3.59 to 4.13 during a storage period of 90 days, irrespective of storage conditions. Islam *et al.* (2012) found out that pH of jelly prepared from dragon fruit was 4.20.

5.3.3.4 *Vitamin C (mg 100 g^{-1})*

All the samples of tender coconut jelly showed significant variation in vitamin C content during storage and showed a decreasing trend under both the storage conditions. The samples stored under refrigerated condition retained higher amount of vitamin C as compared to those stored under ambient condition. Under ambient condition, T_3 (tender coconut jelly from guava pectin) showed highest (11.93 mg 100 g^{-1}) vitamin C and lowest (10.02 mg 100 g^{-1}) was observed in T_4 (control), two

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months after storage. Under refrigerated condition, highest vitamin C content (11.93 mg 100 g^{-1}) was observed in T_3 (tender coconut jelly from guava pectin) and lowest (10.00 mg 100 g-1) in T_2 (tender coconut jelly from banana peel pectin) and T_4 (tender coconut jelly from nutmeg rind pectin), three months after storage. Selvamuthukumaran *et al.* (2007) reported that ascorbic acid content of guava-carrot jelly decreased from 6.361 to 2.035 mg 100g^{-1} during storage and it could be attributed to oxidation of ascorbic acid into dehydroascorbic acid by trapped oxygen in the glass jar. Kumar and Deen (2017) reported that ascorbic acid content of wood apple jelly showed a decreasing trend with storage. Islam *et al.* (2012) reported that vitamin C content of dragon fruit jelly decreased from 2.75 to 2.61 mg 100 g^{-1} during storage.

5.3.3.5 *Sugars*

Sugars showed an increasing trend in all the treatments of tender coconut jelly throughout storage under both the storage conditions. The increase in non-reducing sugars was high in all the treatments stored under ambient condition than refrigerated condition. Kumar and Deen (2017) reported that sugar content in wood apple jelly increased continuously throughout the entire period of storage and this may be due to hydrolysis of polysaccharides like pectin and starch present in the jelly and also reported that reducing sugars were increased from 27.77 to 29.74 per cent at ambient temperature while from 27.77 to 29.33 per cent at refrigerated temperature within storage period of 90 days. Singh (2010) reported that reducing sugars in karonda jelly increased from 26.68 to 33.47 per cent during storage, from 32.84 to 59.60 per cent in pomegranate, sapota and beetroot blended jelly (Gaikwad, 2016). Similar trend in sapota jelly was observed by Relekar *et al.* (2011) and Deen and Singh (2013) in karonda jelly. Islam *et al.* (2012) reported that reducing sugars, non-reducing sugars and total sugars increased from 27.36 to 28.04 per cent, from 36.99 to 38.06 per cent and from 64.01 to 65.02 per cent respectively in dragon fruit jelly.

5.3.3.6 *Protein (%)*

Protein content in all the treatments showed a declining trend during the storage period, irrespective of storage conditions. Tender coconut jelly stored under refrigerated condition retained higher amount of protein compared to those under ambient condition. Tender coconut jelly from agaropectin (T1) retained highest (0.047 %) amount of protein and the lowest (0.040 %) was retained in T_3 (tender coconut jelly from guava pectin), two months after storage under ambient storage condition whereas under refrigerated condition, three months after storage, highest (0.047 %) protein content was observed in T1 (tender coconut jelly from agaropectin) and lowest (0.039 %) in T_2 (tender coconut jelly from banana peel pectin). Ahmmed *et al.* (2015) reported that protein content of jellies (orange, mango, guava and apple) was found to be in the range of 0.02 to 0.06 per cent.

4.3.3.7 *Non-enzymatic browning*

All the treatments of tender coconut jelly showed an increasing trend in non-enzymatic browning. Under ambient condition, lowest non-enzymatic browning (0.10) was observed in T1 (tender coconut jelly from agaro pectin), two months after storage and under refrigerated condition, T1 (tender coconut jelly from agaropectin) showed lowest (0.11) non-enymatic browning, three months after storage. Progressive increase in browning of wood apple jelly was observed during storage and this could be mainly due to Maillard reaction such as reaction of organic acids with sugars or oxidation of phenol which leads to the formation of brown pigments (Kumar and Deen, 2017). Similar results were also reported by Chaudhary *et al* (2007) and Deen and Singh (2013) in karonda jelly. The brown substances formed during evaporation and crystallization of sweet coconut nectar was a result of caramelization and Maillard reaction (Apriantono *et al.*, 2002).

5.3.3.8 *Organoleptic quality*

Organoleptic quality of all the treatments of tender coconut jelly varied significantly under both the storage conditions. Organoleptic quality of all the treatments decreased during storage. The deacrease in organoleptic quality of tender coconut jelly was higher under ambient condition. Tender coconut jelly from nutmeg rind pectin (T_4) showed highest (7.7) overall acceptability, two months after storage under ambient condition. Under refrigerated condition, the highest (7.4) overall acceptability score was observed in T1 (tender coconut jelly from agaropectin), three months after storage.

The acceptability of wood apple jelly was maintained up to 6 months of storage period and the losses in organoleptic quality of jelly during storage due to undesirable changes in the product there by masking the original colour and flavour of the product (Kumar and Deen, 2017). Chauhan *et al.* (2012) reported that the jam prepared with coconut and pineapple pulp showed a good sensory acceptability after 6 months of storage at 37^{o} C. Islam *et al.* (2012) reported that texture quality of dragaon fruit jelly increased with increased pectin level and the jelly quality was found to be highest at an optimum pectin level of 0.5 per cent. Kumar and Deen (2017) reported that overall acceptability score of wood apple jelly gradually decreased from 8.77 to 8.11 at ambient temperature while, from 8.81 to 8.31 at refrigerated condition and the average overall acceptability during 90 days storage was 8.47 and 8.55 at ambient temperature and refrigerated temperature respectively. Sundar Raj (2012) reported that cloudiness in banana peel jelly was observed during storage. During the storage period of coconut jam at room temperature or cold temperature, almost all sensory quality attributes decreased due to the increase in water content and and the influence of storage conditions (Meilgaard *et al.,* 1999).

5.3.3.9 *Microbial load*

Variation in microbial population in all the treatments of tender coconut jelly was non significant. Bacterial population was observed in all the samples of tender coconut jelly, one month after storage, fungal load was observed in T_2 (tender coconut jelly from banana peel pectin) and no yeast load was observed in the samples under ambient condition throughout the storage period. Under refrigerated condition, microbial load was comparatively lower than ambient storage. Bacterial load was observed in all the samples of tender coconut jelly except T_4 (tender coconut jelly from nutmeg rind pectin). Fungal and yeast load was observed only in T_2 (tender coconut from banana peel pectin). Kumar and Deen (2017) reported that microbial growth of wood apple jelly increased up to 2 months of storage at ambient temperature. Ranganna (2010) reported that the microbial count should be less than 10^3 per ml or g of jelly for its storage stability.

Summary

6. SUMMARY

Reasearch work on "Development of novel value added products from tender coconut (*Cocos nucifera* L.)" was carried out in the Department of Post Harvest Technology during 2016-18.

Fresh tender coconut of about 7 months maturity (cv. COD) was procured from different localities of Thrissur district. In the first experiment, RTS beverage was prepared from tender coconut which was added with 100 ppm ascorbic or malic acid in combination with one of the three preservatives, viz. potassium metabisulphite, sodium benzoate and potassium sorbate at a concentration of 100 ppm. Observations on shelf life and biochemical parameters were taken during three months of storage period.

The RTS beverage stored under refrigerated condition gave significantly longer shelf life as compared to samples stored under ambient condition. Tender coconut RTS beverage had a shelf life of 25 days and 50 days under ambient and refrigerated condition without any additives respectively. Among the treatments, tender coconut RTS beverage added with 100 ppm ascorbic acid and 100 ppm KMS was found to be the best combination of food additives. Overall acceptability and microbial quality were better in tender coconut RTS beverage prepared with ascorbic acid and KMS and the same treatment recorded longest shelf life of 50 days under refrigerated condition and was also superior with regard to titratable acidity (0.217 %), ascorbic acid (53.00 mg $100g^{-1}$), protein content (0.053 %) and non-enzymatic browning (0.03).

In the second experiment, tender coconut was blended with fruit juice/pulp of guava, pineapple and sweet orange at different proportions (90:10, 80:20, 70:30, 60:40, 50:50). Tender coconut blended with guava, pineapple and sweet orange at 80:20, 50:50 and 60:40 respectively showed highest overall acceptability. Tender coconut blended with pineapple juice was the best among all tender coconut-juice blends in terms of higher overall acceptability, lesser microbial load and lowest non-enzymatic browning (0.03). Highest vitamin C content was observed in tender coconut blended with sweet orange (47.66 mg 100 g^{-1}), 30 days after storage, under refrigerated condition when compared to ambient condition (47.64 mg 100 g^{-1}).

Jellifying agents such as agaropectin, banana peel pectin, guava pectin and nutmeg rind pectin were incorporated at different concentrations (0.5 %, 1.0 %, 1.5 % and 2 %) to prepare tender coconut jelly and a concentration of 1.5 per cent was found to be ideal for agaropectin and guava pectin where as the optimum concentration for banana peel and nutmeg rind pectin was 2.0 per cent.

Tender coconut jelly stored under refrigerated condition had a shelf life beyond the storage period of 90 days. Tender coconut jelly prepared with agaropectin and pectin extract of nutmeg rind showed highest overall acceptability of 7.7 and 7.4, two months after storage under ambient condition and three months after storage under refrigerated condition respectively. Vitamin C content was highest in tender coconut jelly prepared from guava pectin (11.93 mg 100 g^{-1}) under both storage conditions. Treatment T_4 (tender coconut jelly prepared from nutmeg rind pectin) showed lowest water activity (0.75).

From the study, it is clear that tender coconut is a potential source for developing many novel value added and processed products and the shelf life of such products can be extended by preserving with suitable food additives in combination with ideal storage conditions.

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Appendices

Appendix 1. Sensory score of tender coconut RTS blended with guava pulp

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	7.4	7.5	7.1	7.4	7.1	7.2	7.0	7.1
T2	7.7	7.5	7.6	7.6	7.4	7.7	7.5	7.7
T3	7.3	7.2	7.2	7.2	7.0	7.1	7.0	7.1
T4	6.9	7.0	6.9	6.9	7.0	6.9	7.0	7.0
T5	6.3	6.7	6.4	6.3	6.3	6.0	6.0	6.1
Kendal's W test	0.415	0.258	0.474	0.443	0.240	0.628	0.588	0.581

T1: Tender coconut RTS blend (90 % tender coconut: 10 % guava)

T2: Tender coconut RTS blend (80 % tender coconut: 20 % guava)

T3: Tender coconut RTS blend (70 % tender coconut: 30 % guava)

T4: Tender coconut RTS blend (60 % tender coconut: 40 % guava)

T5: Tender coconut RTS blend (50 % tender coconut: 50 % guava)

Appendix 2. Sensory score of tender coconut RTS blended with pineapple juice

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	5.6	5.5	5.2	5.3	5.4	5.2	5.1	5.2
T2	6.2	5.8	5.7	5.4	5.5	5.5	5.2	5.5
T3	6.3	6.0	6.2	5.9	6.2	6.0	5.7	5.7
T4	7.2	7.0	6.7	6.2	6.6	6.8	6.4	6.9
T5	7.7	7.2	7.2	6.2	7.0	7.0	6.9	7.3
Kendal's W test	0.294	0.294	0.428	0.428	0.428	0.649	0.649	0.806

T1: Tender coconut RTS blend (90 % tender coconut: 10 % pineapple)

T2: Tender coconut RTS blend (80 % tender coconut: 20 % pineapple)

T3: Tender coconut RTS blend (70 % tender coconut: 30 % pineapple)

T4: Tender coconut RTS blend (60 % tender coconut: 40 % pineapple)

T5: Tender coconut RTS blend (50 % tender coconut: 50 % pineapple)

Appendix 3. Sensory score of tender coconut RTS blended with sweet orange juice

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
T1	6.3	6.2	6.0	6.5	5.6	5.3	5.6	5.5
T2	6.8	7.1	6.6	6.5	6.2	5.9	6.4	6.1
T3	7.2	7.0	6.7	6.7	6.7	6.6	6.8	6.9
T4	7.8	7.7	7.6	7.4	7.3	7.6	7.5	7.7
T5	7.2	7.5	7.6	7.8	6.7	7.8	7.7	7.6
Kendal's W test	0.569	0.306	0.394	0.248	0.532	0.478	0.333	0.731

T1: Tender coconut RTS blend (90 % tender coconut: 10 % sweet orange)

T2: Tender coconut RTS blend (80 % tender coconut: 20 % sweet orange)

T3: Tender coconut RTS blend (70 % tender coconut: 30 % sweet orange)

T4: Tender coconut RTS blend (60 % tender coconut: 40 % sweet orange)

T5: Tender coconut RTS blend (50 % tender coconut: 50 % sweet orange)

Appendix 4. Sensory score of tender coconut jelly prepared with agaropectin

Treatments	Appearance	Colour	Flavour	Odour	Body	Texture	After taste	Over all acceptability
C1	7	7.1	6.1	6.1	5.3	6.8	6.6	7.4
C2	7.7	7.9	7.2	6.5	6.8	7.0	7.3	7.2
C3	7.7	7.7	7.0	6.4	6.8	7.1	6.7	7.5
C4	7.7	7.0	7.5	6.2	7.0	7.4	7.2	7.4
Kendal's W test	0.364	0.342	0.260	0.142	0.376	0.105	0.039	0.708

C1: 0.5 per cent

C2: 1.0 per cent

C3: 1.5 per cent

C4: 2.0 per cent

Appendix 5. Sensory score of tender coconut jelly prepared with banana peel pectin

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
C1	7.0	7.0	7.0	6.6	6.1	5.4	6.8	6.9
C2	7.7	7.7	7.1	6.4	6.8	7.1	6.7	7.4
C3	7.7	7.8	7.5	6.5	6.8	7.4	7.1	7.2
C4	7.7	7.7	7.0	6.2	7.0	7.5	7..1	7.5
Kendal's W test	0.363	0.352	0.261	0.144	0.378	0.107	0.049	0.177

C1: 0.5 per cent

C2: 1.0 per cent

C3: 1.5 per cent

C4: 2.0 per cent

Appendix 6. Sensory score of tender coconut jelly prepared with guava pectin

Treatments	Appearance	Colour	Flavour	Odour	Texture	Taste	After taste	Over all acceptability
C1	7.3	7.3	7.1	6.4	7.0	7.5	7.2	6.5
C2	7.2	7.4	7.2	6.7	7.0	7.4	7.4	7.1
C3	7.2	7.3	7.1	6.3	6.8	7.4	7.3	7.2
C4	7.5	7.3	7.6	7.6	6.6	7.5	7.4	7.0
Kendal's W test	0.046	0.008	0.095	0.123	0.048	0.015	0.027	0.061

C1: 0.5 per cent

C2: 1.0 per cent

C3: 1.5 per cent

C4: 2.0 per cent

Appendix 7. Sensory score of tender coconut jelly prepared with nutmeg rind pectin

Treatments	Appearance	Colour	Flavour	Odour	Body	Taste	After taste	Over all acceptability
C1	7.0	7.0	7.0	6.8	6.6	6.9	7.0	7.0
C2	7.5	7.0	7.0	6.8	7.1	7.0	7.3	7.4
C3	7.5	7.8	7.8	6.0	7.1	6.8	7.3	7.4
C4	7.0	7.0	7.6	7.5	7.0	7.0	6.0	7.5
Kendal's W test	0.293	0.039	0.074	0.128	0.019	0.015	0.131	0.011

C1: 0.5 per cent

C2: 1.0 per cent

C3: 1.5 per cent

C4: 2.0 per cent

DEVELOPMENT OF NOVEL VALUE ADDED PRODUCTS FROM TENDER COCONUT
(*Cocos nucifera* L.)

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The study titled 'Development of novel value added products from tender coconut (*Cocos nucifera* L.)' was carried out in the Department of Post Harvest Technology, College of Horticulture, Vellanikkara during 2016-2018.

The immature nut known as tender coconut, contains a sterile liquid which is the endosperm and it has got many health benefits and medicinal values. But the popularisation of tender coconut based products is limited because of the loss in natural freshness unless treated scientifically. Therefore, an attempt was made to prepare some novel value added products from tender coconut and to evaluate their quality and shelf life.

Fresh tender coconut of about 7 months maturity (cv. COD) was procured from different localities of Thrissur district. In the first experiment, RTS beverage was prepared with tender coconut and the beverage was added with 100 ppm ascorbic or malic acid in combination with one of the three preservatives, viz. potassium metabisulphite, sodium benzoate and potassium sorbate at a concentration of 100 ppm.

The RTS beverage stored under refrigerated condition gave significantly longer shelf life as compared to samples stored under ambient condition. The treatment T1 (tender coconut RTS beverage added with 100 ppm ascorbic acid and 100 ppm potassium metabisulphite) gave the maximum shelf life of 25 days under ambient condition and 50 days under refrigerated storage. The same treatment was also superior with regard to titratable acidity (0.217 %), ascorbic acid (53.00 mg $100g^{-1}$), protein content (0.053 %), non-enzymatic browning (0.03), overall acceptability score (7.4) and microbial load among the treatments under refrigerated condition.

Tender coconut was blended with fruit juice/pulp of guava, pineapple and sweet orange in different proportions (90:10, 80:20, 70:30, 60:40, 50:50 v/v) and based on the organoleptic score obtained for each blend, best type of tender coconut-fruit juice blend were identified. Tender coconut blended with guava pulp in 80:20, tender coconut and pineapple in 50:50 and tender coconut with sweet orange in 60:40 proportion was selected for storage studies.

Tender coconut RTS beverage blended with pineapple (T2) gave significantly longer shelf life (40 and 73 days) under ambient and refrigerated storage conditions respectively. The biochemical parameters such as highest TSS (14.23° brix) and total sugar content (14.58 %) and lowest non-enzymatic browning (0.03) were observed in T2 (tender coconut RTS beverage blended with pineapple) and T3 (tender coconut RTS beverage blended with sweet orange) retained highest vitamin C content (47.66 mg 100 g^{-1}), 30 days after storage, under refrigerated condition when compared to ambient condition. Sixty days after storage, the biochemical parameters such as TSS, sugars, pH, protein and overall acceptability score were highest in T2 (tender coconut RTS beverage blended with pineapple) under refrigerated condition.

Tender coconut jelly was preapared from tender coconut by incorporating jellifying agents such as agaropectin, banana peel pectin, guava pectin and nutmeg rind pectin at different concentrations (0.5 %, 1.0 %, 1.5 % and 2 %). Treatments such as C3 (1.5 % agaropectin), C4 (2 % banana peel pectin), C3 (1.5 % guava pectin) and C4 (2 % nutmeg rind pectin) showed highest overall acceptability score of 7.5, 7.5, 7.2 and 7.5 respectively.

Tender coconut jelly could be stored for 73 days under ambient condition whereas under refrigerated condition, the shelf life was beyond 90 days. T4 (tender coconut jelly prepared from nutmeg rind pectin) showed lowest (0.75) water activity Highest vitamin C (11.93 mg 100 g^{-1}) was observed in T3 (tender coconut from guava pectin) under both ambient and refrigerated storage conditions. Tender coconut jelly from nutmeg rind pectin (T4) showed highest overall acceptability value of 7.7

and 7.4, 2 months after storage under ambient condition and 3 months after storage under refrigerated condition respectively.

The results of the study indicated that through scientific handling along with addition of preservatives, the tender coconut can be utilized as a potential source for the production of many novel value added and processed products.