PRODUCT DEVELOPMENT FROM TENDER CASHEW NUT

By

SHARON JACOB

2018-12-027

DEPARTMENT OF POST HARVEST TECHNOLOGY

COLLEGE OF HORTICULTURE, VELLANIKKARA

THRISSUR - 680 656

KERALA, INDIA

2020

PRODUCT DEVELOPMENT FROM TENDER CASHEW NUT

By

SHARON JACOB

2018-12-027

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF POST HARVEST TECHNOLOGY

COLLEGE OF HORTICULTURE, VELLANIKKARA

THRISSUR- 680 656

KERALA, INDIA

2020

DECLARATION

I hereby declare that the thesis entitled **"Product development from tender cashew nut"** 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 any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Date: 24.8.2020

Sharon Jacob

(2018-12-027)

CERTIFICATE

Certified that this thesis entitled **"Product development from tender cashew nut"** is a bonafide record of research work done independently by **Sharon Jacob (2018-12-027)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara
Date: 24.8.2020

Dr. A. Sobhana
(Chairperson, Advisory Committee)
Professor and Head
Fruit Crops Research station
Vellanikkara, Thrissur, Kerala

CERTIFICATE

We, the undersigned members of the advisory committee of **Sharon Jacob (2018-12-027)** a candidate for the degree of **Master of Science in Horticulture**, with major field in **Post Harvest Technology**, agree that the thesis entitled **"Product development from tender cashew nut"** may be submitted by her in partial fulfillment of the requirement for the degree.

Dr. A. Sobhana
(Chairperson, Advisory Committee)
Professor and Head
Fruit Crops Research Station
Vellanikkara, Thrissur, Kerala

Smt. Meagle Joseph P.
Associate Professor and Head
Dept. of Post Harvest Technology
College of Horticulture, Vellanikkara
Kerala Agricultural University, Thrissur

Dr. Jalaja S. Menon
Assistant Professor and Head i/c
Cashew Research Station
Madakkathara, Thrissur

Dr. K. T. Suman
Assistant Professor (Community Science)
KVK, Thrissur

DEDICATED TO MY FAMILY
AND MAJOR ADVISOR

ACKNOWLEDGEMENT

*It is by the immense blessing of **Almighty** and my parents and my sister, I have been able to complete my studies successfully hitherto and present this piece of work uninterruptedly for which I am eternally indebted for them.*

*I am inexpressibly ecstatic to extend my deep sense of gratitude to the chairperson of my Advisory Committee, **Dr. A. Sobhana**, Professor and Head, Fruit Crops Research Station, Vellanikkara, who convincingly guided and encouraged me to be professional and do the right thing even when the road got tough. Without her persistent help, the goal of this research work would not have been realised.*

*I am indebted to **Smt. Meagle Joseph P.**, Associate professor and Head, Department of Post Harvest Technology for her keen interest, ardent support, patience that cannot be underestimated, persistent encouragement and motherly care.*

*I humbly express my intense gratitude to **Dr. Jalaja S. Menon**, Assistant Professor and Head i/c, Cashew Research Station, Madakkathara, for her kind cooperation, immensely valuable and timely help, and precious guidance and encouragement during the course of investigation.*

*I am deeply obliged to **Dr. K. T. Suman**, Assistant Professor (Community Science), KVK, Thrissur, for her unfailing support, encouragement, valuable suggestions and friendly care during my research programme.*

*I am ineffaceable to express my gratitude and indebtedness to **Dr. Saji Gomez**, Assistant Professor (Horticulture), Department of Post Harvest technology, for insightfulness, inspiring guidance, with utmost patience and ever willing help bestowed upon me.*

*I wish to express my sincere gratitude to **Dr. K. B. Sheela**, Former Professor and Head, Department of Post Harvest Technology for showing her immense love and valuable guidance to start my research work and for filling me with confidence and optimistic thoughts.*

I express my heartfelt thanks to ***Reshma chechi****, former Teaching assistant and* ***Ardra chechi****, Teaching assistant, for their insightful guidance, constant help and inextinguishable encouragement.*

I am personally indebted to ***Lathika chechi****, non-teaching staff, and her family for their cooperation and relentless support. I also take this opportunity to sincerely thank all the non-teaching staffs of the Department of Post Harvest Technology especially,* ***Seena chechi, Shiji chechi, Jooby chechi, Maneesha chechi, Prasanna chechi*** *and* ***Sreeja chechi*** *for their kind cooperation and moral support.*

I would like to acknowledge all the teachers and teaching assistants from the ***Department of Fruit Science and Floriculture and landscaping*** *for their constant support and enthusiastic help provided during the course of my research work.*

It gives me immense pleasure to express my profound thanks to my seniors ***Sarthak, Thanseela, Geethu, Aparna, Jesabel, Netravathi****,* ***Simla, Athira, Thatayaone Malikongwa*** *and* ***Shankarprasad*** *for their unwavering support and encouragement. I also thank my juniors* ***Midhuna, Anjali*** *and* ***Janmitha*** *for their moral support.*

I am thankful to ***Mr. Aravind K. S.*** *and* ***Mrs. Rejitha*** *of Students' Computer Club, College of Horticulture for their steadfast cooperation.*

Let me express my heartfelt gratitude to my classmate ***Miss. Harya Krishna V****. who was the best companion for me in my journey of two years. I also thank my friends* ***Meera****,* ***Swega, Aysha, Anju*** *and* ***Riya*** *for their immense love and support. Also, I extend my sincere gratitude to* ***Akhil****, class representative, for his valuable help.*

My family is a priceless gift, greater than anything I can imagine. I am blessed to have a loyal, supportive and caring parents, ***Mr. Lalu Jacob*** *and* ***Mrs. Lizamma****, and my sister,* ***Sherin****, who stood with me during all of my ups and downs, for which I am so grateful and thankful.*

Sharon Jacob

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

APPENDICES

1.INTRODUCTION

1. INTRODUCTION

Cashew, an important horticultural crop of India, has great socioeconomic significance in our country. It is native of Brazil and the Lower Amazons. The cashew was introduced to the Americas, the West Indies, Madagascar, India and Malaysia, where it became a valuable cash crop (Frankel, 1991).

Even though cashew is considered as an export oriented crop, data on trade indicate that domestic consumption of cashew kernels is almost 70 – 100 percent of the production (Balasubramanian, 2009). The demand for raw and processed cashew nut is bright in internal and export markets. According to the annual report of CEPC (2019), India continued to be the largest producer of cashew nut in the year 2017-2018 and Maharashtra contributed the maximum (33%), followed by Andhra Pradesh (14%), Kerala (11%) and Karnataka (11%). India exported 84,352 MT and imported 4652 MT of cashew kernels during 2017-2018 (DGCI&S).

At present cashew kernels are consumed directly or used for various food preparations. Raw cashews contain 5% water, 30% carbohydrates, 44% fat, and 18% protein. In a 100 gram reference quantity, raw cashews provide 553 Calories, 67% of the Daily Value (DV) in total fats, 36% DV of protein, 13% DV of dietary fibre and 11% DV of carbohydrates (USDA, 2015).

Cashew seed is often considered as a nut in the culinary sense and this nut is eaten on its own, used in recipes, or processed into cashew cheese or cashew butter. The kernel is used for garnishing sweets or curries or ground into paste that forms a base of sauces for curries or some sweets. They are widely used in confectionery, as additions to biscuits, sweets and cakes (Wanlapa and Jindal, 2006).

Substantial quantities of cashew nuts are produced during rainy season in Kerala, especially in the late season flowering types, which are inferior in quality and are being wasted. The occurrence of late season flowering is mostly noticed in

Wayanad and Idukki districts – hilly regions or high range regions of Kerala. The quality of nut is affected mainly by the infestation of pests and diseases. It is estimated that more than 50% of the crop is lost annually due to pests and diseases in cashew (Haribabu *et al*., 1983). If the immature nuts can be economically utilized, the loss during rainy season can be reduced to a greater extent.

The immature nuts are harvested in tender form, when the shells are not hardened and are green in colour. The shell is soft and can be cut with a knife and kernel can be extracted. Small scale utilization of immature cashew nuts is being practised in certain areas of Kerala for culinary purposes. The immature kernel is mostly found in Kerala cuisines, typically *avial* and also used for pickle making and non-vegetarian curries. The kernels are put to use in a variety of ways like serving as a snack, relished as salads by combining with mango and preparation of sweets as *tikka* and cashew cake (Anandkumar *et al.,* 2011).

Works conducted on immature cashew kernels are very meagre. Research work on the utilisation of immature cashew nuts, storage methods and potential of value addition will be useful for reducing the losses usually experienced in the rainy season crops and for additional income to the growers. In this context the present study was undertaken with the objective of the preparation of value added products from tender cashew kernels as well as storage studies. The study also envisaged the evaluation of varieties for their kernel characters.

2.REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Cashew (*Anacardium occidentale* L.), belonging to the family Anacardiaceae is an evergreen dicotyledonous tree, native to Brazil. It is one of the most important commercial crops of India. The raw cashew nut is kidney shaped with 3.5mm thick soft leathery outer skin (epicarp) and thin hard inner skin (endocarp). The nut has a mean size of about 30mm length, 22mm width and 17mm thickness. Between the two walls of the shell is a honeycomb structure, which contains the phenolic material, commercially known as cashew nut shell liquid (CNSL) (Ohler, 1979). The kernel is inside the shell wrapped in a thin brown skin known as the testa. The kernel has a mean size of about 24mm length, 16mm width and 12mm thickness.

Cashew kernels, which are known as cashew nuts in trade, are grouped under tree nuts along with almonds, walnuts, pecans, filberts, Brazil nuts and pistachios. Demand for cashew kernel and its value added products seems to be very positive. By increasing the awareness about the health advantages of cashew nuts, the benefits can be enjoyed by new segments such as school going children, old people requiring nutritional supplements, pregnant women, *etc*. (Varma and Venkiteswaran, 2009).

The intensity and timing of flowering in cashew vary greatly among varieties. The early varieties flower between October to November, mid-season varieties between November to December and late season varieties flower after December under Kerala conditions (Pushpalatha, 2000).

India has been earning sizeable foreign exchange by exporting cashew kernels and had a pre-eminent position in the global cashew trade (Adiga and Kalaivanan, 2013). Cashew, till recently, was considered as a poor man’s crop and the rich man’s food and as such the consumption of cashew kernels was mostly oriented around rich and developed nations (Bhoodes, 2014). In the agri-product exports, cashew kernels were ranked as sixth by contributing 4.39 percent of the total 6.65 percent export earnings (DGCI&S, 2019).

During processing cashew nut kernel, being highly hygroscopic, was found to be susceptible to microbial deterioration and spoilage, when not properly stored (Adebajo and Diyaolu, 2003). From the nutritional point of view, cashew kernel is a store house of nutrients, having a unique combination of proteins, fats, carbohydrates, minerals and vitamins (Sobhana and Mathew, 2013).

Literature relevant to the study entitled 'Product development from tender cashew nut' is reviewed in this chapter under the following sections.

2.1 Evaluation for nut and kernel characters

2.1.1 Physical characteristics of cashew nut

2.1.2 Physical characteristics of other tree nuts

2.1.3 Biochemical characteristics of cashew kernel

2.1.4 Biochemical characteristics of other tree nuts

2.2 Storage studies

2.2.1 Pest and microbial attack on cashew nut

2.2.2 Preservation by salt

2.2.3 Preservation by sugar

2.2.4 Preservation by drying

2.3 Product development

2.3.1 Product development from nuts

2.3.2 Product development from non-conventional materials other than nuts

2.1 Evaluation for nut and kernel characters

2.1.1 Physical characteristics of cashew nut

Narayanakutty (2000) studied extensively about cashew apple and nut development pattern. He observed that cashew apple took 52 to 60 days for completion of maturation and development process and the developing nut became visible by 5^{th} or 6^{th} day which is called as pea nut stage. The nut length, width and thickness increased up to 40 days after fertilization stage (DAFS) and then declined. The maximum length of nut was recorded at 30-35 DAFS for early varieties while it was observed at 40-45 DAFS for mid and late season varieties. Formation of kernel started from 20 DAFS and it continued to gain weight till 52-54 DAFS. Kernel accounted for 29.3% in matured nut. Nut colour changed from light green to gray and nut cavity was completely filled by 50 DAFS.

Sobhana and Mathew (2014) evaluated the kernel recovery from immature nuts of different varieties, harvested at different days after flowering. They observed that recovery was highest when the nuts were harvested at 55 days after flowering. Among the varieties Madakkathara-1, Dhana, Damodhar, Poornima, Priyanka and Vridhachalam-3, highest percentage of kernel recovery was for Madakkathara-1.

Pushpalatha (2009) reported that the cashew nuts attained full size in 30 days after fruit setting followed by hardening in 10 days and size reduction by 10% at harvest. The cashew apple started developing only when the nut growth ceased.

Jayaprakash Naik (2009) reported shelling percentage of Madakkathara-2, Sulabha, Dhana, Priyanka and Poornima as 26, 29.4, 29.8, 26.57 and 31 respectively. He also reported the kernel weight of different varieties *viz*., 1.88g for Madakathara-2, 2.88g for sulabha, 2.08g for kanaka, 2.44g for Dhana, 2.87g for Priyanka and 2.6g for Poornima.

The mean values of 100 kernels for the parameters like length, width, thickness and unit mass were 24.67mm, 12.99mm, 12.06mm and 1.89g respectively as reported by Balasubramanian (2001).

Ramakrishna (1986) reported that the ratio of all dimensions of the cashew nut and the corresponding kernel were found to be higher than muskmelon and also found higher than karingda seed [*Citrullus lanatus* (Thumb) Mansf] (Suthar and Das, 1996).

A higher mass ratio of 3.20 of nut to kernel indicated a relatively lower yield of kernel per unit weight of raw cashew nut (Balasubramanian, 2001).

The equivalent diameter of soybean (Deshpande *et al*., 1991), pumpkin seed (Joshi *et al*., 1993), karingda seed (Suthar and Das, 1996) and sunflower seed (Gupta and Das, 1997) was found to be lower than that of cashew, which was observed as 11.82-19.73mm with a mean of 15.56 mm (Balasubramanian, 2001).

Arogba (1999) made a comparison of physical properties of kolanut (*Cola nitida*) and cashew nut kernels. The colour of kolanut kernel was purple while it was pale yellow for cashew nut kernel. Size of both kernels was found to be medium, with two lobes. Kernel of kolanut showed recurvate shape while that of cashew nut kernel was observed as crescent shape. The dimensions of kolanut kernel were 5.0 ± 0.8cm length and 3.2 ± 0.3cm breadth while that of cashew kernel were 2.5 ± 0.3cm length and 0.9 ± 0.2cm breadth. The fresh weight of kolanut kernel was 15.51 ± 1.3g per unit lobe whereas fresh weight of cashew nut kernel was 2.93 ± 0.2g per unit lobe.

Good quality cashew kernels were considered to have slightly off white colour as reported as Azam-Ali and Judge (2001).

In an experiment conducted by Ogunsina (2013), the nut count of the raw cashew nuts which was calculated as the number of raw nuts per kilogram, was 197 per kilogram.

2.1.2 Physical characteristics of other tree nuts

The most popular tree nuts other than cashew include almond (*Prunus* spp.), Brazil nut (*Bertholleti celsa*), hazel nut (*Corylus avellana*), macadamia (*Macadamia* spp.), pecan

(*Carya illinoinensis*), pine nut (*Pinus* spp.), pistachio (*Pistachio vera*) and walnut (*Juglans regia*) (Alasalvar and Shahidi, 2008).

Connell *et al*., (2000) observed that early harvest of almonds do not affect the lipid content but induce variation to the physical properties of the seeds. Aydin (2003) evaluated the physical characteristics of almond nut and kernel as a function of its moisture content. According to his report, the average length, width, thickness, the geometric mean diameter, unit mass and volume of kernels were 21.19mm, 14.34mm, 6.38mm, 11.42mm, 0.69g and 0.71cm^3respectively.

Kashaninejad (2006) while studying the physical properties of pistachio nut and kernel observed that these properties increased with increasing moisture content. The range of length, width, height, shell splitting and unit mass of pistachio nut were 16.07 to 17.25 mm, 12.41 to 12.75 mm, 10.98 to 12.24 mm, 3.59 to 4.47 mm and 0.90 to 1.30 g respectively, as the moisture content varied from 4.10 to 38.10%. The respective values for pistachio kernel varied from 15.21 to 16.22 mm, 9.11 to 10.53 mm, 8.73 to 9.66 mm and 0.51 to 0.80 g. Nazari *et al*., (2008) evaluated the physical parameters of wild pistachio nut and kernel. The average length, width and thickness of wild pistachio nuts at 5.83% moisture content were 13.98, 8.76 and 7.25 mm respectively while the corresponding values of kernels at 6.03% moisture content were 11.07, 5.92 and 4.83mm.

Arogba (1997) reported that the ratio of length and breadth of the shell and the enclosed kernel of Nigerian mango seeds belonging to the same family of cashew, were 1:1 and 3:2 respectively.

Santos *et al.,* (2013) reported that the average weight, length and width of Brazil nut kernel were 3.81 ± 1.75g, 3.41 ± 1.85mm and 1.60 ± 1.22mm respectively.

2.1.3 Biochemical characteristics of cashew kernel

The kernel derived by processing of raw nuts is highly nutritious and rich source of protein, carbohydrate and fat. The growing conditions or the cultivated variety of cashew may have an influence on kernel composition (Ohler, 1979).

Cashew nut was reported to have the lowest fat content of 46.4% as compared to almond (50.6%), Brazil nut (66.4%), hazel nut (60.8%), macadamia nuts (75.8%), pecanut (72%) and walnut (65.2%) (USDA, 2015).

Akinhanmi *et al*. (2008) estimated the proximate composition of cashew nut kernel and it was observed that cashew kernel contains 7.2% moisture content, 2.8% ash, 49.1% fat, 36.3% crude protein and 3.2% crude fibre.

Nair (2009) reported the average composition of cashew kernels as 47% fats, 21% proteins, 25% carbohydrates, 2% minerals and 5% water.

The protein content of the cashew kernel was reported in the range of 14.27 to 14.33 percent by Panda and Pal (1993).

Cashew nuts were considered as good source of proteins (20%), carbohydrates (23%) and fats (45%) as reported by Bhattacharjee *et al*. (2003a).

Venkatachalam and Sathe (2006) evaluated the proximate composition of cashew nut kernel as 4.39 ± 0.04g moisture, 43.71 ± 1.13g lipids, 18.81 ± 0.06g proteins, 2.66 ± 0.21g ash content and 3.96 ± 0.08g sugars per 100g edible portion.

According to Griffin and Dean (2017), the total protein content and sugar content of raw cashew kernels were observed as 17.2 ± 0.13% and 6.0 ± 0.26% respectively.

Pearson (1976) reported that cashew kernel contained 46% fat on an average. The relative abundance of monounsaturated fatty acids in cashew nut is conducive to the

promotion of good health and that the relative abundance of fat in cashew nut in no way poses a nutritional risk (Achal, 2002).

According to Sobhana and Mathew (2014), the tannin content of cashew nut varieties harvested at 55 days after flowering were observed as 0.22% for Madakkathara-1 and Dhana, 0.24% for Priyanka, 0.26% for Poornima and 0.28% for Damodhar and Vridhachalam each in cashew kernels.

Cashew testa was observed to have 24-26% of tannin content which may cause astringent and tingling sensations in mouth on consumption, because of which these were removed and utilized in leather industry (Nair, 2003; Salam and Peter, 2010).

Arogba (1999) compared properties of kolanut and cashew nut kernels. The cashew kernel had higher contents of crude fat and protein, by three and ten folds respectively compared to the kolanut kernel. The dried powdered sample of cashew nut was observed to contain 51% crude fat, 36% crude protein, 0.3% ash and 3.4% carbohydrate.

Some essential nutrients are crucial to maintain human health (Ros, 2010). Cashew along with other nuts like almond, canarium, pistachio *etc*., is a rich source of protein (Bai *et al*., 2019).

According to the research findings of Ogunsina (2013), the raw cashew nuts were chemically composed of 21.32% proteins, 42.19% crude fat, 4.35% crude fibre, 2.79% ash content, 5.16% moisture content, 24.19% carbohydrates and provides an energy of 561.75 kcal per 100g.

2.1.4 Biochemical characteristics of other tree nuts

Tree nuts are rich source of macronutrients such as carbohydrates, proteins and fats, and micronutrients such as phosphorous, potassium, copper, calcium, magnesium, iron and sodium (Nanos *et al*., 2002; Ayadi *et al*., 2006; Venkatachalam and Sathe, 2006; King *et al*., 2008; Bai *et al*., 2018; Gama *et al*., 2018a, b).

According to Clark and Smith (1988), nutrient concentrations in fruit generally increases while maturing which is not much noticed in kernels. However some of the nutrients change in kernels with maturity.

Venkatachalam and Sathe (2006) reported the proximate composition of almond as 9.51 ± 0.08g moisture content, 43.36 ± 0.62g lipids, 19.48 ± 0.51g protein, 2.48 ± 0.05g ash content and 2.11 ± 0.11g sugars per 100g of edible portion.

Bai et al. (2019) reported that the protein content of almond and pistachio nuts was significantly higher than that of cashew and canarium.

Shokraii (1977) conducted research work on chemical composition of pistachio nuts and found the percentage composition of pistachio nuts as 57% oil, 20.8% crude protein, 2.2% soluble protein, 13.8% total carbohydrates and 0.4% free fatty acid. Shokraii (1977) and Maskan and Karatas (1998) reported that pistachio kernels were good source of fat (50–60%) and contained unsaturated fatty acids such as linoleic, linolenic and oleic acids, which are essential for human diet. Venkatachalam and Sathe (2006) estimated the proximate composition of pistachio nuts as 5.74 ± 0.03g moisture content, 45.09 ± 0.27g lipids, 19.80 ± 0.49g proteins, 3.21 ± 0.03g ash content and 1.52 ± 0.07g carbohydrates per 100g of edible portion. According to Bansil (2015), pistachio nuts contain 19.3% protein, 52% fat, 19% carbohydrates and 2% crude fiber.

Venkatachalam and Sathe (2006) reported the moisture content, lipids, protein, ash and carbohydrate content of macadamia nut for 100g edible portion as 2.10 ± 0.12g, 66.16 ± 0.92g, 8.40 ± 0.71g, 1.16 ± 0.04g and 1.36 ± 0.05g respectively. Wang *et al*., (2013) and Sinanoglou *et al*., (2014) reported that macadamia nut, which is one of the valuable nuts in the world, contained the highest monounsaturated fatty acid, mainly oleic (60%) and palmitoleic (20%) acids that may possibly reduce cholesterol and triglyceride levels, hence minimizing the risk of heart diseases. Macadamia nut is also rich in bioactive macronutrients such as protein, dietary fibre, essential minerals, vitamin E, and plant sterols and contains a significant amount of antioxidants (Rengel *et al*., 2015).

Patel and Kheni (2018) estimated that kernel of mango, which belongs to the same family of cashew nut, contains 70g carbohydrate, 15g fat, 10g protein and 2g fibre per 100g of kernel.

Venkatachalam and Sathe (2006) estimated the proximate composition of Brazil nut as 3.07 ± 0.37g moisture content, 66.71 ± 1.17g lipids, 13.93 ± 0.40g proteins, 3.28 ± 0.01g ash content and 0.69 ± 0.04g carbohydrates. Santos *et al.,* (2013) conducted research work on Brazil nut kernels and the average composition of kernels were estimated as 7.60 ± 0.83g carbohydrates, 18.58 ± 0.30g proteins, 67.20 ± 0.21g lipids and 3.19 ± 0.13% moisture content.

According to Venkatachalam and Sathe (2006), the composition of pecanut was estimated as 7.40 ± 0.08g moisture content, 66.18 ± 0.53g lipids, 7.50 ± 0.24g proteins, 1.88 ± 0.07g ash content and 1.55 ± 0.04g carbohydrates per 100g edible portion. Similarly for walnut the moisture content, lipids, protein, ash and carbohydrate content were estimated as 2.70 ± 0.20g, 64.50 ± 0.45g, 13.46 ± 0.47g, 1.82 ± 0.02g and 2.06 ± 0.23g respectively.

2.2 Storage studies

Irtwange and Oshodi (2009) described shelf life as the length of time that a food, drink, or medicine remains fit for sale or consumption.

Nuts are highly susceptible to deterioration and hence the shelf life of nuts are particularly important (Kashaninejad *et al*., 2003; Christopoulos and Tsantili, 2015; Walton *et al*., 2017).

Kazantzis *et al.* (2003) evaluated the storage conditions for almond kernels. The quality and composition of shelled kernels were found similar to that of in-shell almonds. Storage of almonds at 5°C-20°C did not alter the composition of kernel significantly.

The chemical composition of tree nuts, and differences in the concentrations of individual chemical compounds, determine their shelf life (Venkatachalam and Sathe, 2006; Bakkalbasi *et al*., 2012).

Conditions to which the nuts are exposed before and after harvest can affect their physicochemical composition, leading to quality loss and reduced shelf life (Kazantzis *et al*., 2003; Walton and Wallace, 2009, 2010; Raei *et al*., 2010; Ghirardello *et al*., 2013).

Pre-treatments like soaking, blanching and brining of the fruit results in loss of tannin and vitamin C contents in aonla preserves (Anand, 1970). Steam blanching or microwave blanching followed by air cooling results is minimal (5-10%) loss of water-soluble nutrient (Kalia and Sood, 2007). According to Young (2007), some of the nut kernels were blanched before processing to remove the skin or membrane surrounding the white meat. Almonds were soaked in hot water for blanching whereas pecanuts were not blanched. Afoakwa *et al*. (2007) reported that blanching of Bambara groundnuts before canning reduced anti-nutrient compounds like phytates and tannin content.

Generally, the reason for changes in quality of the kernel was reported as the result of lipid oxidation and the initial stages of lipid oxidation was due to the characteristic production of hydrogen peroxides (Kashaninejad *et al*., 2003; Raisi *et al*., 2015). Peroxide values were used as the classic indicator of oxidative rancidity of fats and oils (Severini *et al*., 2000; Ozkan *et al*., 2007; Bakkalbaşı *et al*., 2012; Ajith *et al*., 2015; Raisi *et al*., 2015). According to Mexis and Kontominas (2009) acceptable peroxide value of cashew nut was reported as 1.24 meq O_2 per kilogram oil.

According to Phatanayindee *et al*. (2012) and Ling *et al*. (2014), the enzymatic lipid hydrolysis produced free fatty acids and this process was the result of the reaction between moisture and oil present in the kernels. Levels of free fatty acids in tree nuts need to be monitored carefully prior to and during storage because change in the levels of free fatty acids is an indication of diminishing nutritional quality and shelf life of nuts (Arena *et al*., 2013; Christopoulos and Tsantili, 2015).

High hexanal levels and peroxide values indicate lipid oxidation and rancidity of nuts and they will be rejected by the judges during sensory evaluation due to rancid taste (Mexis and Kontominas, 2009; Mexis *et al*., 2009; Mexis and Kontominas, 2010; Bakkalbasi *et al*., 2012).

Young (2007) reported that rancidity was considered as the first sign of deterioration of nuts because most edible nuts are high in oil content. High temperature, humidity as well as sunlight could favour the development of rancidity.

2.2.1 Pest and microbial attack on cashew nut

Onilude *et al*. (2010) studied about the microbial load and physical quality of cashew nuts on storage under different values of relative humidity. Eight fungal isolates were obtained from various treatments of cashew nuts which were identified as *Aspergillus niger, Aspergillus flavus, Penicillium sp., Botryodiplodia sp., Rhizopus sp., Fusarium compactum, Trichoderma sp* and *A. ochraeous*. Bacteria isolates were identified as *Bacillus subtilis, Bacillus licheniformis and Staphylococcus sp*. The fungal count increased at 90% relative humidity on 12th day of storage. The moisture content increased on storage at relative humidity of 70%, 80% and 90% while it was stable at 30 percent relative humidity.

Nair *et al*. (1985) reported that twenty species of beetles, five species of caterpillars, some psocids and mites infest stored cashew kernels. Among these, those causing direct damage to kernels were *Cadra cautella, Corcyra cephalonica, Tribolium castaneum* and *Necrobia rufipes*, while others contaminate kernels with its presence and excreta.

Bhattacharjee *et al*. (2003b) reported that over 100 species of insects and mites were known to attack cashew nuts on storage by feeding and multiplying on it. Cashew nuts like other nuts were reported as susceptible to infestation by moulds, insects and larvae (Khan *et al*. 2005).

2.2.2 Preservation by salt

Food preservatives inhibit, stop or delay the growth of microorganisms or any deterioration of food due to microorganisms and are used alone or in conjunction with other substances to achieve shelf life prolongation of foods (FSSAI, 2012).

Raw vegetables destined for pickling had an extensive flora of microorganisms, majority of which were inhibited and prevented from causing spoilage when the vegetables were placed in a brine giving 8-11 percent equilibrium salt content overall (Ranken *et al*., 1997). Salt performs a multi-purpose role in many manufactured food and drinks (Brady, 2002). Besides its flavour and other characteristic properties, it mainly acts as a preservative against microbial growth, primarily through its influence on water activity, and commonly in combination with other antimicrobial agents (Hutton, 2002).

Rosengarten (1984) reported cashew nut as a popular dessert, eaten out of hand, mixed with other nuts and used in baking and confectionaries and about 60 percent of the total cashews are eaten as salted nuts.

When macadamia kernel pieces were immersed in salt solution, unacceptable changes occurred as the storage period extended (Ross *et al*., 2002).

2.2.3 Preservation by sugar

Sugar uptake by the product kept in sugar solution, through the osmotic process, modified the composition and the taste of the final product (Ponting, 1973).

Preserves are made with whole fruit, if the fruits are sufficiently small, or with pieces of large fruit (Ahmed, 1981). A preserve is minimally 45 parts of prepared fruit with 55 parts of sugar and is concentrated to 68 percent of solids, resulting in a semisolid product (Kalia and Sood, 2007).

Canned preserves of chestnut such as chestnut in sugar syrups or chestnut purees were available in Italian and European market (Breisch, 1995; Bounous, 2002).

Preservation of fruits in syrup reduces the available water for microrganisms and the final product acquires organoleptic characteristics that were appreciated by the consumers (Carranza *et al*., 2012).

According to Sethi and Maini (2000), steeping preservation of fruits and vegetables with permissible chemical preservatives was considered as one of the methods to enhance their storability without much quality deterioration. Steeping can be done in salt, sugar or in combination of salt and sugar, along with small quantity of spices.

2.2.4 Preservation by drying

Preservation of foods by drying is one of the oldest methods of processing. Dehydration of food could extend storage life, saves storage space and could be easily handled (Kalia and Sood, 2007).

Cashew nuts were considered as very popular among dry fruits because of its characteristic odour and taste (Shobha *et al*., 1992).

Cashew required a temperature of 65-70°C for 4-6 hours to reduce the moisture content of raw cashew kernels from 9 percent to 3 percent (Mohad *et al*., 2010).

Kader *et al*. (1982) studied about the nut quality of pistachio nut. He observed that the pistachio kernels dried to 4 percent moisture content had higher firmness, crispness and sweetness with less bitter and rancid taste compared to the kernels dried to 11 percent moisture content. Pistachio kernels dried to 11 percent had three fold more rancidity and more than fourfold bitterness than pistachios dried to 4 percent.

Presence of high moisture content in macadamia nut decreased its quality, shelf life and market value, hence the moisture content should be reduced to acceptable limits after harvest as soon as possible (Mason, 2000; Mason *et al*., 2004; Borompichaichartkul *et al*., 2009).

Artificial drying was found to be more effective method to preserve hazelnut than sun drying as reported by Turan and Karaosmanoglu (2019).

According to Bounous (2002), the dried chestnut was considered as a semi manufactured product, which after proper rehydration, could be used in food preparations.

For the storage of tree nuts like almond, Brazil nut, cashew nut, hazelnut, macadamia nut, pecanut, pine nut, pistachio and walnut, the optimum water activity (A_w) of nuts should be less than 0.53 A_w (Venkatachalam and Sathe, 2006).

2.3 Product development

2.3.1 Product development from nuts

Pickling is an age old practice of preservation. Main ingredients for pickling include salt and vinegar. Salt lowers the water activity of food, which makes the environment unfavourable for the growth of microorganisms (Kushner, 1971).

Cashew nut kernel has a pleasant taste and flavour and can be eaten raw, fried and sometimes salted or sweetened with sugar (Manay and Shadaksharaswamy, 1987).

The nutrient rich kernels of cashew nut make it a healthy ingredient for confectionery and bakery products (Agnoloni and Giuliani, 1977; Ohler, 1979; Andrighetti *et al*., 1994; Azam-Ali and Judge, 2001). The use of cashews in breakfast cereals, health food, salads and baked foods as an ingredient makes these as a very good expanding markets for cashew nuts (Azam-Ali and Judge, 2001).

Olife *et al*. (2013) reported that 60 percent of cashew kernels were estimated to be consumed in the form of snacks and the remaining 40 percent were included in confectionery.

Young (2007) reported cashew as one of the most popular salted and roasted nut kernels along with macadamia nut, English walnut, filbert, almond, Brazil nut, peanut and pistachio nut.

Van Ejinatten (1991) reported that the cashew kernels contain 35 – 40 percent high quality edible oil which was found to be comparable enough with olive oil that can be extracted from low grade kernel by cold pressure extraction. The kernel residues after oil extraction can be used to produce kernel butter.

The Kerala State Cashew Development Corporation Ltd. introduced value added products from cashew, and the products were, cashew vita - a nutritious health drink targeted to growing children, cashew soup in powder form, cashew powder, which can be used as thickener in dishes and targeted to house wives and cashew bits mixed with masala that can be eaten as a snack (Retheesh, 2012).

Baby bits are the lowest grade cashew kernels marketed commercially. The sweetened and vanillin flavoured cashew spread is possible and it is more preferred than salted spread (Bhaskara Rao and Swamy, 2002). Baby bits coated with honey, cardamom essential oil and apple green colour were most preferred by tasters. Lower grade kernels are processed into cashew flour which has high protein content and is easily digestible (Kurian and Peter, 2007). Sweetened and flavoured milk could be prepared from cashew kernel baby bits.

A good quality product was prepared from the nuts which are evenly coated with honey solution followed by mixing with sugar-starch mix which will avoid adherence between nuts. Then it was roasted to get a good snack (US Patent, Green *et al*., 1979).

According to Woodroof (1979), the pistachio kernel, because of its deep green colour, is used in ice cream and pastry industries.

Almond nuts peeled or whole nuts serve as ingredients for processed foods such as bakeries, confectionaries and chocolates (Takeoka *et al*., 2000).

Sobhana and Mathew (2014) studied about the utilisation of immature nuts in order to overcome the loss of matured nuts during rainy season. It was reported that immature cashew kernels could be used in culinary preparations like curries along with mushroom, egg, cauliflower or potato and in confectionery preparation like sugar or honey coating. The confectionaries prepared from immature cashew kernels *i.e*., sugar and honey coated kernels, had fairly good acceptance among consumers during organoleptic evaluation.

Cookies when prepared with different combinations of wheat flour and cashew nut paste, the most accepted one during sensory evaluation was the cookies made with a combination of 70% wheat flour and 30% cashew nut paste as reported by Ojinnaka and Agubolum (2013). This combination was better than other combinations like 90% wheat flour + 10% cashew nut paste, 80% wheat flour + 20% cashew nut paste and 60% wheat flour + 40% cashew nut paste.

2.3.2 Product development from non-conventional materials other than nuts

The sensory evaluation of sweet potato pickles prepared by lactic acid fermentation revealed that the pickle prepared using 10% brine rated high in acceptability considering the attributes like texture, taste, aroma, flavour, colour, appearance and aftertaste as reported by Panda *et al*. (2007).

Before pickling of vegetables, the brined vegetables were freshened or debrined to 5% salt using potable water before pickling. But in case of brined olives, they were not freshened but packed in brine containing 8-10% salt and 0.5% lactic acid (Ranken *et al*., 1997).

Blanched cauliflowers steeped in 10 and 15 percent salt solution containing 0.2% potassium metabisulphite remained acceptable for up to 180 days. The preserved cauliflower was freshened and used to prepare pickle and pakora which were ranked above acceptable range for various quality attributes, by a panel of judges (Barwal *et al*., 2005).

Amla murabba (preserve) was developed by Verma *et al*. (2006) by using honey and found that both the fresh and preserved honey based murabba had pleasant flavour, taste, colour, texture and overall acceptability.

According to Anis Alam Siddiqui *et al*. (2012), the preserve of ginger prepared from 70° brix sugar syrup was found best in organoleptic evaluation as it scored highest in colour, flavour, texture and overall acceptability. During the storage of ginger preserve, they could not detect any possible fungal growth up to 60 days.

Durrani *et al*. (2011) observed that the carrot candy prepared in sugar syrup scored highest for all sensory parameters compared to jaggery based candies.

3.MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation on "Product development from tender cashew nut" was carried out in the Department of Post Harvest Technology, College of Horticulture, Vellanikkara, Thrissur, during 2018-2020. The details of the materials used and the methods adopted are discussed in this chapter.

The study was conducted with three experiments:

3.1 Evaluation of cashew varieties for immature kernel characters

3.2 Storage studies of immature cashew kernels

3.3 Product development from immature cashew kernels

3.1 EVALUATION OF CASHEW VARIETIES FOR IMMATURE KERNEL CHARACTERS

Six varieties of cashew were collected from Cashew Research Station, Madakkathara, Thrissur, for evaluating the characters of immature kernels as listed below.

Madakkathara-2

It is a late season variety, flowering in January-March and comes to fruiting in February-May. The variety is a high yielder with medium sized nut and an export grade of W240.

Sulabha

The variety belongs to late season type which yields bold nuts. The export grade is W210 and is highly suitable to the coastal and midlands of the west coast.

Dhana

It is a hybrid that flowers in December-January (mid-season type).the nuts are bold and the export grade is W210. It was released for cultivation in national level.

Priyanka

It is mid-season type hybrid whose nuts and kernel are very bold. The export grade is W180 and it is a very popular variety in Kerala.

Poornima

This variety has desirable characters like high nut weight, high kernel weight and good export grade (W210). It has a mid-season flowering behaviour.

Kanaka

It is an early flowering hybrid with medium sized nut. The export grade of the kernel is W280.

3.1.1 Collection of immature cashew nut and recovery of kernel

The inflorescences of selected cashew varieties were tagged on the day of anthesis. Immature cashew nuts from the tagged inflorescence were collected when they attained the age of 50-55 days and kernels were extracted. Physical and biochemical characters of the kernels were recorded for each variety, as listed below.

Physical characteristics:

Shelling percentage
Kernel weight
Colour of the kernel
External appearance
Kernel shape
Kernel size
Weight of shell
Weight of testa

Plate 1: Tagged inflorescence of cashew

Plate 2: Development of immature cashew nuts

Biochemical characteristics:

Tannin

Carbohydrate

Fat

Protein

Total Sugar

3.1.2 Evaluation for immature kernel characters

3.1.2.1 Shelling percentage

Shelling percentage is the percentage of kernel content which is calculated as percentage weight of kernel to the total weight of cashew nut.

$$\text{Shelling percentage} = \frac{\text{Weight of kernel}}{\text{Total weight of nut}} \times 100$$

3.1.2.2 Kernel weight

The immature kernel was weighed using a standard weighing machine and expressed in grams.

3.1.2.3 Colour of the kernel

Kernel colour was recorded using standard Royal Horticulture Society (RHS) colour chart.

3.1.2.4 External appearance

External appearance of the kernel was noted visually and denoted as smooth or wrinkled as per the guidelines on cashew given by Protection of Plant varieties and Farmer's Rights Authority.

3.1.2.5 Kernel shape

Shape of the kernel was recorded as kidney shaped and oblong-ellipsoid shaped, as per the guidelines on cashew given by Protection of Plant Varieties and Farmer's Rights Authority.

3.1.2.6 Kernel size

Size of the kernel was measured both length wise and width wise using Vernier callipers and expressed in centimetres.

3.1.2.7 Weight of shell

Weight of shell was recorded using a standard weighing machine and expressed in grams.

3.1.2.8 Weight of testa

Testa is the outer covering of cashew kernel, the weight of which was measured using standard weighing machine and expressed in grams.

3.1.2.9 Tannin

Tannins are polyphenolic biomolecules that are widespread in nature and these are probably present in all plant materials. The tannins are estimated by Folin-Denis method which is based on the non-stoichiometric oxidation of the molecules containing a phenolic hydroxyl group. In alkaline medium tannin-like compounds reduce phosphotungstomolybdic acid which produces highly blue coloured solution, the intensity of which is proportional to the amount of tannins (Schanderl, 1970).

Weighed 0.5g of the powdered cashew kernel sample was transferred to a 250ml conical flask. 75ml of water was added to this and the flask was boiled for 30 minutes. Then the content in the flask was centrifuged at 2000 rpm for 20 minutes and the supernatant was collected in 100ml volumetric flask and made up the volume. One ml of the sample extract was transferred to 100ml volumetric flask containing 75ml of water.

Then 5ml of Folin-Denis reagent and 10ml of sodium carbonate were added to the flask followed by diluting to 100ml using distilled water. The flask was shaken well. A blank was prepared using distilled water instead of sample and a standard graph was made using 0-100µg tannic acid. The absorbance was read at 700 nm in a spectrophotometer and the tannin content was calculated as tannic acid equivalents from the standard graph.

3.1.2.10 Carbohydrate

Carbohydrate content was estimated using the anthrone method where the carbohydrates are first hydrolysed into simple sugars using dilute hydrochloric acid followed by dehydration of glucose into hydroxymethyl furfural in hot acidic medium. This compound along with anthrone reagent forms a green coloured product with an absorption maximum at 630nm (Hedge and Hofreiter, 1962).

Weighed 100mg of cashew kernel sample and this was hydrolysed using 5ml of 2.5N hydrochloric acid in a boiling tube by keeping it in a boiling water bath for three hours. After three hours it was cooled to room temperature followed by neutralisation with sodium carbonate. Volume was made up to 100ml and centrifuged to collect the clear supernatant from which 1ml was used as aliquot for analysis.

Different aliquots of standards and extracted samples were pipetted out to test tubes. Volume was made up to 1ml in all test tubes including the blank using distilled water. Then 4ml of anthrone reagent was added to all the test tubes and heated for eight minutes in a boiling water bath after which the test tubes were cooled rapidly to read the absorbance at 630nm in a spectrophotometer. A standard curve was drawn by plotting concentration of standard in x-axis and absorbance on the y-axis and the carbohydrate content was calculated.

3.1.2.11 Fat

A known weight of sample was taken in a thimble which was made using two folds of filter paper. A piece of cotton wool was placed at the top of the thimble to evenly distribute the solvent as it drops during the extraction process. The sample packet was kept

in the soxhlet tube connected to soxhlet apparatus and extraction was carried out using petroleum ether at 60ºC - 80ºC without interruption for six hours. Then it was allowed to cool and the extraction flask was dismantled. The solvent was allowed to evaporate till it weighed constant weight and the following formula was used to calculate the total fat content in immature cashew kernel.

$$\text{Total crude fat (\%)} = \frac{\text{Weight of the fat (g)}}{\text{Weight of sample (g)}} \times 100$$

3.1.2.12 Protein

Protein content was estimated using Lowry's method (Sadasivam and Manickam, 2007). The amino acid (basic unit of protein) in the sample reduces phosphomolybdic-phosphotungstic component present in the Folin-ciocalteau reagent to develop a blue colour. Also, the biuret reaction of protein with the alkaline cupric tartarate produces blue colour. The total intensity of blue colour corresponds to the quantity of protein present in the sample, which was measured at 660nm in a spectrophototmeter.

Immature cashew kernel sample (500mg) was ground using 5-10ml of Tris HCl buffer followed by centrifugation. From this 0.2 ml of supernatant was collected and used for the rest of the estimation. Standards were prepared by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of working standard in test tubes. The sample of 0.2ml was taken in one test tube. The volume of test tube was made up to 1ml using distilled water and another test tube with 1 ml distilled water served as blank. Five ml of reagent C, a mixture of 50ml of reagent A (2% sodium carbonate in 0.1N sodium hydroxide) and 1ml of reagent B (0.5% copper sulphate in 1% potassium sodium tartarate), was added to all the test tubes and were allowed to stand for 10 minutes. This was followed by adding 0.5ml of Folin-ciocalteaus reagent, mixing it well and then incubated in room temperature, in dark, for 30 minutes after which a blue colour was developed. Spectrophotometer readings were taken at 660nm and protein content in the sample was calculated with the help of a standard graph.

3.1.2.13 Total sugars

The total sugar content in the sample was estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of Fehling's solution (Ranganna, 1986).

To estimate the total sugar, 30g of sample was ground in a pestle and mortar and transferred to a 250ml volumetric flask followed by addition of 100 ml distilled water. This solution was clarified with 2ml of 45% neutral lead acetate. The excess lead acetate was neutralised using 2ml of 22% potassium oxalate solution. Then the volume was made up to 250ml using distilled water and filtered the solution. This solution (50ml) was pipetted to a 250ml conical flask and added 5g of citric acid and 50ml of water. It was boiled gently for 10 minutes to complete the inversion of sucrose and then cooled to room temperature. This was transferred to a 250ml volumetric flask and neutralised with 1N sodium hydroxide using phenolphthalein as indicator and the volume was made up to 250ml.

Fehling's solution (10ml) was prepared in a conical flask and the burette was filled with 50ml of the prepared sample solution for titration. Some amount from the burette, which was required to reduce the Fehling's solution, was allowed to the conical flask. Then the content of flask was thoroughly mixed and boiled moderately for 2 minutes. Three drops of methylene blue was added to the solution. Titration was carried out with continuous boiling until the indicator was completely decolourised. The end point was the brick-red colour of precipitated cuprous oxide. Using the volume of the solution used during titration, quantity of total sugar present in the sample was estimated and expressed in percentage.

$$\text{Total sugar (\%)} = \frac{\text{Factor} \times \text{Dilution} \times 100}{\text{Titre value} \times \text{Volume of filtrate} \times \text{Weight of sample}}$$

3.2 STORAGE STUDIES OF CASHEW KERNELS

Immature cashew nuts, at 55 days after flowering, were collected and the kernels were scooped out. Kernels were washed properly in water for three to four times followed by steam blanching for two to three minutes. These kernels were used for storage studies carried out up to four months. Kernels were stored in glass containers and keeping quality of the treatments was assessed at the beginning and end of the storage period.

Design : CRD

No. of treatments : 7

No. of replications : 3

The treatments involved in the experiment are given below.

T_1- Preservation of immature kernels in 5% brine

T_2- Preservation of immature kernels in 10% brine

T_3- Preservation of immature kernels in 15% brine

T_4- Preservation of immature kernels in 50º brix sugar syrup

T_5- Preservation of immature kernels in 60º brix sugar syrup

T_6- Preservation of immature kernels in 70º brix sugar syrup

T_7- Preservation of immature kernels by drying (dried in hot air oven until it reaches a moisture content of 2-3%)

Except for T_7, preservative (0.1% KMS) was added to every treatments along with 0.5% acetic acid to brine solution and 0.5% citric acid to sugar syrup. The following observations were taken at the first and fourth months of storage.

Harvested immature cashew nuts

Immature nuts cut into halves

Scooped out kernels

Shell and testa after extraction of kernels

Plate 3a: Post harvest handling of immature cashew nut

Washing of kernels in water

Steam blanched kernels

Plate 3b: Post harvest handling of immature cashew kernel

3.2.1 Organoleptic evaluation

Quality of immature cashew kernels under different treatments was evaluated by a panel of judges of different age groups for parameters *viz*., appearance, colour, texture, flavour, taste, mouthfeel and overall acceptability. The rating was given based on nine point hedonic sale. The scores were given in the range of 9 (like extremely) - 1 (dislike extremely) for each organoleptic parameter (Austin and Ram, 1971).

3.2.2 Tannin content

Tannin content of the kernels under storage studies was estimated as described in 3.1.3.9.

3.2.3 Microbial count of keeping solution and kernel

In this context, the population of bacteria, fungi and yeast were observed using suitable media.

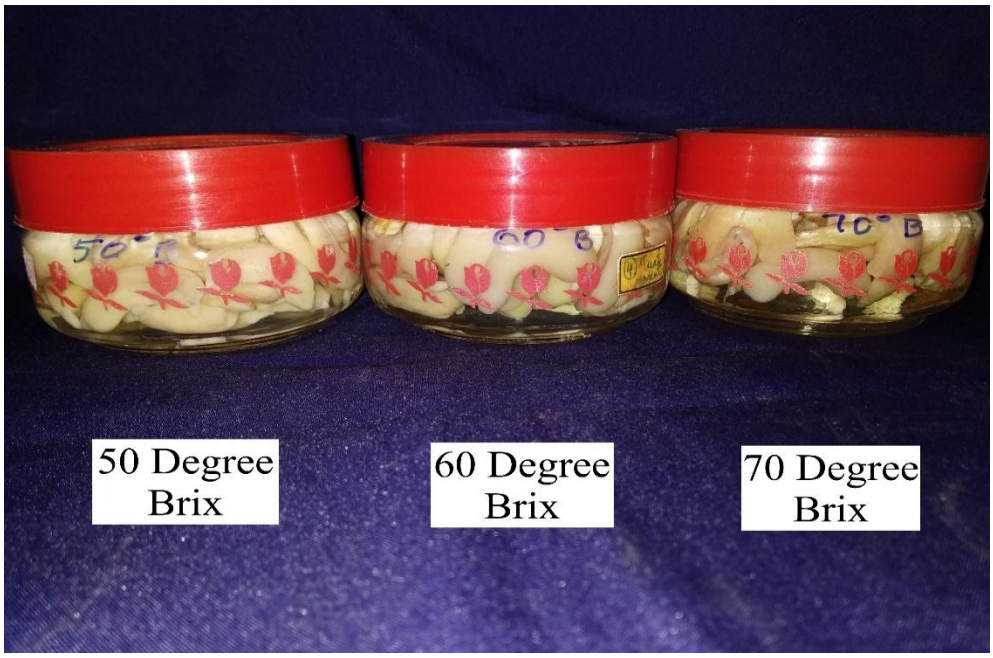
Bacterial population was estimated using 10^{-7} dilution of sample which was micropipetted into a sterile petridish. About 20ml of melted and cooled Nutrient Agar (NA) medium was poured into the petridish in sterile condition and swirled evenly. After solidification, it was kept for incubation for 48 hours. Three replications were kept for each sample. The number of bacterial colonies was counted and expressed as cfu/ml of sample.

Fungal population was estimated using 10^{-3} dilution of sample. One millilitre of the 10^{-3} dilution was poured into a sterilised petridish using a sterile micropipette. Then 20ml of melted and cooled Martin Rose Bengal Agar (MRBA) medium was poured into the petridish and swirled evenly. Three replications were kept for each sample. After solidification, the petridishes were incubated in room temperature for 2-3 days and number of fungal colonies was counted and expressed as cfu/ml of sample.

Total count of yeast was estimated using Sabourad's Dextrose Agar (SDA) medium. Dilution used was 10^{-4} for getting yeast count in the sample. One millilitre of the dilution was micropipetted into a sterile petridish under sterile condition and about 20 ml

of the melted and cooled medium was poured into it. Then it was evenly stirred and kept for incubation at room temperature after solidification. Three petridishes were kept as replication for each sample. Number of yeast colonies on the media were counted after 4-5 days of incubation and expressed as cfu/ml of sample.

Plate 4a: Kernels preserved in different concentrations of brine solution



(a)

(b)

Plate 4b: Kernels preserved in (a) sugar syrup and (b) after drying

4.RESULTS

4. RESULTS

The results of the present investigation entitled 'Product development from tender cashew nut' carried out in the Department of Post Harvest Technology, College of Horticulture, Vellanikkara, Thrissur using varieties collected from Cashew Research Station, Madakkathara, are presented in this chapter under the following headings.

4.1 Evaluation of cashew varieties for immature kernel characters

4.2 Storage studies of immature cashew kernels

4.3 Product development from immature cashew kernels

4.1 EVALUATION OF CASHEW VARIETIES FOR IMMATURE KERNEL CHARACTERS

4.1.1 Physical characteristics of immature cashew kernels of different varieties

The data on the physical characteristics of immature cashew kernels of different varieties are depicted in Table 1a and Table 1b.

4.1.1.1 Shelling percentage

The shelling percentage of the six varieties under evaluation found to be non-significant (Table 1a). However, the highest shelling percentage was observed for Madakkathara-2 (17.88%) and the lowest was for the variety Priyanka (14.83%).

4.1.1.2 Kernel weight

The weight of immature cashew kernels of the selected varieties was found to be statistically non-significant (Table 1a). Highest kernel weight was observed for the variety Poornima with 2.76g, followed by Priyanka (2.64g), Sulabha (2.49g), Dhana (2.23g), Madakkathara-2 (2.18g) and Kanaka (2.17g).

4.1.1.3 Colour of the kernel

The colour of the kernel was visually observed using the RHS colour chart. The kernel colour was observed as pale yellow for Dhana, greenish white for Priyanka and yellowish white for Madakkathara-2, Sulabha, Poornima and Kanaka (Table 1b).

4.1.1.4 External appearance of immature kernels

The external appearance of the immature kernels of the selected varieties was observed visually as with or without wrinkles and as glossy or not. As given in Table 1b, the external appearance observed for the variety Dhana was glossy and smooth and for Priyanka, it was less glossy with wrinkles. For all other varieties *viz*., Madakkathara-2, Sulabha, Poornima and Kanaka, the kernels were glossy with few wrinkles (Plate 6).

4.1.1.5 Immature kernel shape

The kernel shape of the varieties Sulabha, Dhana, Poornima and Kanaka was observed as oblong-ellipsoid (Table 1b). The kernel shape of Madakkathara-2 was oblong and that of Priyanka was observed as kidney shaped.

4.1.1.6 Immature kernel size

Kernel size of the varieties was recorded both length wise and width wise and found to be significantly different with respect to varieties. The immature kernel of variety Priyanka was observed to have the highest mean length (3.21cm) which was found to be on par with that of Poornima (3.08cm). Sulabha had a kernel size of 2.84cm, Madakkathara-2, 2.58cm and Dhana, 2.42cm. The least size was recorded in Kanaka (2.38cm) which was on par with Dhana (2.42cm).

When the kernel size was calculated width wise, variety Priyanka was observed with highest mean width (1.23cm) followed by Sulabha (1.19cm) which was statistically on par with Madakkathara-2 (1.09cm) and Poornima (1.06cm). The least width was observed in Kanaka (0.84cm) which was statistically different from all others.

Madakkathara-2

Dhana

Sulabha

Priyanka

Poornima

Kanaka

Plate 5: Immature cashew kernels of different varieties

Table1a: Physical characteristics of immature cashew kernels of different cashew varieties

Varieties	Shelling percentage (%)	Kernel weight (g)	Kernel size		Weight of shell (g)	Weight of testa (g)
			Length (cm)	Width (cm)		
Madakkathara-2	17.88	2.18	2.58	1.09	8.83	0.75
Sulabha	16.21	2.49	2.84	1.19	11.47	0.87
Dhana	15.68	2.23	2.42	0.96	11.18	0.52
Priyanka	14.83	2.64	3.21	1.23	13.24	1.66
Poornima	16.08	2.76	3.08	1.06	12.81	1.045
Kanaka	16.13	2.17	2.38	0.84	10.39	0.65
CD (5%)	**NS**	**NS**	**0.179**	**0.113**	**2.102**	**0.486**

NS – Non-significant

Table1b:Physical characteristics of immature kernel of different cashew varieties

Varieties	Colour of the kernel	External appearance	Kernel shape
Madakkathara-2	Yellowish white	Glossy with few wrinkles	Oblong
Sulabha	Yellowish white	Glossy with few wrinkles	Oblong-ellipsoid
Dhana	Pale yellow	Glossy and smooth	Oblong-ellipsoid
Priyanka	Greenish white	Less glossy with wrinkles	Kidney
Poornima	Yellowish white	Glossy with few wrinkles	Oblong-ellipsoid
Kanaka	Yellowish white	Glossy with few wrinkles	Oblong-ellipsoid

4.1.1.7 Weight of immature cashew shell

The weight of the immature cashew shell of selected varieties varied significantly. The highest shell weight was observed for the variety Priyanka (13.24g) which was on par with Poornima (12.81g). It was followed by the varieties Sulabha (11.47g) and Dhana (11.18g). Madakkathara-2 had the least shell weight (8.83g) and was found to be on par with the variety Kanaka (10.39g).

4.1.1.8 Weight of Testa

The weight of testa of the varieties under study ranged between 0.52g to 1.66g. The highest testa weight was observed for Priyanka (1.66g) which was significantly superior to all others. The weight of testa of Poornima was 1.05g which was on par with Sulabha (0.87g), Madakkathara-2 (0.75g) and Kanaka (0.65g). The least testa weight was observed for Dhana (0.52g) which was on par with Sulabha, Madakkathara-2and Kanaka.

4.1.2 Biochemical characteristics of immature cashew kernels of different cashew varieties

The biochemical characters analysed for the varieties under study included tannins, carbohydrates, fat, protein and sugar, and the data are presented in Table 2.

4.1.2.1 Tannins

The level of tannins estimated in the immature kernels of the varieties under study varied between 0.19% - 0.23%. The highest estimated content of tannins among the six varieties was for Poornima (0.23%) which was on par with Priyanka (0.22%) and Dhana (0.21%). The least tannin content was recorded for Sulabha and Kanaka (0.19% for each).

4.1.2.2 Carbohydrates

There was significant difference in the carbohydrates content of kernels of the selected varieties as presented in Table 2. The average carbohydrate content varied between 4.9% (Dhana) - 9.6% (Kanaka). The variety Priyanka was on par with kanaka and these were superior to all other varieties under study.

4.1.2.3 Fat

The fat content of immature cashew kernels varied significantly with the varieties. The average fat content was highest for the variety Poornima with 9.08% fat which was on par with Kanaka (8.16%) and Sulabha (7.82%). Priyanka had a fat content of 7.27%. Dhana had the minimum fat content of 5.08% which was on par with Madakkathara-2 (6.05%).

4.1.2.4 Protein

The protein content also varied significantly with the varieties. The highest protein content was estimated for the variety Priyanka with a value of 12.46% which was on par with Poornima (10.27%). The protein content of Madakkathara-2 was 8.89%. The least protein content was estimated for Dhana (7.29%) which was on par with Sulabha (7.60%) and Kanaka (7.36%).

4.1.2.5 Total sugars

Sugar was not detected in the immature kernel of any of the selected cashew varieties.

Table 2: Biochemical characteristics of immature cashew kernels of different cashew varieties

Varieties	Tannins (%)	Carbohydrates (%)	Fat (%)	Protein (%)	Sugar (%)
Madakkathara-2	0.21	5.92	6.05	8.89	ND
Sulabha	0.19	6.65	7.82	7.60	ND
Dhana	0.21	4.88	5.08	7.29	ND
Priyanka	0.22	9.30	7.27	12.45	ND
Poornima	0.23	7.35	9.08	10.26	ND
Kanaka	0.19	9.63	8.16	7.36	ND
CD (5%)	**0.024**	**0.408**	**1.447**	**2.545**	**-**

ND – Not detected

4.2 STORAGE STUDIES OF IMMATURE CASHEW KERNELS

The immature cashew kernels were stored employing seven treatments and observations were taken at the starting and end of the storage period which was four months.

4.2.1 Organoleptic evaluation

The immature kernels stored in brine solution and sugar solution and those of dry storage were evaluated organoleptically by a judging panel of fifteen members and the score results are presented in Tables 3 and 4. Among the seven treatments, the flavour of immature kernels in sugar syrup was preferred over those in brine solution and dried ones, both at the beginning and end of the storage time (Table 3 and 4). After one month of storage, it was observed that overall acceptability was highest for the kernels preserved in 70°B sugar syrup followed by kernels in 60°B and 50°B sugar syrups. Among the kernels preserved in brine, highest acceptability was for the kernels preserved in 10 percent brine solution followed by the dried kernels. Least overall acceptability was observed for kernels preserved in 15% brine solution.

After four months of storage, the most accepted treatment was 10% brine followed by 60°B sugar syrup. T_1 (kernels in 5% brine) and T_3 (kernels in 15% brine) were found unacceptable, since the mean value of overall acceptability was less than five (3.80 for T_1 and 3.27 for T_2). The dried kernels were also observed as less acceptable to the judging panel because of the development of off taste.

4.2.2 Tannin content

Tannin content could not be detected in the kernels after first and fourth month of storage in any of the treatments.

4.2.3 Microbial count of keeping solution and kernel

The bacterial, fungal and yeast count were assessed separately for the keeping solution and kernel from all treatments and the data are presented in Table 5 and Table 6. The maximum bacterial count was observed in 5% brine solution (0.93×10^7 cfu/ml) followed by 50° B syrup (0.77×10^7 cfu/ml), after first month of storage. After four months of storage bacterial count was reduced to 0.86×10^7 cfu/ml in 5% brine and

Kernels in 5% Brine

Kernels in 10% Brine

Kernels in 15% Brine

Kernels in 50° Brix syrup

Kernels in 60° Brix syrup

Kernels in 70° Brix syrup

Dried kernels

Plate 6: Immature cashew kernels stored in brine, sugar syrup and after drying

Table 3: Effect of preservation treatments on organoleptic qualities of immature cashew kernels at first month of storage

Treatments	Appearance	Colour	Texture	Flavour	Taste	Mouth feel	Overall acceptability
T_1	6.27	6.33	6.53	5.93	6.00	6.40	6.27
T_2	7.27	7.53	7.27	6.40	5.93	6.07	7.00
T_3	6.93	7.20	6.67	5.93	5.47	5.73	6.13
T_4	6.87	6.73	6.20	6.67	6.73	6.47	7.07
T_5	7.27	7.20	6.73	7.13	7.13	6.80	7.60
T_6	7.60	7.53	7.07	7.40	7.27	7.00	7.80
T_7	5.73	5.33	6.13	6.47	6.87	6.87	6.87
Kendall's W Test	**0.272**	**0.453**	**0.147**	**0.017**	**0.245**	**0.060**	**0.317**

T_1- Kernels preserved in 5% brine

T_2- Kernels preserved in 10% brine

T_3- Kernels preserved in 15% brine

T_4- Kernels preserved in 50º brix sugar syrup

T_5- Kernels preserved in 60º brix sugar syrup

T_6- Kernels preserved in 70º brix sugar syrup

T_7- Kernels preserved by drying

Table 4: Effect of preservation treatments on organoleptic qualities of immature cashew kernels at fourth month of storage

Treatments	Appearance	Colour	Texture	Flavour	Taste	Mouth feel	Overall acceptability
T_1	5.00	4.33	4.87	3.80	3.67	3.40	3.80
T_2	8.00	7.80	7.47	7.07	7.00	7.07	7.60
T_3	4.60	3.67	4.33	3.47	3.13	3.00	3.27
T_4	6.67	6.93	6.60	6.40	6.00	6.20	6.60
T_5	7.07	6.73	7.20	6.60	6.33	6.53	7.00
T_6	7.53	7.60	7.33	7.07	7.07	7.00	7.40
T_7	4.93	4.53	4.67	5.13	4.67	4.73	5.40
Kendall's W Test	**0.730**	**0.794**	**0.607**	**0.527**	**0.571**	**0.600**	**0.608**

T_1- Kernels preserved in 5% brine

T_2- Kernels preserved in 10% brine

T_3- Kernels preserved in 15% brine

T_4- Kernels preserved in 50º brix sugar syrup

T_5- Kernels preserved in 60º brix sugar syrup

T_6- Kernels preserved in 70º brix sugar syrup

T_7- Kernels preserved by drying

0.26×10^7 cfu/ml in 50°B sugar syrup (Table 5). The fungal count, estimated at first month of storage, was high in 5% brine (0.42×10^3 cfu/ml) and 50°B sugar syrup (0.36×10^3 cfu/ml). This count was increased to 0.48×10^3 cfu/ml in 50° B sugar syrup and to 0.75×10^3 cfu/ml in 5% brine. There was no detectable fungal population in the sugar solution of T_3 (15% brine), T_5 (60°B sugar syrup) and T_6 (70°B sugar syrup) at both first and fourth months of storage. At first month of storage, the yeast population could only be detected in 5% brine solution (0.36×10^4 cfu/ml) whereas it could be detected in 50°B sugar syrup (0.42×10^4 cfu/ml) after four months of storage.

Similarly, in case of kernels, the highest bacterial count was observed for those in 5% brine (0.82×10^7 cfu/ml) followed by kernels in 50°B sugar syrup (0.63×10^7 cfu/ml) at first month of storage (Table 6). After four months of storage, the bacterial count was 0.73×10^7 cfu/ml in kernels of 5% brine and 0.3×10^7 cfu/ml in kernels of 50°B sugar syrup. For rest of the treatments, bacteria were undetectable at both first and fourth months of storage. The fungal count was highest for the kernels stored in 50°B sugar syrup (0.63×10^3 cfu/ml) at first month of storage and the count after four months of storage was 0.6×10^3 cfu/ml. The fungal count of kernels of T_2 (10% brine) and T_7 (dried) was nil at first month of storage and then increased to 0.1×10^3 cfu/ml for both the treatments. Yeast population was detected in kernels of 5% brine (0.1×10^4 cfu/ml) and 50°B sugar syrup (0.1×10^4 cfu/ml) at first month of storage which increased to 0.3×10^4 cfu/ml in T_1 kernels (5% brine) and 0.42×10^4 cfu/ml in T_4 kernels (50°B sugar syrup). The microbial population was not detected in the kernels of 70°B sugar syrup.

Table 5: Microbial count of the keeping solution in different storage treatments

Treatments	Bacteria (10^7 cfu/ml)		Fungi (10^3 cfu/ml)		Yeast (10^4cfu/ml)	
	1 MAS	**4 MAS**	**1 MAS**	**4 MAS**	**1 MAS**	**4 MAS**
T_1 (5% brine)	7.67 (0.93)	6.33 (0.86)	1.67 (0.42)	4.67 (0.75)	1.33 (0.36)	1.67 (0.42)
T_2 (10% brine)	0.00	0.00	0.00	0.33 (0.10)	0.00	0.00
T_3 (15% brine)	0.00	0.00	0.00	0.00	0.00	0.00
T_4 (50°B syrup)	5.00 (0.77)	1.67 (0.26)	1.33 (0.36)	2.00 (0.48)	0.00	1.67 (0.42)
T_5 (60°B syrup)	0.00	0.00	0.00	0.00	0.00	0.00
T_6 (70°B syrup)	0.00	0.00	0.00	0.00	0.00	0.00
CD (5%)	**0.111**	**0.327**	**0.204**	**0.140**	**0.074**	**0.104**

MAS - Months after storage (Logarithmically transformed values are given in parenthesis)

Cfu/ml - Colony forming unit per ml

Table 6: Microbial count of the kernels preserved in different storage treatments

Treatments	Bacteria (10^7 cfu/ml)		Fungi (10^3 cfu/ml)		Yeast (10^4 cfu/ml)	
	1 MAS	**4 MAS**	**1 MAS**	**4 MAS**	**1 MAS**	**4 MAS**
T_1 (5% brine)	5.67 (0.82)	4.33 (0.73)	0.67 (0.20)	1.67 (0.42)	0.33 (0.10)	1.00 (0.30)
T_2 (10% brine)	0.00	0.00	0.00	0.33 (0.10)	0.00	0.00
T_3 (15% brine)	0.00	0.00	0.00	0.00	0.00	0.00
T_4 (50°B syrup)	3.33 (0.63)	1.00 (0.30)	3.33 (0.63)	3.00 (0.60)	0.33 (0.10)	1.67 (0.42)
T_5 (60°B syrup)	0.00	0.00	0.00	0.00	0.00	0.00
T_6 (70°B syrup)	0.00	0.00	0.00	0.00	0.00	0.00
T_7 (dried)	0.00	0.00	0.00	0.33 (0.10)	0.00	0.00
CD (5%)	**0.045**	**0.030**	**0.121**	**0.176**	**NS**	**0.067**

MAS - Months after storage (Logarithmically transformed values are given in parenthesis)
Cfu/ml - Colony forming unit per ml
NS - Non-significant

4.3 PRODUCT DEVELOPMENT FROM IMMATURE CASHEW KERNELS

Many products were prepared from the immature cashew kernels after four months of storage which were preserved employing various treatments. The products were salted bits and pickle from kernels preserved in brine; dried bits and preserve from kernels preserved in sugar syrup; and cashew ball, cookies, jaggery coated cashew bits and honey coated cashew bits from kernels preserved after drying. These products were compared with those made from fresh immature cashew kernels and the results of the organoleptic scoring are presented in Table 5 to Table 8.

4.3.1 Organoleptic evaluation

4.3.1.1 Evaluation of products prepared from kernels stored in brine solution

The organoleptic evaluation of products prepared from the kernels preserved in salt solution at different concentrations revealed that the salted bits were less acceptable (overall acceptability score 4.93-5.93) than pickles (overall acceptability score 6.20-6.80). Among the salted bits, those prepared from 15% brine had the least acceptance with the overall acceptability score of less than five (4.93) on the nine point Hedonic scale. Pickles prepared from all the three salt concentrations did not differ much in organoleptic qualities (Table 5). However, pickle prepared from kernels of 10% brine was found comparatively better acceptable. When these three pickles were compared with the pickle prepared from fresh immature cashew kernels, the latter had higher overall acceptability (6.80), but the difference was only narrow.

4.3.1.2 Evaluation of products prepared from kernels stored in sugar syrup

The kernels stored in sugar syrup were used to prepare dried bits and preserve and the results of sensory scoring are presented in Table 6. Dried bits made from all the three concentrations of sugar syrup *viz*., 50° brix, 60° brix and 70° brix, were almost similar in organoleptic qualities and all of them scored above seven in overall acceptability. Scores for taste and mouth feel were the same for all the three products. The preserve from 70° brix sugar syrup after four months of storage was compared with the preserve prepared from fresh kernels and it was observed that the latter was less

acceptable to the judging panel (Table 6). Fresh kernel preserve got a score of 6.60 for overall acceptability, while it was 7.40 for that from stored kernel.

4.3.1.3 Evaluation of products prepared from dried kernels

Products prepared from dried kernels after four months of storage were evaluated organoleptically and the results are presented in Table 7. The most accepted product from dried kernel was cashew ball (overall acceptability score 6.73-7.80). And among the three types of preparations, cashew balls prepared with ingredients like cashew powder, rice powder and jaggery, had the highest overall acceptability (score 7.80). Jaggery coated cashew kernel bits had the least acceptability among all the products with the least score for all the parameters evaluated (Table 7). The same products were prepared from fresh kernels also and subjected to organoleptic scoring. Highest acceptability score for products from fresh kernels was observed for cashew balls prepared using ingredients like cashew powder, rice powder and jaggery, the same recipe as observed in the organoleptic evaluation of dried kernel products. Similarly the least accepted product was honey coated cashew bits with all score values being the minimum (overall acceptability score 5.47).

4.3.2 Microbial count of syrup and kernel

The microbial count of syrup and kernel were analysed for the preserve made from both fresh kernels and kernels preserved in sugar syrup. There were no microbial count that could be detected in the fresh preserve and in the preserve after four months storage.

Table 7: Organoleptic evaluation of the products prepared from kernels preserved in brine solution

Products		Appearance	Colour	Texture	Flavour	Taste	Mouth feel	Overall acceptability
Salted bits from kernels stored in	**5% brine**	6.13	6.20	6.07	5.87	5.73	5.93	5.93
	10% brine	6.33	6.33	6.13	5.80	5.47	5.33	5.60
	15% brine	6.13	6.33	5.67	4.73	4.47	4.40	4.93
Kendall's W Test		**0.102**	**0.049**	**0.028**	**0.174**	**0.200**	**0.325**	**0.299**
Pickle prepared from kernels in	**5% brine**	7.60	7.53	6.53	6.40	6.20	6.27	6.20
	10% brine	7.80	7.80	7.00	6.87	6.80	6.53	6.60
	15% brine	8.00	7.33	6.73	6.40	6.20	6.40	6.27
	Fresh kernels	7.13	7.27	7.00	7.13	6.80	6.80	6.80
Kendall's W Test		**0.264**	**0.106**	**0.100**	**0.165**	**0.129**	**0.092**	**0.165**

Dried kernel bits from 5% brine

Dried kernel bits from 10% brine

Dried kernel bits from 15% brine

Pickle from kernel bits preserved in 5 % brine

Pickle from kernel bits preserved in 10% brine

Pickle from kernel bits preserved in 15% brine

Pickle from fresh kernels

Plate 7: Products prepared from kernels preserved in brine solution of different concentration and fresh kernels

Dried kernel bits from 50° brix sugar syrup

Dried kernel bits from 60° brix sugar syrup

Dried kernel bits from 70° brix sugar syrup

Preserve from stored kernel

Preserve from fresh kernel

Plate 8: Products prepared from kernels preserved in sugar syrup at different concentrations and fresh kernels

Table 8: Organoleptic evaluation of the products prepared from kernels preserved in sugar syrup and fresh kernel

Products		Appearance	Colour	Texture	Flavour	Taste	Mouth feel	Overall acceptability
Dried bits from kernels preserved in	**50° brix**	7.27	7.40	7.20	7.27	7.13	7.20	7.33
	60° brix	7.53	7.53	7.00	7.27	7.13	7.20	7.13
	70° brix	7.60	7.47	7.27	7.00	7.13	7.20	7.27
Kendall's W Test		**0.175**	**0.022**	**0.079**	**0.002**	**0.000**	**0.000**	**0.036**
Kernel preserve from	**70° brix**	7.53	7.60	7.33	7.07	7.07	7.00	7.40
	Fresh kernels	5.73	5.53	6.73	6.60	6.60	6.60	6.60
Kendall's W Test		**0.356**	**0.305**	**0.089**	**0.200**	**0.200**	**0.152**	**0.200**

Table 9: Organoleptic scoring of the products prepared from dried kernels after the storage period of four months

Products from dried kernels		Appearance	Colour	Texture	Flavour	Taste	Mouth feel	Overall acceptability
Cashew ball	**Recipe 1**	7.73	7.53	7.33	7.40	7.67	7.60	7.80
	Recipe 2	7.80	7.60	7.80	7.07	7.07	7.00	7.40
	Recipe 3	7.00	7.47	6.87	6.73	6.60	6.80	6.73
Cashew cookies		7.73	7.80	6.87	6.87	6.87	6.80	6.87
Honey coated kernel bits		6.93	6.80	7.00	6.80	6.53	6.53	6.60
Jaggery coated kernel bits		6.33	6.40	6.20	6.13	6.13	5.87	6.07
Kendall's W test		**0.290**	**0.312**	**0.197**	**0.040**	**0.138**	**0.202**	**0.215**

Recipe 1- Cashew ball with cashew powder, rice powder and jaggery

Recipe 2- Cashew ball with cashew powder, rice powder, jaggery and coconut

Recipe 3- Cashew ball with cashew powder, rice powder, jaggery, dried ginger powder and cumin powder

Table 10: Organoleptic scoring of the products prepared from fresh kernels

Products from freshly dried kernels		Appearance	Colour	Texture	Flavour	Taste	Mouth feel	Overall acceptability
Cashew ball	**Recipe 1**	7.53	7.40	7.60	7.53	8.00	7.87	7.87
	Recipe 2	7.53	7.73	7.80	7.60	8.00	7.67	7.67
	Recipe 3	6.73	6.60	7.00	7.13	7.00	6.67	7.00
Cashew cookies		7.60	7.67	7.4	7.40	7.53	5.33	7.53
Honey coated kernel bits		6.73	6.40	6.13	6.13	5.33	5.80	5.47
Jaggery coated kernel bits		5.47	5.40	5.73	6.20	6.00	5.67	5.60
Kendall's W test		**0.432**	**0.573**	**0.596**	**0.235**	**0.507**	**0.473**	**0.492**

Recipe 1- Cashew ball with cashew powder, rice powder and jaggery

Recipe 2- Cashew ball with cashew powder, rice powder, jaggery and coconut

Recipe 3- Cashew ball with cashew powder, rice powder, jaggery, dried ginger powder and cumin powder

Cashew balls from stored kernel	Cashew balls from fresh kernel

Cashew balls made from recipe 1

Cashew balls made from recipe 2

Cashew balls made from recipe 3

Plate 9: Cashew balls made from fresh and stored kernels

Products from stored kernel

Products from fresh kernel

Cookies prepared from cashew kernel bits

Jaggery coated cashew kernel bits

Honey coated cashew kernel bits

Plate 10: Products prepared from fresh and stored cashew kernels

5.DISCUSSION

5. DISCUSSION

The research work entitled 'Product development from tender cashew nut' was conducted at the Department of Post Harvest Technology, College of Horticulture, Vellanikkara to study about the utilisation of immature cashew kernels. The research was carried out in three different experiments and the results of these experiments are briefly discussed under the following headings.

5.1 Evaluation of cashew varieties for immature kernel characters

5.2 Storage studies of immature cashew kernels

5.3 Product development from immature cashew kernels

5.1 EVALUATION OF CASHEW VARIETIES FOR IMMATURE KERNEL CHARACTERS

The varieties under study included Madakkathara-2, Sulabha, Dhana, Priyanka, Poornima and Kanaka. Immature nuts of these varieties were harvested at 55 days after flowering and different physical and biochemical characteristics were studied.

5.1.1 Physical characteristics of immature kernels of six cashew varieties

The highest mean value of shelling percentage for immature nuts was observed for the variety Madakkathara-2 (17.88%) and the least was for Priyanka (14.83%). However, shelling percentage was statistically non-significant among the varieties studied (Figure 1). Sobhana and Mathew (2014) reported the shelling percentage (kernel recovery) of immature cashew nuts as 32.7% for Madakkathara-1, 22% for Vridhachalam-3, 20.7% for Priyanka, 18.3% for Dhana, 18% for Poornima and 17% for Damodhar. The immaturity of nuts might have resulted in the lesser shelling percentage. Shelling percentage for the mature nuts of cashew varieties Madakkathara-2, Sulabha, Dhana, Priyanka and Poornima, as reported by Jayaprakash Naik (2009) were 26, 29.4, 29.8, 26.57 and 31 percent respectively.

The immature kernel weight recorded for the varieties ranged from 2.173g (Kanaka) to 2.759g (Poornima), Poornima having the highest kernel weight even though there was no significant difference (Figure 2). Jayaprakash Naik (2009) reported the kernel weight for mature nuts of different varieties *viz*., 1.88g for Madakathara-2, 2.88g for sulabha, 2.44g for Dhana, 2.87g for Priyanka, 2.6g for Poornima and 2.08g for kanaka. From these results, it is clear that the kernel weight is not much influenced by the maturity of nuts.

Colour of the immature cashew kernel was observed as pale yellow for Dhana, greenish white for Priyanka and yellowish white for Madakkathara-2, Sulabha, Poornima and Kanaka. Arogba (1999) reported pale yellow colour for cashew nut kernels while making comparison of kolanut (*Cola nitida*) and cashew nut kernels. According to Azam-Ali and Judge (2001), good quality cashew kernels had slightly off-white colour.

The immature kernels of the cashew varieties Madakkathara-2, Sulabha, Poornima and Kanaka were observed as glossy along with few wrinkles on external appearance unlike Dhana, which had glossy and smooth kernels, and Priyanka, with wrinkles and less glossy kernels.

The shape of the immature kernels varied with varieties. The immature kernel was observed as oblong-ellipsoid for Sulabha, Dhana, Poornima and Kanaka; oblong for Madakkathara-2 and kidney shaped for Priyanka. Arogba (1999) reported the shape of cashew kernel as crescent shape.

The highest immature kernel size, when measured lengthwise, was observed for the variety Priyanka (3.20cm) followed by Poornima (3.08cm), Sulabha (2.84cm), Madakkathara-2 (2.58cm), Dhana (2.42cm) and Kanaka (2.38cm). Kernel size, when measured width wise, Priyanka (1.23cm) was found to have the highest mean value (Figure 3). Arogba (1999) reported the dimensions of matured cashew kernel as 2.5 ± 0.3cm length wise and 0.9 ± 0.2cm width wise. According to Pushpalatha (2009), the nut length, width and thickness increased up to 40 days after fertilisation and declined later. This is in agreement with the present findings.

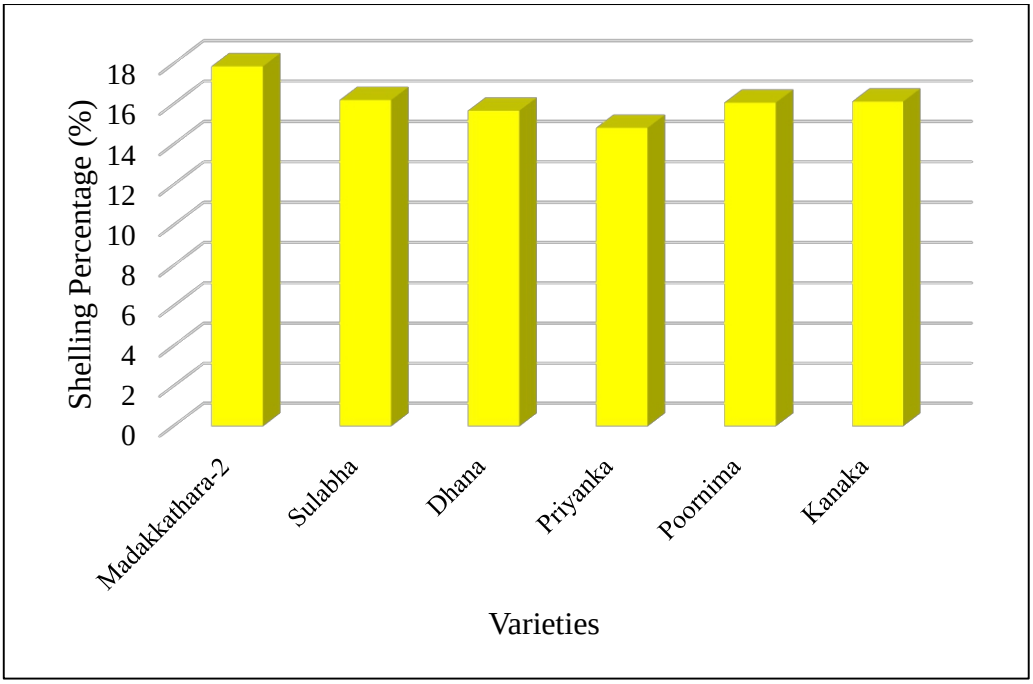


Figure 1: Shelling percentage of different varieties

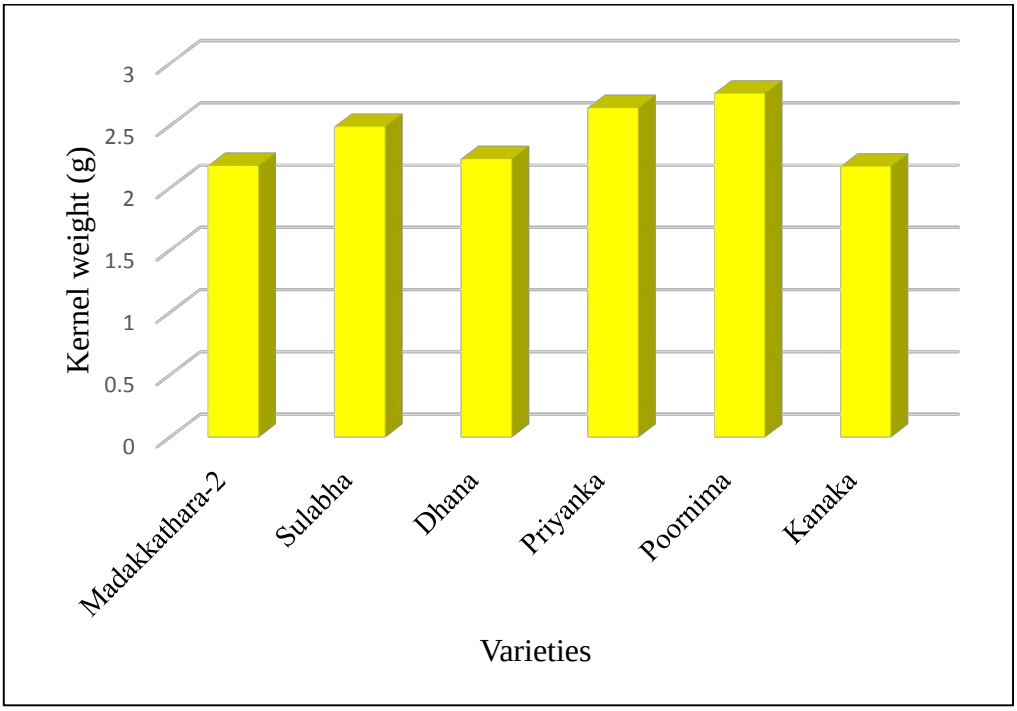


Figure 2: Kernel weight of different varieties

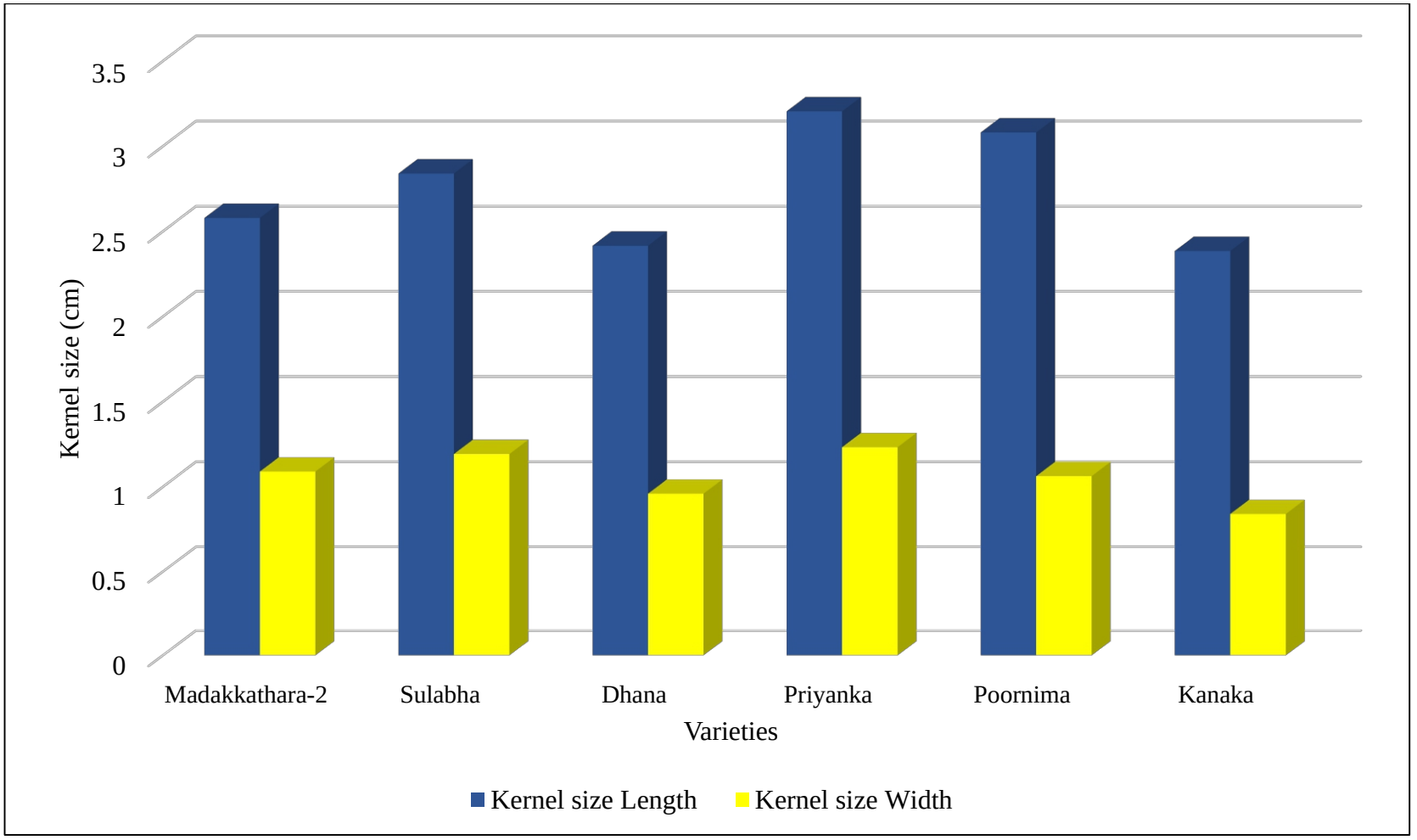


Figure 3: Kernel size measured in length and width of immature cashew kernels for different varieties

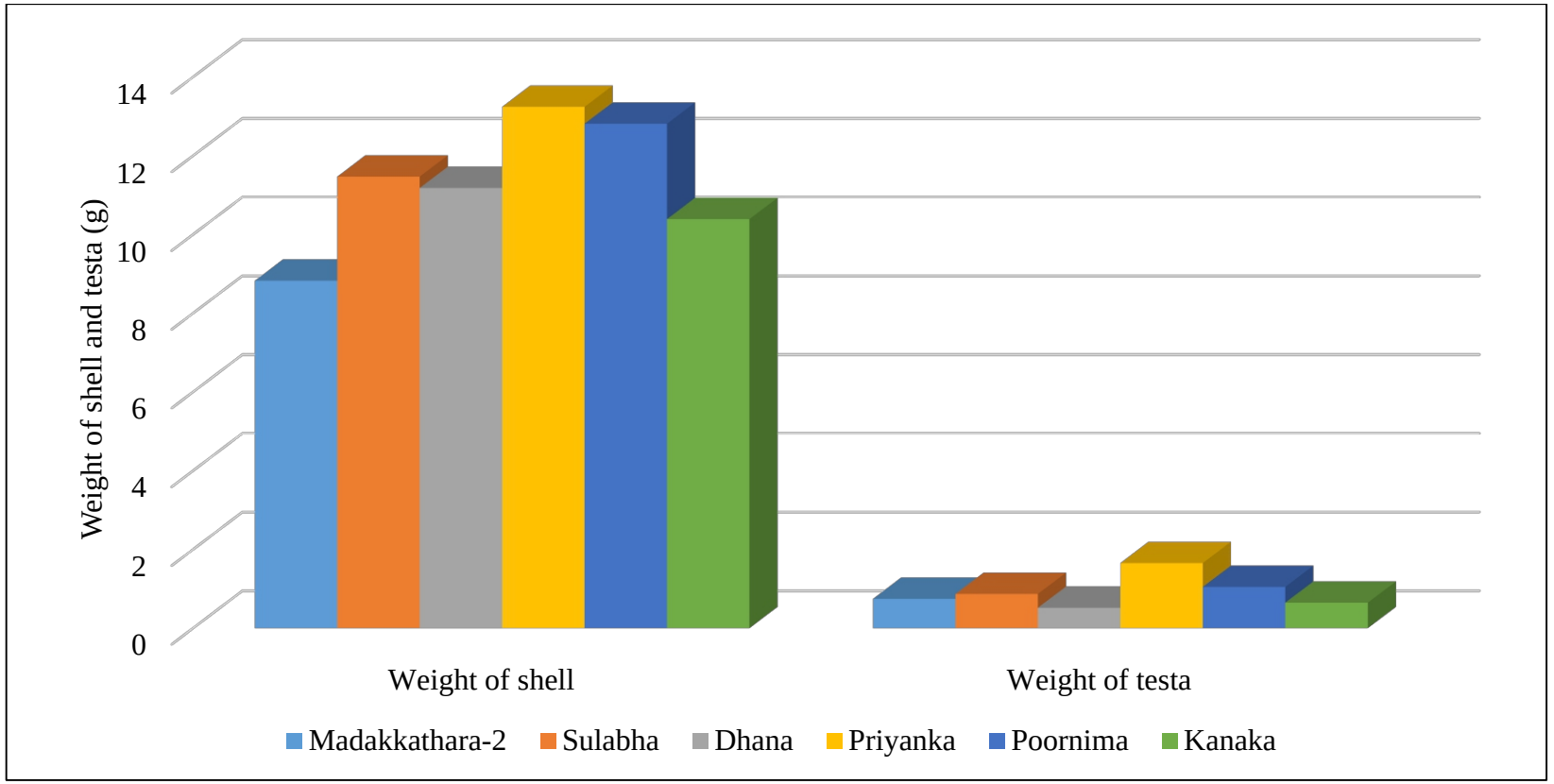


Figure 4: Weight of shell and testa of different varieties

Weight of shell and testa were the other physical parameters evaluated for the selected varieties. Both characters were observed maximum for the variety Poornima with shell weight of 13.24g and testa weight of 1.65g. The minimum shell weight was observed for Madakkathara-2 (8.83g) and minimum testa weight was for Dhana (0.52g) (Figure 4).

5.1.2 Biochemical characteristics of immature kernels of cashew varieties

The estimated tannin content was very low in immature cashew kernels and did not vary much with respect to varieties studied. The tannin content of the varieties were 0.19% for Sulabha and Kanaka, 0.21% for Madakkathara-2, 0.21% for Dhana, 0.22 for Priyanka and 0.23% for Poornima, Poornima having the highest value (Figure 5). This is in conformity with the finding of Sobhana and Mathew (2014), wherein tannin was reported as 0.22% for Dhana, 0.24% for Priyanka and 0.26% for Poornima. According to Nair (2003) and Salam and Peter (2010), the cashew peel, also called as testa, was rich in tannin content (24-26%). Since the cashew kernel is tightly adhered to this testa at the early stages of development, there might be more chance for immature kernels to contain more amount of tannins.

The carbohydrate content of the varieties varied with the varieties (Figure 6). The carbohydrate content estimated was 9.63% for Kanaka, 9.3% for Priyanka, 7.35% for Poornima, 6.65% for Sulabha, 5.92% for Madakkathara-2 and 4.88% for Dhana. Carbohydrate content of immature cashew kernel was not reported in earlier works. Carbohydrate content of immature cashew kernel was found to be less and might be increasing towards maturity of nuts. There are many reports on the carbohydrate content of mature kernels. According to Nair (2009), the carbohydrate content for mature cashew kernel was recorded as 25 percent. In another study by Ogunsina (2013), the carbohydrate content reported for mature cashew kernel was 24.19 percent.

The average fat content ranged between 5.08% - 9.08% among the varieties (Figure 7). The variety Poornima was superior (9.08%) followed by Kanaka (8.16%) among the six varieties. Dhana had the least fat content of

5.08%. As in the case of carbohydrates, fat content also might be increasing with advancement of maturity and cashew nut is regarded as one of the nuts rich in fat, especially monounsaturated and poly unsaturated fatty acids. There are reports pertaining to fat content of mature cashew kernels. Pearson (1976) reported the average fat content of cashew kernel as 46 percent; Akinhanmi *et al*. (2008) and Nair (2009) reported the fat content in matured cashew kernels as 49.1% and 47% respectively. Ogunsina (2013) reported the crude fat content as 42.19 percent in matured cashew kernels. Thus, it is evident that the fat content of cashew kernel increases with maturity and development, and immature kernel contain very little fat as observed from the present study.

The average protein content varied significantly with varieties. Highest protein content was estimated for the variety Priyanka (12.46%). This was followed by Poornima (10.27%) and Madakkathara-2 (8.89%). The least protein content was estimated for Dhana (7.29%) which was on par with Sulabha and Kanaka (Figure 8). Panda and Pal (1993) reported protein content in mature cashew kernel as 14.27% - 14.33% while it was 20% as reported by Bhattacharjee *et al*. (2003a). Venkatachalam and Sathe (2006) reported the protein content as 18.81 ± 0.06% whereas it was 21% as reported by Nair (2009). According to Ogunsina (2013), the protein content of matured cashew kernel was 21.32%. Protein content of immature kernel was found lesser than that of mature kernel. However, when compared to other biochemical parameters like carbohydrate and fat, much difference could not be noticed with respect to protein content of immature and mature kernels which makes utilization of immature kernel as a healthy food item especially in the growing stages.

Sugar content could not be detected in the immature kernels of any of the varieties. According to Venkatachalam and Sathe (2006), the sugar content of matured cashew kernel was estimated as 3.96 ± 0.08g per 100g kernel. Griffin and Dean (2017) reported the sugar content of raw cashew kernels as 6.0 ± 0.26%. Accordingly, the sugar content in the matured kernels is very less when compared to carbohydrate, fat and protein. This might be the reason for not getting detectable quantity of sugar in the immature stage of the kernel.

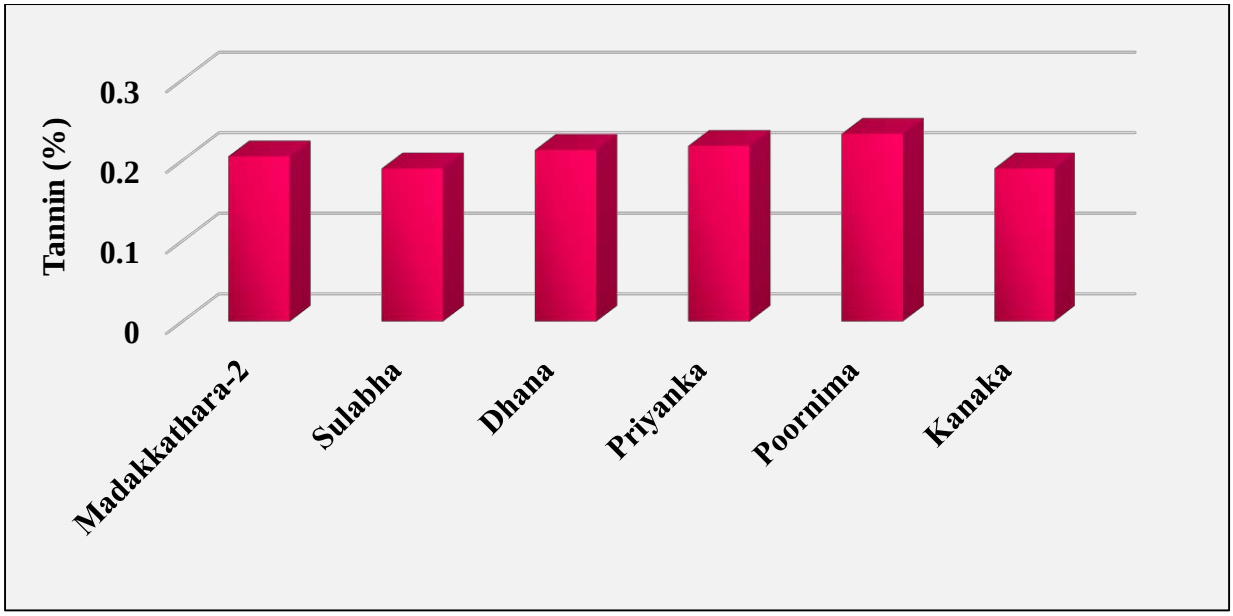


Figure 5: Estimated tannin content for immature cashew kernels of six varieties

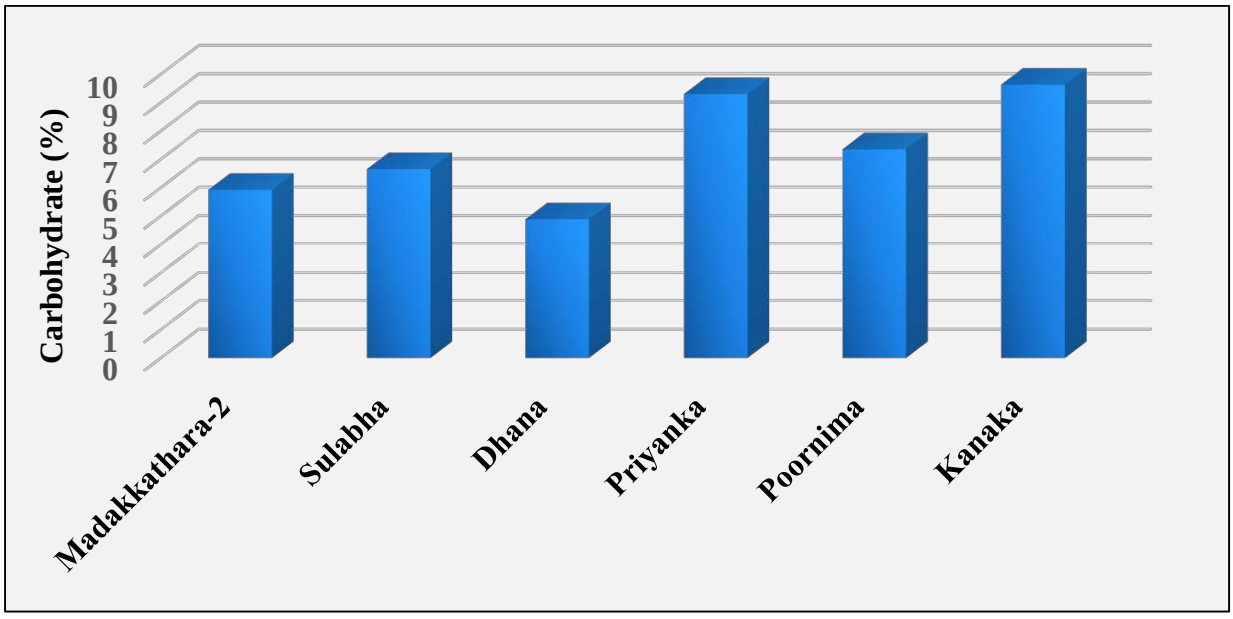


Figure 6: Estimated carbohydrate content for immature cashew kernels of six varieties

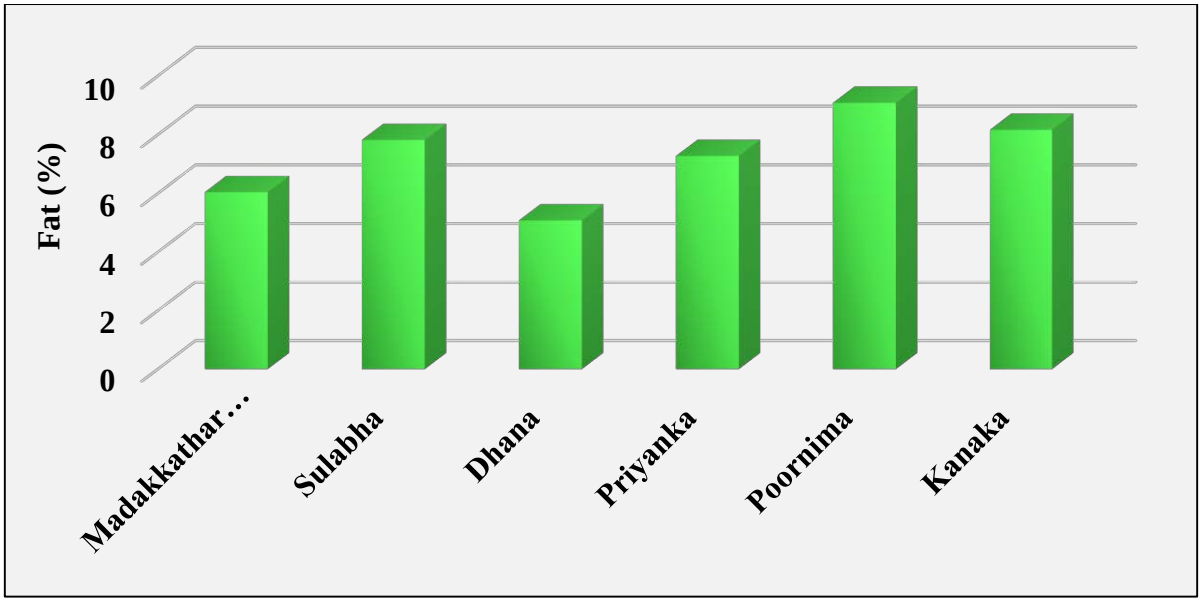


Figure 7: Estimated fat content for immature cashew kernels of six varieties

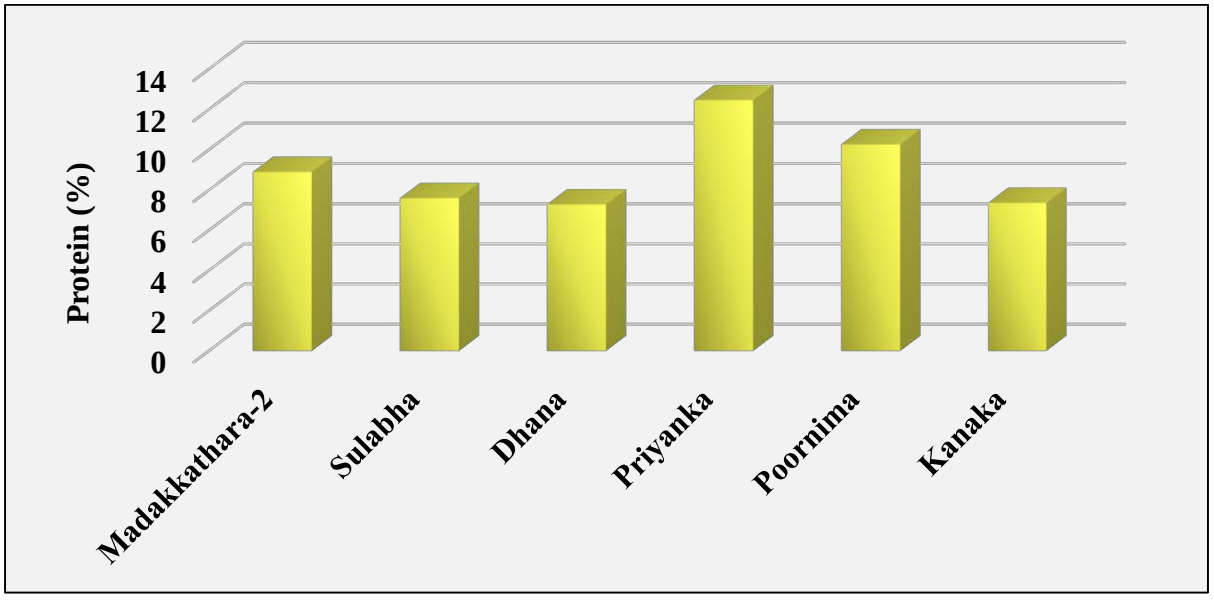


Figure 8: Estimated protein content for immature cashew kernels of six varieties

5.2 STORAGE STUDIES OF IMMATURE CASHEW KERNELS

5.2.1 Organoleptic evaluation

Organoleptic evaluation of the kernels, stored with seven different treatments, was carried out at the beginning and ending of the storage period and the scores obtained are graphically represented in Figure 9 and 10. Among the seven treatments of storage, kernels stored in sugar syrup were the most accepted ones, both at the first and last months of storage. According to Ponting (1973), sugar uptake by the product kept in sugar solution, through osmotic process, modified the composition and taste of the final product. In this experiment, the scores obtained for flavour (6.40-7.07) and taste (6.00-7.07) were higher for kernels in sugar syrup. The uptake of sugar in the kernel might have resulted in the increased taste and flavour leading to enhanced palatability and higher score. Kernels preserved in 70° brix sugar syrup had the highest overall acceptability score (7.40) followed by kernels in 60° brix (7.00) and 50° brix (6.60) sugar syrup; higher sugar level might have resulted in more absorption.

Kernel stored in 15% brine was the least accepted treatment might be due to its high salt content which became unpalatable after four months of storage. Ross *et* al. (2002) reported that macadamia kernel pieces, which were immersed in salt solution, became unacceptable on extended storage. Kernels in 10% brine was found better than 5% and 15% brine solutions in sensory parameters like appearance, colour, texture, flavour and overall acceptability. According to Hutton (2002), salt act as a preservative against microbial growth and also imparts characteristic flavour. All the quality parameters of organoleptic evaluation were found better for kernels stored in 10% brine after four months of storage compared to the first month. The preservative action of salt leading to enhanced storage life has been reported in many vegetables. Barwal *et al*. (2005) reported that blanched cauliflowers steeped in 10% and 15% salt solution were found acceptable up to 180 days.

In dry storage, the dried kernels had an off taste after four months of storage which could be attributed to the rancidity of the kernels as experienced in nuts with high fat content. According to Mexis and Kontominas (2009), the rancid taste of nuts during sensory evaluation occurred due to lipid oxidation. Young (2007) reported that rancidity was considered as the first sign of deterioration of nuts, since most edible nuts are rich in oil content. Hence the dried immature kernels cannot be used as such for consumption after a storage period of four months.

5.2.2 Tannin content

Tannin content was undetectable in the kernels preserved in all the seven treatments. It might be because of the primary processing like washing and steam blanching after scooping out the kernel from nuts, followed by different treatments imposed for storage of kernels in the second experiment. The tannin content of fresh kernels itself was very low as detailed under the section 5.1.2. According to Afoakwa *et al*. (2007), blanching of Bambara groundnuts before canning reduced the tannin content. Anand (1970) also reported loss of tannins and vitamin C content during pre-treatments like soaking, blanching and brining of fruits during preparation of aonla preserve. Based on the results of storage study, all the treatments and pre-treatments employed for storage can be recommended for reducing the tannin content in the immature cashew kernels.

5.2.3 Microbial count of solution and kernel

Among the seven treatments of storage, the bacterial count was beyond permissible limit both in the solution and kernels stored in T_1 (5% brine) as well as in T_4 (50°B sugar syrup). The fungal population was within the acceptable limit for all the treatments. The yeast population was also found above the permissible limit for T_1 and T_4. This might be due to the less concentration of salt and sugar content in both these treatments which might not be sufficient to control the microbes. Ranken *et al*. (1997) reported that placing vegetables in 8-11% of salt content inhibited the microorganisms that may cause spoilage of vegetables. Thus, the immature cashew kernels can be stored for four months

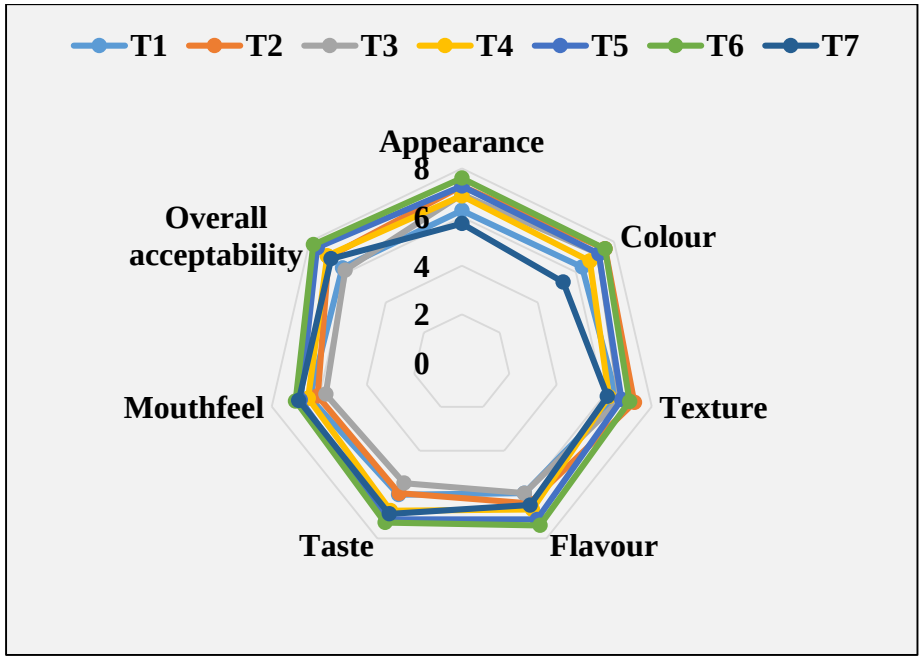


Figure 9: Effect of different treatments on sensory attributes of immature cashew kernel at first month of storage

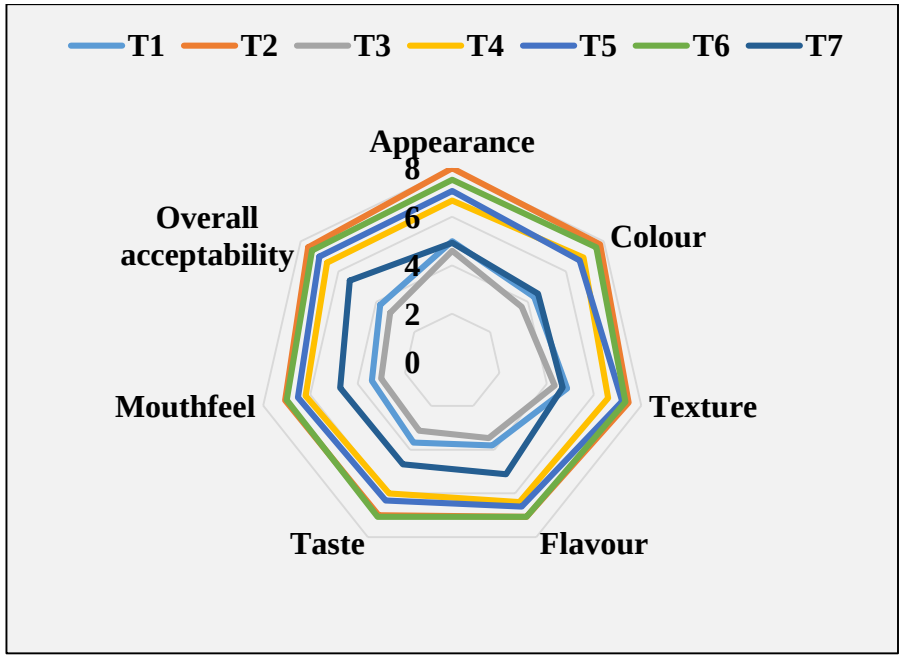


Figure 10: Effect of different treatments on sensory attributes of immature cashew kernel at fourth month of storage

T_1- Kernels preserved in 5% brine

T_2- Kernels preserved in 10% brine

T_3- Kernels preserved in 15% brine

T_4- Kernels preserved in 50º brix sugar syrup

T_5- Kernels preserved in 60º brix sugar syrup

T_6- Kernels preserved in 70º brix sugar syrup

T_7- Kernels preserved by drying

without microbial attack in 10% brine, 15% brine, 60°B sugar syrup and 70°B sugar syrup.

5.3 PRODUCT DEVELOPMENT FROM IMMATURE CASHEW KERNELS

Preparation of value added products is one of the techniques for the preservation and storage of perishable commodities like fruits and vegetables, when they are in surplus quantities or have seasonal production. Cashew, being a seasonal crop, needs to be stored for further use in off season, without deterioration in quality. Hence various products were prepared using the immature kernels, both fresh and stored ones, which were organoleptically evaluated to know the consumer acceptance and potential for future usage.

5.3.1 Organoleptic evaluation of products from immature kernels

Organoleptic qualities like appearance, colour, texture, flavour, taste, mouthfeel and overall acceptability were evaluated for all the products prepared from preserved kernels and also from fresh kernels. The graphical representation of organoleptic scoring of all products are given in Figures 11 to 16.

5.3.1.1 Products prepared from kernels stored in salt solution

Salted bits prepared by drying the kernels stored in brine solutions with three concentrations, were not so much acceptable by the panel of judges where the overall acceptability score was in a range of 4.93 - 5.93. However, dried kernel from 5% and 10% brine were found better among the three treatments (Figure 11). Pickles prepared from brined kernels had higher acceptability than salted bits (Figure 12). The overall acceptability score of the pickle prepared from fresh kernels was only slightly higher than those from stored kernels which is evident from Figure 12. This indicates that both fresh as well as preserved immature kernels can be used for the preparation of pickles. According to Barwal *et al*. (2005), the pickles prepared from cauliflower preserved in 10% and 15%

brine were ranked above acceptable range in various quality attributes. According to Panda *et al*. (2007), the sensory evaluation of sweet potato pickles prepared by lactic acid fermentation using 10% brine rated high in acceptability considering the attributes like texture, taste, aroma, flavour, colour, appearance and aftertaste. Based on this result, pickling can also be considered as a method of preservation for immature cashew kernels since salt in pickle protects the food from microbial spoilage by lowering the water activity (Kushner, 1971).

5.3.1.2 Products prepared from kernels stored in sugar syrup

The kernels preserved in sugar syrup were dried in cabinet drier to prepare dried bits. All the treatments were almost equally liked by the panel of judges with overall acceptability score range of 7.13 - 7.33 (Figure 13). Dried sweet products like candies were successfully prepared from many fruits using sugar syrup, with good acceptability. According to Durrani *et al*. (2011), the carrot candy prepared in sugar syrup scored highest for all sensory parameters compared to jaggery based candies. Another product prepared from the kernels in syrup was the preserve. As depicted in Table 6, all the sensory parameters scored above seven, in 9 point Hedonic scale scoring (Figure 14). On the other hand, preserve prepared from fresh kernels had less acceptability (6.60) compared to the stored preserve (7.40). The organoleptic qualities of immature cashew kernel preserve was not reported in earlier works. However, there are such reports in other horticultural crops. In a research work conducted for ginger preserve development, Anis Alam Siddiqqui *et* al. (2012), reported that the preserve of ginger prepared from 70° brix sugar syrup was found best in organoleptic evaluation as it scored highest in colour, flavour, texture and overall acceptability.

5.3.1.3 Products prepared from dried kernels

Among the products prepared from dried kernels, cashew balls scored highest for all the organoleptic attributes. The overall acceptability score ranged from 6.73 - 7.80, among the three recipes of cashew balls, recipe 1 (Cashew ball with cashew powder, rice powder and jaggery) being the highest (Figure 15).

Although the overall acceptability scores of other products *viz*. cashew cookies, honey coated kernel bits and jaggery coated kernels bits, were comparatively less, they were above the acceptable range (6.87, 6.60 and 6.07 respectively). Sobhana and Mathew (2014) reported that honey coated and sugar coated immature cashew kernels had fairly good acceptance among the consumers. Cookies prepared with 70% wheat flour and 30% cashew nut paste had highest overall acceptability among the cookies with different combinations of wheat flour and cashew nut paste, as reported by Ojinnaka and Agubolum (2013). The dried kernels had an off taste due to rancidity after four months of storage which made it less acceptable for the panel of judges. However, the products prepared from these kernels were scored high by the judging panel as evidenced from Table 9. Thus, the off taste of kernels due to extended storage could be masked for a certain extent, by preparing some products especially cashew balls.

These same products were prepared from fresh kernels and it was observed that the attributes were scored highest for cashew balls, followed by cashew cookies (Figure 16). The least accepted products were honey coated and jaggery coated kernel bits. Reports show that dried kernels are more preferred compared to fresh ones. Shobha *et al*. (1992) reported that cashew kernels were popular in the category of dry fruits and nuts because of its characteristic odour and taste. Kader *et* al. (1982) reported that the pistachio kernels dried to 4% had higher firmness, crispness, sweetness and less bitter taste when compared with the pistachio kernels dried to 11% moisture content. This shows that fresh kernels might not be a favourite item for consumers. This might be the reason for less acceptability for the products prepared from fresh kernels compared to those from dried kernels.

5.3.2 Microbial count of syrup and kernel

The presence of microbes *i*.e. bacteria, fungi and yeast could not be detected in the syrup and kernel of the preserve. Generally growth of microorganisms will be arrested in high sugar concentrations, which is one of the reasons for considering sugar as preservative. Carranza *et al*. (2012) reported that preservation of fruits in sugar syrup reduces the available water for

microrganisms and the final product acquires organoleptic characteristics that were appreciated and well accepted by the consumers. According to Anis Alam Siddiqui *et al*. (2012), any fungal growth could not be detected in the ginger preserve which was stored up to 60 days. Thus, the present result obtained is in line with these findings.

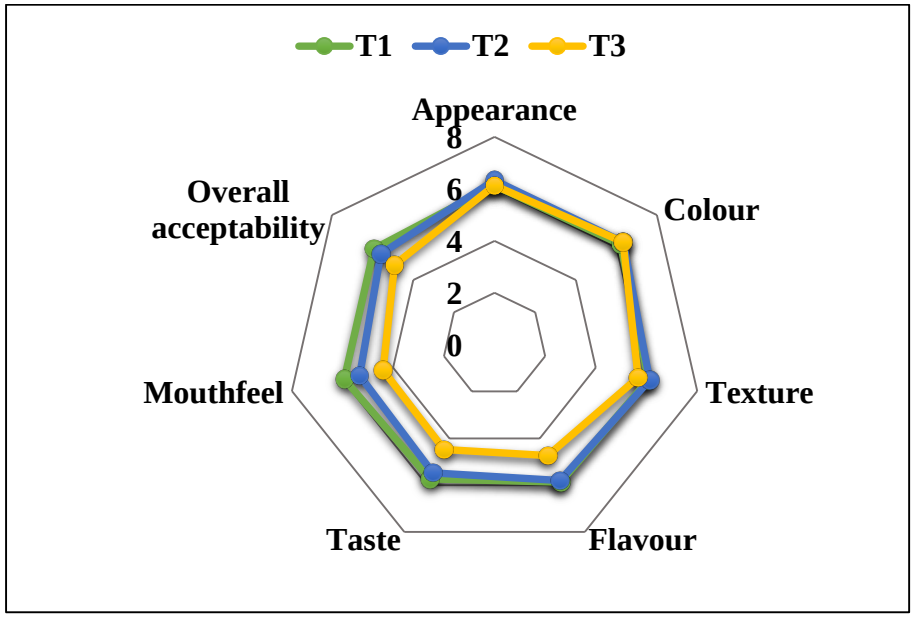


Figure 11: Effect of salt concentration on sensory attributes of salted kernel bits

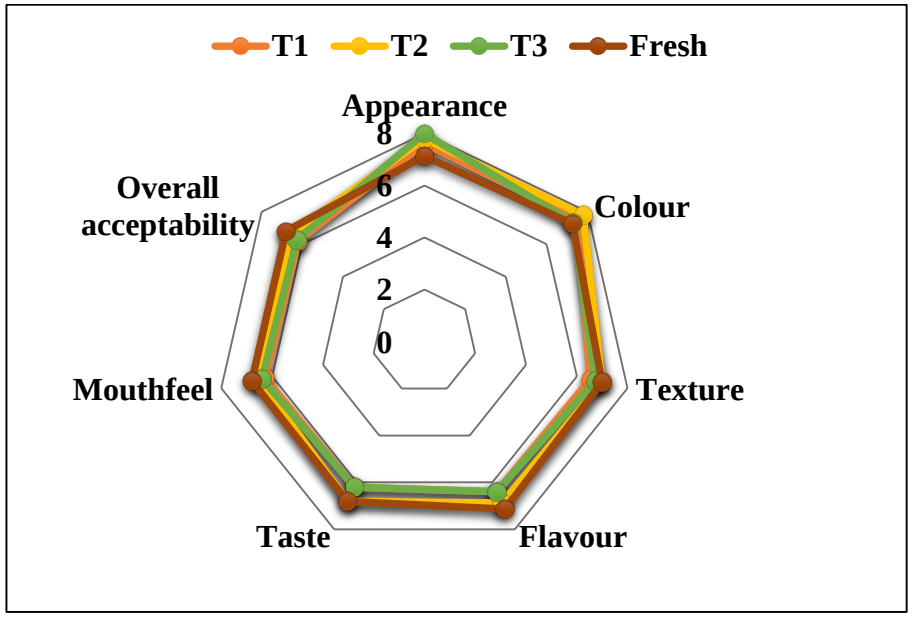


Figure 12: Effect of salt concentration on sensory attributes of pickle prepared from stored and fresh kernels

T_1- Salted bits from 5% brine

T_2- Salted bits from 10% brine

T_3- Salted bits from 15% brine

T_1- Pickle from 5% brine

T_2- Pickle from 10% brine

T_3- Pickle from 15%brine

T_4- Pickle from fresh kernel

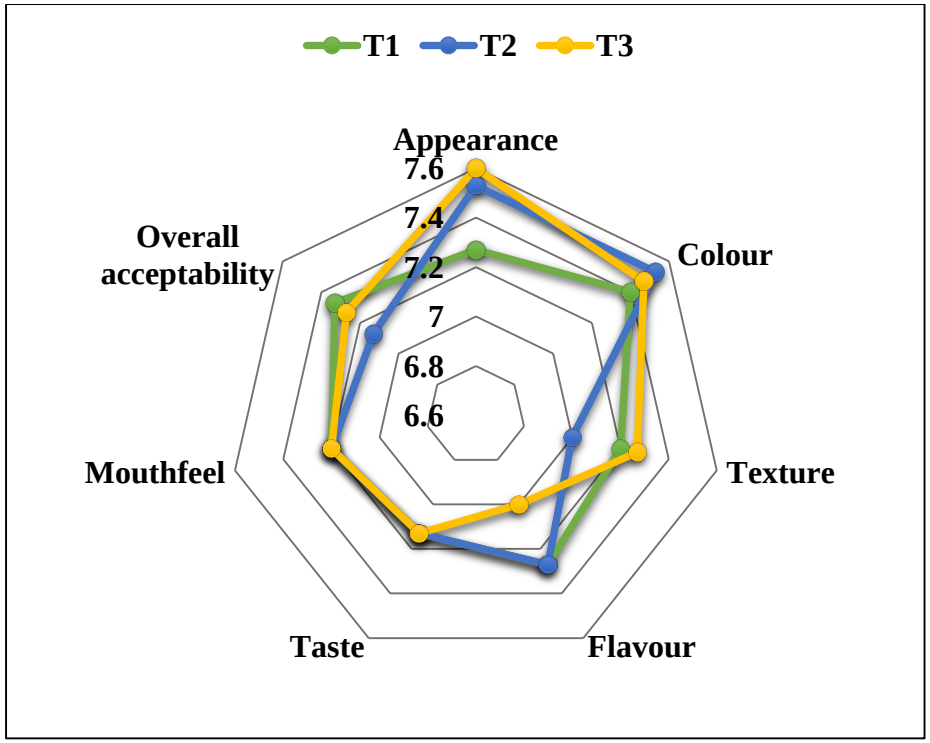


Figure 13: Effect of syrup concentration on sensory attributes of dried kernel bits

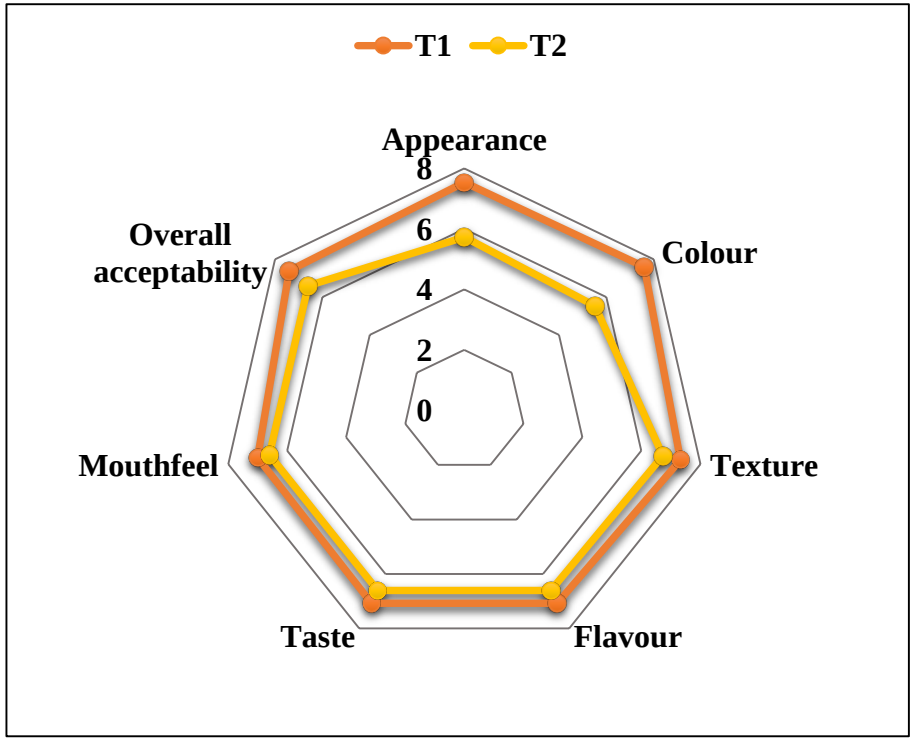


Figure 14: Effect of stored and fresh kernels on sensory attributes of preserve prepared with dried and fresh kernels

T_1- Dried bits from kernels preserved in 50ºB sugar syrup

T_2- Dried bits from kernels preserved in 60ºB sugar syrup

T_3- Dried bits from kernels preserved in 70ºB sugar syrup

T_1- Preserve from stored kernels in 70ºB sugar syrup

T_2- Preserve from fresh kernels

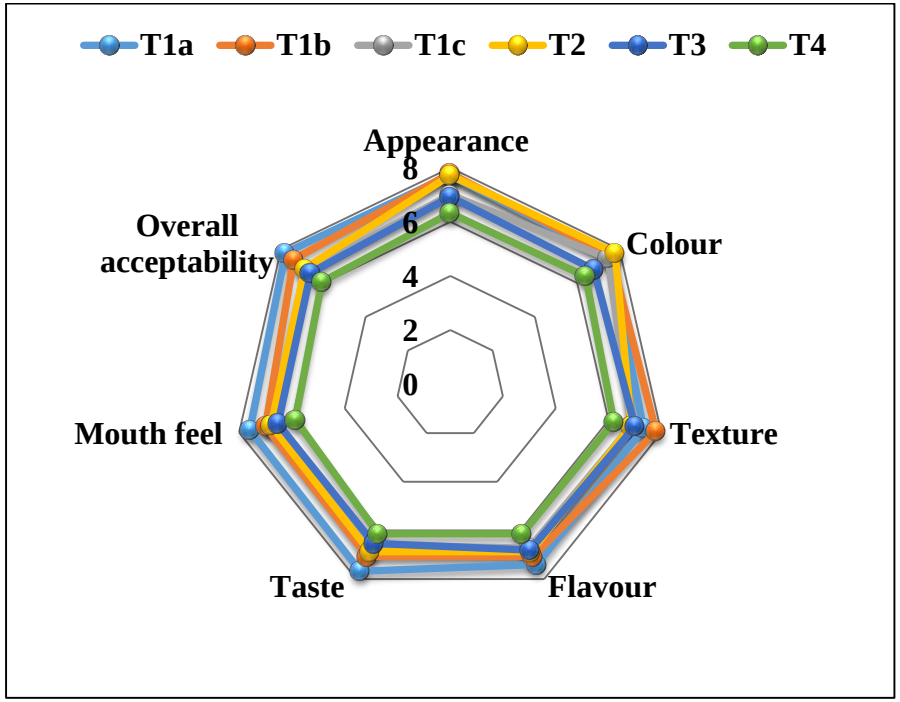


Figure 15: Organoleptic scoring of products prepared from dried immature kernels

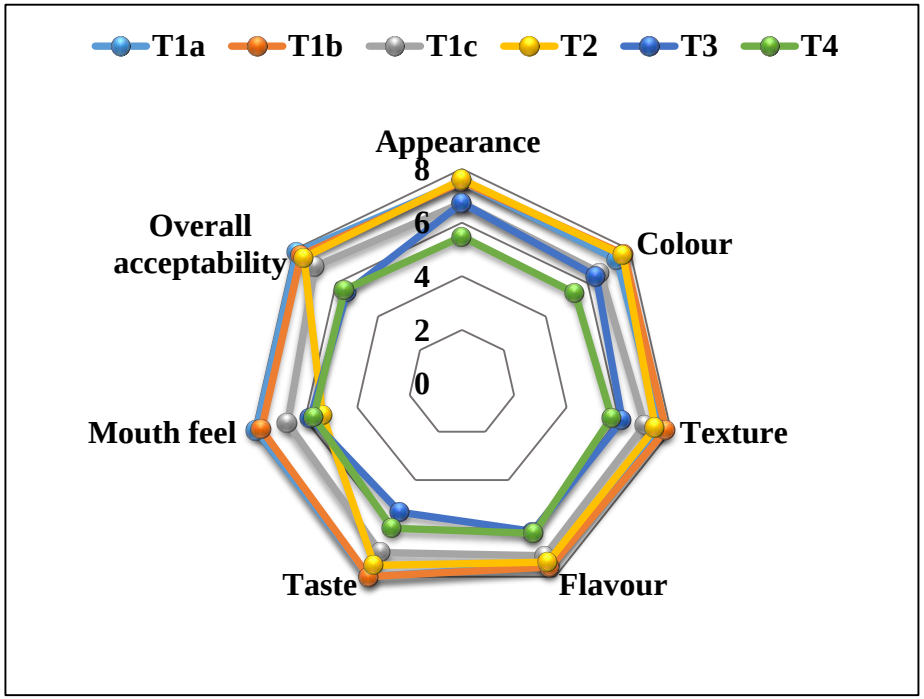


Figure 16: Organoleptic scoring of products prepared from fresh immature kernels

T_{1a}- Cashew ball prepared using recipe 1

T_{1b}- Cashew ball prepared using recipe 2

T_{1c}- Cashew ball prepared using recipe 3

T_2- Cashew cookies

T_3- Honey coated kernel bits

T_4- Jaggery coated kernel bits

6.SUMMARY

6. SUMMARY

The present study entitled '*Product development from tender cashew nut*' was carried out in the Department of Post Harvest Technology, College of Horticulture, Vellanikkara, with the objective to study the varietal difference in immature kernel characters, its storage methods and product development.

The first experiment involved evaluation of the selected cashew varieties for physical and biochemical characters of immature kernel. The varieties included Madakkathara-2, Sulabha, Dhana, Priyanka, Poornima and Kanaka, which were collected from Cashew Research Station, Madakkathara, 55 days after flowering. This is the stage where the nuts are still in green colour, before it turns to ash colour which indicates complete maturity.

Among the physical characters, highest shelling percentage was observed for Madakkathara-2 (17.88%) and lowest for Priyanka (14.83%), however, the varietal difference was statistically non-significant. Kernel weight was also found non-significant among the varieties, which ranged from 2.76g (Poornima) to 2.17g (Kanaka). The kernel colour was observed as pale yellow for Dhana, greenish white for Priyanka and yellowish white for Madakkathara-2, Sulabha, Poornima and Kanaka. The immature kernel of variety Dhana was found glossy and smooth, whereas Priyanka had wrinkled kernels with less glossiness. For the other four varieties *viz*., Madakkathara-2, Sulabha, Poornima and Kanaka, the kernels were glossy with few wrinkles. The kernel shape of the varieties Sulabha, Dhana, Poornima and Kanaka were oblong-ellipsoid. Madakkathara-2 had oblong shaped kernels and Priyanka had kidney shaped kernels. Variety Priyanka was found to be superior in kernel size with 3.21cm mean length and 1.23cm mean width. It was found to be superior in shell weight (13.24g) and weight of testa (1.66g) as well.

The immature kernels contained very less tannin. The lowest was observed for the varieties Sulabha and Kanaka with 0.19% tannin content each and highest tannin content was for Poornima (0.23%). The carbohydrate content was statistically

non-significant with respect to varieties and the value ranged from 9.63% (Kanaka) to 4.88% (Dhana). Variety Poornima (9.08%) was found to be superior in fat content and variety Dhana (5.08%) had the least fat content. Immature cashew kernels were found to be moderately rich in protein content, Priyanka (12.45%) having the highest protein content and Dhana, the lowest (7.29%). Sugar content could not be detected in the immature kernel of any of the selected cashew varieties.

The second experiment was regarding the storage studies of immature cashew kernels. The best treatments were found to be the kernels preserved in 10% brine and 70°B sugar syrup with highest organoleptic scoring and with acceptable limit of microbial count. The kernels preserved in 5% brine and 15% brine were found unacceptable during organoleptic evaluation after four months of storage and the overall acceptability score was below five in the 9 point Hedonic scale scoring. The microbial count was above the permissible limit in the treatments with 5% brine and 50°B sugar syrup. The kernels stored after drying developed an off taste during storage owing to rancidity of the kernels. Hence the dried immature kernels cannot be used as such for consumption after a storage period of four months.

The third experiment dealt with the product development from immature cashew kernels. The products were salted bits and pickle from kernels preserved in brine; dried bits and preserve from kernels preserved in sugar syrup; and cashew ball, cookies, jaggery coated cashew bits and honey coated cashew bits from kernels preserved after drying.

Among the products prepared from kernels preserved in brine, salted bits were least accepted. The organoleptic qualities for pickles prepared from all the three brine concentrations were very good. The overall acceptability was comparatively high for the pickles prepared from fresh kernels. Pickle could be considered as a successful product that can be prepared from immature cashew kernels- fresh or after four months of storage. The products prepared from kernels stored in sugar syrup included dried bits and preserve. All these products had high acceptability which

showed the interest of consumers towards confectioneries. Among the products prepared from dried immature cashew kernel, cashew ball and cookies had higher acceptance. The off taste developed on storage could be masked to an extent by converting it to value added products. The organoleptic scoring of products from stored dried kernels were comparable to those from fresh kernels. The overall acceptability of honey coated and jaggery coated cashew bits from stored kernels was higher than those from fresh kernels.

7.REFERENCES

7. REFERENCES

Achal. 2002. *Cashew: Nutrition and Medicinal value*. Colorado, Colorado State University Press. pp. 159-165.

Adebajo, L. O. and Diyaolu, S. A. 2003. Mycology and Spoilage of retail Cashew nuts. *Afr. J. Biotechnol*. 2(10): 369 - 373.

Adiga, J. D. and Kalaivanan, D. 2013. Cashew. In: Dhillon, W. S. (ed.) *Fruit Production in India*. Narendra Publishing House, Delhi, 145p.

Afoakwa, E. O., Budu, A. S. and Merson, A. B. 2007. Response surface methodology for studying the effect of processing conditions on some nutritional and textural properties of Bambara groundnuts (*Voandzei subterranean*) during canning. *Int. J. Food Sci. Nutr.* 58: 270-281.

Agnoloni, A., and Giuliani. F. 1977. *Cashew Nut Cultivation*. Ministry of Foreign Affairs, Instituto Agronomico per Oltremare, Italy. 539p.

Ahmed, G. E. 1981. *High Methoxyl Pectins and their Uses in Jam Manufacture – A Literature Survey*. The British Manufacturing Industries Research Association, Scientific and Technical Surveys. 127p.

Ajith, S., Pramod, S., Kumari, C. P. and Potty, V. 2015. Effect of storage temperatures and humidity on proximate composition, peroxide value and iodine value of raw cashew nuts. *J. Food Sci. Technol*. 52: 4631–4636.

Akinhanmi, T. F., Atasie, V. N. and Akintokun, P. O. 2008. Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid. *J. Agri. Food Envtal. Sci.* 2(1): 1-10.

Alasalvar, C. and Shahidi, F. (eds.) 2008. *Tree Nuts Composition, Phytochemicals and Health Effects* (9th Ed.). CRC press, Boca Roton, London, New York. 326p.

Anand, J. C. 1970. Retention of added vitamin C in amla preserves. *Indian Food Packer*, 24(5): 19-20.

Anandkumar, S., Kumar, V., and Anandraj, N. 2011. Processing and value addition of cashew nut [abstract]. In: Souvenir and Abstracts- 1st International Symposium on Cashew nut, 9-12 Dec. 2011, Madurai, 129p.

Andrighetti, L., Bassi, G. F., Capella, p., De Logu, A. M., Deolalikar, A. B., Haeusler, G., Franca, F. M. C. Rivoira, G., Vannini, L. and Deserti, R. N. 1994. *The World Cashew Economy*. (2nd Ed.) Linchiostroblu, Italy, 125p.

Anis Alam Siddiqui, Bhuiyan, M. H. R. and Easdani, M. 2012. Ginger (*Zingiber officinale*) preserve and candy development. *Bangladesh Pub. J.* [On-line] 7(3): 283-290. Available: http://www.bdresearchpublications.com/admin/journal/upload/09340.pdf [12 July 2020].

Arena, E. G., Ballistreri and Fallico, B. 2013. Effect of post harvest storage temperatures on the quality parameters of pistachio nuts. *J. Food Sci.* 31: 467-473.

Arogba, S. S. 1997. Physical, chemical and functional properties of Nigerian mango (*Mangifera indica*) kernel and its processed flour. *J. Sci*. *Food Agri*. 73: 321-328.

Arogba, S. S. 1999. Studies on kolanut and cashew kernels: moisture adsorption isotherm, proximate composition and functional properties. *Food Chem.* 67: 223-228.

Austin, A., & Ram, A. 1971. Studies on chapati making quality of wheat, Indian Council of Agricultural Research, Technical Bulletin, New Delhi 31: 96–101.

Ayadi, M., Ghrab, M., Gargouri, K., Elloumi, O., Zribi, F., Ben Mimoun, M., Boulares, C. and Guedri, W. 2006. Kernel characteristics of almond cultivars under rainfed conditions. *Acta Hortic.* 26: 366-381.

Aydin, C. 2003. Physical properties of almond nut and kernel. *J. Food Eng*. 60:315-320.

Azam-Ali, S. H., and Judge, E. C. 2001. *Small Scale Cashew Nut Processing*. Intermediate Technology Development Group. Schumacher Centre for Technology Development. Warwickshire, UK. FAO. 70p.

Bai, S. H., Tahmasbian, I., Zhou, J., Nevenimo, T., Hannet, G., Walton, D., Randall, B., Gama, T. and Wallace, H. M. 2018. A non-destructive determination of peroxide values, total nitrogen and mineral nutrients in an edible tree nut using hyperspectral imaging. *Comp. Electron. Agric.* 151: 492-500.

Bai, S. H., Brooks, P., Gama, R., Nevenimo, T., Hannet, G., Hannet, D., Randall, B. Walton, D., Grant, E. and Wallace, H. 2019. Nutritional quality of almond, canarium, cashew, and pistachio and their oil photooxidative stability. *J. Food Sci. Technol.* 56: 792-798.

Bakkalbasi, E., Yilmaz, O. M., Javidipour, I. and Artik, N. 2012. Effects of packaging materials, storage conditions and varieties on oxidative stability of shelled walnuts. *Food Sci. Technol.* 46: 203-209.

Balasubramanian, D. 2001. Physical properties of raw cashew nut. *J. Agric. Eng. Res.* [On-line] 78(3): 291-297. Available: 10.1006/jaer.2000.0603 [15 April 2020].

Balasubramanian, P. P. 2009. Indian cashew in global arena. In: Mathew, J., Mini, C. and Abraham, M. *Cashew Research and Development in Humid Tropics with Emphasis on Cashew Apple Processing. Cashew Research Station, Kerala Agricultural University*, Thrissur. pp. 11-15.

Bansil, P. C. 2015. *Fruits and Nuts*. Vol. 2. Economics of Agricultural commodities. CBS Publishers and Distributors Pvt Ltd, New Delhi. 1388p.

Barwal, V. S., Sharma, R. and Singh, R. 2005. Preservation of cauliflower by hurdle technology. *J. Food Sci. Technol.* 42(1): 26-31.

Bhaskara Rao, E. V. V. and Swamy, K. R. M. 2002. Indian cashew industry. In: Singh, H. P., Balasubramanium, P. P. and Venkatesh, N. H. (eds.) Directorate of Cashew Nut and Cocoa Development, Kochi, pp. 30–41.

Bhattacharjee, P., Singhal, R., Gholap, A., Variyar, P. and Bongirwar, D. 2003a. Hydrocarbons as marker compounds for irradiated cashew nut. *Food Chem.* 80:151-157.

Bhattacharjee, P., Singhal, R., Gholap, A., Variyar, P. and Bongirwar, D. 2003b. Compositional profiles of γ-irradiated cashew nuts. *Food Chem.* 80: 159-163.

Bhoodes, R. K., 2014. Dealing with broken Kernels - practices in India. *Cashew Handbook*, 2014–Global Prospective. International Agriculture Commodity Traders. pp. 93-97.

Borompichaichartkul, C., Luengsode, K., Chinprahast, N. and Devahastin, S. 2009. Improving quality of macadamia nut (*Macadamia integrifolia*) through the use of hybrid drying process. *J. Food Eng.* 93: 348-353.

Bounous, G. 2002. *The Chestnut- Culture, Environment and Uses in Italy and in the World*. Bologna, Edagricole. 311p.

Brady, M. 2002. Sodium - Survey of the usage and functionality of salt as an ingredient in UK manufactured food products. *British Food J.* 104(2): 84-125.

Breisch, H. 1995. *Chestnuts and Chestnuts. Monograph*. Interprofessional Technical Centre for Fruits and Vegetables, CTIFL, Paris. 158p.

Carranza Concha, J., Camacho Vidal, M. M. and Martinez Navarrete, N. 2012. Effects of blanching on grapes (*Vitis vinifera*) and changes during storage in syrup. *J. Food Proc. Pres*. 36(1): 11-20.

CEPCI [The Cashew Export Promotion Council of India], 2019. In: 63rd Annual Report 2017-2018 of The Cashew Export Promotion Council of India, Kaju India 2019, The Global Cashew Summit (6th Ed.). 13th-15th February, 2019, Taj Palace, Diplomatic Enclave, Delhi pp. 5-11.

Christopoulos, M. and Tsantili, E. 2015. Oil composition in stored walnut cultivars-quality and nutritional value. *Eur. J. Lipid Sci. Technol.* 117: 338-348.

Clark, C. and Smith, G. 1988. Seasonal accumulation of mineral nutrients by kiwifruit- 2. Fruit. *New Phytol*. 108:399-409.

Connell, J. H., Labavitch, J. M., Sibbett, G. S., Reil, W. O., Barnett, W. H. and Heintz, C. 2000. Early harvest of almonds to circumvent late infestation by navel orangeworm. *J. Am. Society Horti. Sci.* 114:595–599.

Deshpande, S. D., Bal, S. and Ojha, T. P. 1991. Physical properties of soya bean. *J. Agri. Eng. Res.* 50: 305-313.

DGCI&S [Directorate General of Commercial Intelligence and Statistics], 2019. In: 63rd Annual Report 2017-2018 of The Cashew Export Promotion Council of India, Kaju India 2019, The Global Cashew Summit (6th Ed.). 13th-15th February, 2019, Taj Palace, Diplomatic Enclave, Delhi pp. 11-15.

Durrani, A. M., Srivastava, P. K. and Verma, S. 2011. Development and quality evaluation of honey based carrot candy. *J. Food Sci. Technol.* 48(4): 502-502.

FSSAI [Food Safety and Standards Authority of India], 2012. Manual of methods of analysis of food additives, Food Safety and Standard Authority of India, Ministry of Health and Family Welfare, The Government of India, New Delhi. pp. 287-529.

Frankel, E. 1991. Poison ivy, Poison oak, Poison sumac and their relative pistachios: Mangoes and Cashew. The Boxwood Press pacific grove, CA, 2:15-16.

Gama, T., Wallace, H. M., Trueman, S. J. and Bai, S. H. 2018a. Variability in crude protein and mineral nutrient concentrations of almonds. *Acta Hortic.* (in press).

Gama, T., Wallace, H. M., Trueman, S. J., Tahmasbian, I. and Bai, S. H. 2018b. Hyperspectral imaging for non-destructive prediction of total nitrogen concentration in almond kernels. *Acta Hortic.* (in press).

Ghirardello, D., Contessa, C., Valentini, N., Zeppa, G., Rolle, L., Gerbi, V. and Botta, R. 2013. Effect of storage conditions on chemical and physical characteristics of hazelnut (*Corylus avellana* L.). *Postharvest Biol. Technol*. 81: 37–43.

Green, W. M. and Hoover, W. 1979. Honey coated roasted nut product and method for making same. US Patent No. 4161545.

Griffin, L. E. and Dean, L. L. 2017. Nutrient composition of raw, dry roasted, and skin-on cashew nuts. *J. Food Res.* [On-line] 6(6): 13-28. Available: https://doi.org/10.5539/jfr.v6n6p13 [26th June 2020].

Gupta, R. K. and Das, S. K. 1997. Physical properties of sunflower seeds. *J. Agri. Eng. Res*. 66: 1-8.

Haribabu, R. S., Rath, S., and Rajput, C. B. S. 1983. Tea mosquito bug on cashew. *Indian J. Plant. Crops* 14:1-10.

Hedge, J. E. and Hofreiter, B. T. 1962. In: Whistler, R. L. and Be Miller, J. N. (eds.) *Carbohydrate Chemistry* (17th Ed), Academic Press, New York. 529p.

Hutton, T. 2002. Technological functions of salt in the manufacturing of food and drink products. *British Food J*. 104(2): 126-152.

Irtwange, S. and Oshodi, A. 2009. Shelf life of roasted cashew nuts as affected by relative humidity, thickness of polythene packaging material and duration of storage. *Res. J. Applied Sci. Eng. Technol.* 1: 149-153.

Jayaprakash Naik, B. 2009. Cashew varieties. In: Mathew, J., Mini, C. and Abraham, M. *Cashew Research and Development in Humid Tropics with Emphasis on Cashew apple Processing*. Cashew Research Station, Kerala Agricultural University, Thrissur. pp. 125-133.

Joshi, D. C., Das, S. K. and Mukherjee, R. K. 1993. Physical properties of pumpkin seed. *J. Agri. Eng. Res.* 54: 219-229.

Kader, A. A., Heintz, C., Labavitch, J. and Rae, H. 1982. Studies related to the description and evaluation of pistachio nut quality. *J. Am. Soc. Hortic.* 107: 812-816.

Kalia, M. and Sood, S. 2007. *Food Processing and Preservation* (Reprint, 2010). Kalyani Publishers, Ludhiana. 545p.

Kashaninejad, M., Tabil, L., Mortazavi, A. and Safe Kordi, A. 2003. Effect of drying methods on quality of pistachio nuts. *Dry Technol.* 21: 821-838.

Kashaninejad, M., Mortazavi, A., Safe Kordi, A. and Tabil, L. G. 2006. Some physical properties of pistachio (*Pistacia vera* L.) nut and its kernel. *J. Food Eng.* 72: 30-38.

Kazantzis, I., Nanos, G. D. and Stavroulakis, G. G. 2003. Effect of harvest time and storage conditions on almond kernel oil and sugar composition. *J. Sci. Food Agri.* 83:354-359.

Khan, A., Khan, H. and Delincee, H. 2005. DNA comet assay- a rapid screening method for detection of irradiated cereals and tree nuts. *Food Control* 16: 141-146.

King, J. C., Blumberg, J., Ingwersen, L., Jenab, M. and Tucker, K. L. 2008. Tree nuts and peanuts as components of a healthy diet. *J. Nutr.* 138: 1736S-1740S.

Kurian, A. and Peter, K. V. 2007. *Commercial Crops Technology*. New India Publishing Agency, New Delhi, pp. 63–98.

Kushner, D. J. 1971. Influence of solutes and ions on microorganisms. In: Hugo, W. B. (ed.). Inhibition and destruction of the microbial cell. Academic Press, London. pp. 259-282.

Ling, B., Hou, L., Li, R. and Wang, S. 2014. Thermal treatment and storage condition effects on walnut paste quality associated with enzyme inactivation. *LWT- Food Sci. Technol.* 59(2): 786-793.

Manay, M. and Shadaksharaswamy, M. 1987. *Foods: Facts and Principles*. Wiley Eastern Ltd, New Delhi.

Maskan, M. and Karatas, S. 1998. Fatty acid oxidation of pistachio nuts stored under various atmospheric conditions and different temperatures. *J. Sci. Food Agri*. 77: 334–340.

Mason, R. 2000. Macadamia nut quality research-The processing challenge. *Food Aus*. 52: 416-419.

Mason, R., Nottingham, S., Reid, C. and Gathambiri, C. 2004. The quality of macadamia kernels stored in simulated bulk retail dispensers. *Food Aus*. 56: 133-139.

Mexis, S. F., Badeka, A. V. and Kontominas, M. G. 2009. Quality evaluation of raw ground almond kernels (*Prunus dulcis*): Effect of active and modified atmosphere packaging, container oxygen barrier and storage conditions. *Innov. Food Sci. Emerg. Technol*. 10: 580–589.

Mexis, S. F. and Kontominas, M. G. 2009. Effect of γ-irradiation on the physicochemical and sensory properties of cashew nuts (*Anacardium occidentale* L.). *Food Sci. Technol* 42: 1501–1507.

Mexis, S. F. and Kontominas, M. G. 2010. Effect of oxygen absorber, nitrogen flushing, packaging material, oxygen transmission rate and storage conditions on quality retention of raw whole unpeeled almond kernels (*Prunus dulcis*). *Food Sci. Technol*. 43: 1–11.

Mohad, A., Jain, S. and Powar, A. G. 2010. Energy for small scale cashew nut processing in India. *Energy Res. J*. 1(1): 47-50.

Nair, M. R. G. K., Oommen, C. N. and Mohandas, N. 1985. Pests of processed cashew and their control. ISHS International Cashew Symposium, *Acta Horticulturae 108*. Available: https://doi.org/10.17660/ActaHortic.1985.108.23 [3rd June 2020].

Nair, H. 2003. Washington, DC: U.S. Patent and Trademark Office. US Patent No. US20050089613 A1.

Nair, C. K. 2009. Cashew Processing. In: Mathew, J., Mini, C. and Abraham, M. *Cashew Research and Development in Humid Tropics with Emphasis on Cashew apple Processing*. Cashew Research Station, Kerala Agricultural University, Thrissur. pp. 125-133.

Nanos, G. D. Kazantzis, I., Kefalas, P., Petrakis, C. and Stavroulakis, G. G. 2002. Irrigation and harvest time affect almond kernel quality and composition. *Sci. Hortic.* 96: 249-256.

Narayanankutty, M. C. 2000. Development pattern, storage behaviour and variability in processing characters of cashew apple. PhD Thesis. Kerala Agriculture University, College of Horticulture, Vellanikkara, Thrissur, Kerala.

Nazari Galedar, M., Jafari, A. and Tabatabaeefar, A. 2008. Some physical properties of wild pistachio (*Pistacia vera* L.) nut and kernel as a function of moisture content. *Inter*. *Agrophysics* 22: 117-124.

Ogunsina, B. S. 2013. Crackability and chemical composition of pre-treated cashew nuts using a hand operated knife cutter. *Agri. Eng. Inter.* 15(2): 275-283.

Ohler, J. G. 1979. Cashew. Publication number 71. Department of Agricultural Research, Royal Tropical Institute, Amsterdam 65:201-207.

Ojinnaka, M. C. and Agubolum, F. U. 2013. Nutritional and sensory properties of cashew nut-wheat based cookies. *Am. J. Food Nutr.* 3(3): 127-134.

Olife, I. C., Jolaoso, M. A. and Onwualu, A. P. 2013. Cashew processing for economic development in Nigeria. *Agri. J.* 8(1): 45-50. Available: https://medwelljournals.com/abstract/?doi=aj.2013.45.50. [29th May 2020].

Onilude, A. A., Igbinadolor, R. O. and Wakil, S. M. 2010. Effect of time and relative humidity on the microbial load and physical quality of cashew nuts (*Anacardium occidentale* L) under storage. *African J. Microbiol. Res.* 4(19): 1939-1944.

Ozkan, G., Simsek, B. and Kuleasan, H. 2007. Antioxidant activities of *Satureja cilicica* essential oil in butter and in vitro. *J. Food Eng*. 79: 1391–1396.

Panda, J. M. and Pal, H. K. 1993. Effect of 2,4-D and NAA on fruit set, its retention and quality in cashew. *The Cashew* 7(4): 9-10.

Panda, S. H., Parmanick, M. and Ray, R. C. 2007. Lactic acid fermentation of sweet potato (*Ipomoea batatas* L.) into pickles. *J. Food Proc. Preservation* 31: 83-101.

Patel, G. N. and Kheni, J. 2018. Mango seed kernel, a highly nutritious food, should we continue to trash or use? *J. Pharmacognosy and phytochem.* 7(4): 4-7.

Pearson, D. 1976. *The Chemical Analysis of Foods* (7th Ed.). Edinburgh, Churchill Livingstone. 575p.

Phatanayindee, S., Borompichaichartkul, C., Srzednicki, G.., Craske, J. and Wootton, M. 2012. Changes of chemical and physical quality attributes of macadamia nut during hybrid drying and processing. *Drying Technol.* 30: 1870-1880. Available: http://dx.doi.org/10.1080/07373937.2012.703275.

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

Pushpalatha, P. B. 2000. Morphophysiological analysis of growth and yield in cashew (*Anacardium occidentale* L.). PhD Thesis. Kerala Agricultural University, College of Horticulture, Vellanikkara, Thrissur, Kerala.

Pushpalatha, P. B. 2009. Morphology of cashew. In: Mathew, J., Mini, C. and Abraham, M. *Cashew Research and Development in Humid Tropics with Emphasis on Cashew apple Processing*. Cashew Research Station, Kerala Agricultural University, Thrissur. pp. 125-133.

Raei, M., Mortazavi, A. and Pourazarang, H. 2010. Effects of packaging materials, modified atmospheric conditions, and storage temperature on physicochemical properties of roasted pistachio nut. *Food Anal. Methods* 3: 129–132.

Raisi, M., Ghorbani, M., Mahoonak, A. S., Kashaninejad, M. and Hosseini, H. 2015. Effect of storage atmosphere and temperature on the oxidative stability of almond kernels during long term storage. *J. Stored Prod. Res*. 62: 16–21.

Ramakrishna, P. 1986. Melon seeds: Evaluation of physical characteristics. *J. Food Sci. Technol*. 23(3): 158-160.

Ranganna, S. 1986. *Manual of Analysis of Fruit and Vegetable Products*. Tata Mc. Graw Hill Publishing Co. Ltd., New Delhi, pp.22-40.

Ranken, M. D., Kill, R. C. and Baker, C. G. J. 1997. *Food Industries Manual* (24th Ed), Blackie Academic & Professional, Glasgow.

Rengel, A., Perez, E., Piombo, G., Ricci, J., Servent, A., Tapia, M.S., Gibert, O. and Montet, D., 2015. Lipid profile and antioxidant activity of macadamia nuts (*Macadamia integrifolia*) cultivated in Venezuela. *Nat. Sci.* (Irvine) 7: 535–547.

Retheesh, K. A. 2012. Value addition in cashew nut through improved technology perspectives and recent developments. In: Singh, G. and Hubballi, V. N. (eds). *Cashew Development in India - Challenges and Opportunities*. Directorate of Cashew nut and Cocoa Development, Ministry of Agriculture, Department of Agriculture and Co-operation, Government of India, Kera Bhavan, Kochi, Kerala. pp. 131-132.

Ros, E. 2010. Health benefits of nut consumption. *Nutrients* 2:652–682.

Rosengarten, F. 1984. *The Book of Edible Nuts* (5th Ed). Walker and Co. New York, USA. 384p.

Ross, A. I., Mason, R. L., Nottingham, S., Keilar, S. and Kowitz, T. 2002. The effect of water, brine and ethanol flotation on the quality and shelf life of macadamia kernels. *Food Aus.* 54(12): 584-587.

Sadasivam, S. and Manickam, A. 2007. *Biochemical Methods*. New Age International (P) Ltd. 284p.

Salam, M. A. and Peter, K. V. 2010. *Cashew- A monograph*. Studium Press Pvt Ltd. New Delhi, India. 257p.

Santos, O. V., Correa, N.C. F., Carvalho, R. N., Costa, C. E. F., Franca, L. F. F. and Lannes, S. C. S. 2013. Comparative parameters of the nutritional contribution and functional claims of Brazil nut kernels, oil and defatted cake. *Food Res. Inter*. 51: 841-847. Available: https://doi.org/10.1016/j.foodres.2013.01.054 [25th May 2020].

Schanderl, S. H. 1970. Tannins and related phenolics. In: Joslyn, M. A. (ed.) *Methods in food analysis*, Academic Press, New York. 728p.

Sethi, V. and Maini, S. B. 2000. "Steeped preserved products". In: *Post harvest Technology of Fruits and Vegetables*. Indian Pub. Co. New Delhi pp: 941-961.

Severini, C., Gomes, T., De Pilli, T., Romani, S., Massini, R., 2000. Autoxidation of packed almonds as affected by Maillard reaction volatile compounds derived from roasting. *J. Agric. Food Chem*. 48: 4635–4640.

Shobha, S., Krishnaswamy, P. and Ravindranath, B. 1992. Phenolic lipid composition during development of cashew. *Phytochemistry* 31(7): 2295-2297.

Shokraii, E. H. 1977. Chemical composition of the pistachio nuts of Kerman, Iran. *J. Food Sci*. 42: 244–245.

Sinanoglou, V. J., Kokkotou, K., Fotakis, C. Strati, I., Proestos, C. and Zoumpoulakis, P. 2014. Monitoring the quality of γ- irradiated macadamia nuts based on lipid

profile analysis and chemometrics. Traceability models of irradiated samples. *Food Res. Inter*. 60: 38-47.

Sobhana, A. and Mathew, J. 2013. Nutritional and health benefits of cashew. In: *Cashew Week ACA Conference Special.* 13(38): 98-100.

Sobhana, A. and Mathew, J. 2014. Studies on the utilisation of immature cashew nuts. *Inter. J. Trop. Agri.* 32 (3-4): 647-653.

Suthar, S. H. and Das, S. K. 1996. Some physical properties of karingda [*Citrullus lanatus* (Thumb) Mansf] seeds. *J. Agri. Eng. Res.* 65: 15-22.

Takeoka, G., Dao, L., Teranishi, R., Wong, R., Flessa, S., Harden, L. and Edwards, R. 2000. Identification of three triterpenoids in almond hulls. *J. Agric. Food Chem.* 48: 3437-3439.

Turan, A. and Hasan Karaosmanoglu. 2019. Effect of drying methods on long term storage of hazelnut [On-line]. ISSN 1678-457X. *Food Sci. Technol.* 39(2).

USDA [United States Department of Agriculture], 2015. Full Report (All Nutrients): 12087, Nuts, cashew nuts, raw, database version SR 27. *Agricultural Research Service – United States Department of Agriculture. 2015.* Archived from the original on 18-08-2015. Retrieved 6 August 2015.

Van Eijnatten, C. L. M. 1991. Edible fruits and nuts. In: Verheij, E. W. M. and Coronel, R. E. (eds.). *Plant Resources of South East Asia No. 2*. Pndoc-DLO, Wageningen, 446p.

Varma, K. S. and Venkiteswaran, K. A. 2009. Cashew Export Scenario. In: Mathew, J., Mini, C. and Abraham, M. *Cashew Research and Development in Humid Tropics with Emphasis on Cashew Apple Processing*. Kerala Agriculture University, Vellanikkara, Thrissur. pp:134-136.

Verma, S., Srivastava, P. K. and Durrani, A. 2006. Organoleptic characteristics of honey based amla murabba. 40th ISAE annual convention, Tamil Nadu Agricultural University, Coimbatore, 19-21 Jan.

Venkatachalam, M. and Sathe, S. K. 2006. Chemical composition of selected edible nut seeds. *J. Agric. Food Chem.* 54: 4705-4714.

Walton, D. A. and Wallace, H. M. 2009. Delayed harvest reduces quality of raw and roasted macadamia kernels. *J. Sci. Food Agric*. 89: 221–226.

Walton, D. A. and Wallace, H. M. 2010. Dropping macadamia nuts-in-shell reduces kernel roasting quality. *J. Sci. Food Agric*. 90: 2163–2167.

Walton, D. A., Randall, B. W., Poienou, M., Nvenimo, T., Moxon, J. and Wallace, H. M. 2017. Shelf life of tropical canarium nut stored under ambient conditions. *Horticulturae* 3: 24.

Wang, Y., Zhang, L., Gao, M., Tang, J. and Wang, S. 2013. Temperature and moisture dependant dielectric properties of macadamia nut kernels. *Food Bioproc. Tech.* 6: 2165-2176.

Wanlapa, A. and Jindal, V. K. 2006. Instrumental and sensory evaluation of textural changes during roasting of cashew kernels. *J. Texture Studies* 37: 263-275.

Woodroof, J. G. 1979. *Tree nuts-production, processing and products* (2nd Ed.). The AVI Pub. Co. Westport. 731p.

Young, C.T. 2007. *Nuts*. In: Kirk-Othmer Encyclopedia of Chemical Technology. pp. 1-42. Available: https://doi.org/10.1002/0471238961.1421201925152114.a01.pub2 [30th May 2020].

APPENDICES

APPENDIX I

Score card for organoleptic evaluation

Name of the judge:

Date:

Attributes	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Appearance							
Colour							
Texture							
Flavour							
Taste							
Mouthfeel							
Overall acceptability							

9 point Hedonic scale

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

Signature

APPENDIX II

MEDIA COMPOSITION

1. NUTRIENT AGAR MEDIA (for bacteria)

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

2. MARTIN ROSE BENGAL AGAR (for fungus)

Glucose	: 10 g
Peptone	: 5 g
KH_2PO_4	: 1 g
$MgSO_4$ $7H_2O$	: 0.5 g
Rose Bengal	: 0.035 g
Agar	: 18 g
Distilled water	: 1000 ml

3. SABOURAUD DEXTROSE AGAR MEDIA (for yeast)

Dextrose	: 40 g
Mycological, peptone	: 10 g
Agar	: 15 g
Final pH	: 5.6 ± 0.2
Distilled water	: 1000 ml

APPENDIX III

A. Mean rank scores for cashew kernels stored under different treatments at first month of storage

Treatments	Appearance	Colour	Texture	Flavour	Taste	Mouthfeel	Overall acceptability
T1	2.80	2.67	3.97	2.97	3.23	3.93	2.70
T2	4.73	4.33	5.17	4.13	3.60	3.87	4.37
T3	4.13	4.83	4.27	3.17	2.37	3.20	2.47
T4	3.63	3.53	2.77	4.00	4.33	3.70	3.80
T5	4.73	4.50	3.90	4.97	5.07	4.47	4.00
T6	5.33	5.27	4.53	5.17	5.07	4.67	5.17
T7	2.63	1.87	3.40	3.60	4.33	4.17	5.50
Kendal's W Test	**0.272**	**0.453**	**0.147**	**0.017**	**0.245**	**0.060**	**0.317**

B. Mean rank scores for cashew kernels stored under different treatments at last month of storage

Treatments	Appearance	Colour	Texture	Flavour	Taste	Mouthfeel	Overall acceptability
T1	2.47	2.27	2.40	2.30	2.03	2.07	2.27
T2	6.30	6.03	5.73	5.50	5.53	5.53	5.67
T3	2.23	1.53	2.03	1.97	2.00	1.60	1.47
T4	4.07	4.97	4.13	4.70	4.60	4.67	4.30
T5	5.00	4.80	5.27	4.77	5.03	5.07	4.87
T6	5.70	5.90	5.70	5.33	5.47	5.40	5.63
T7	2.23	2.50	2.73	3.43	3.33	3.67	3.80
Kendal's W Test	**0.730**	**0.794**	**0.607**	**0.527**	**0.571**	**0.600**	**0.608**

C. Mean rank scores for the products prepared from kernels preserved in brine solution

Products		Appearance	Colour	Texture	Flavour	Taste	Mouthfeel	Overall acceptability
Salted bits	**5%**	1.93	1.83	2.10	2.30	2.40	2.57	2.47
	10%	2.27	2.17	2.07	2.13	2.00	1.83	2.03
	15%	1.80	2.00	1.83	1.57	1.60	1.60	1.50
Kendal's W Test		**0.102**	**0.049**	**0.028**	**0.174**	**0.200**	**0.325**	**0.299**
Pickle	**5%**	2.50	2.53	2.10	2.20	2.30	2.20	2.23
	10%	2.70	2.93	2.73	2.73	2.83	2.47	2.57
	15%	3.07	2.40	2.50	2.07	2.03	2.37	2.10
	Fresh	1.73	2.13	2.67	3.00	2.83	2.97	3.10
Kendal's W Test		**0.264**	**0.106**	**0.100**	**0.165**	**0.129**	**0.092**	**0.165**

D. Mean rank scores for organoleptic evaluation for the products prepared from kernels preserved in sugar syrup

Products		Appearance	Colour	Texture	Flavour	Taste	Mouthfeel	Overall acceptability
Dried bits	**50° brix**	1.70	1.90	2.07	1.97	2.00	2.00	2.13
	60° brix	2.10	2.10	1.77	2.03	2.00	2.00	1.83
	70° brix	2.20	2.00	2.17	2.00	2.00	2.00	2.03
Kendal's W Test		**0.175**	**0.022**	**0.079**	**0.002**	**0.000**	**0.000**	**0.036**
Preserve	**70° brix**	1.77	1.77	1.63	1.70	1.70	1.67	1.70
	Fresh	1.23	1.23	1.37	1.30	1.30	1.33	1.30
Kendal's W Test		**0.356**	**0.305**	**0.089**	**0.200**	**0.200**	**0.152**	**0.200**

E. Mean rank scores for the organoleptic evaluation of the products prepared from dried kernels stored for four months

Products from dried kernels		Appearance	Colour	Texture	Flavour	Taste	Mouthfeel	Overall acceptability
Cashew balls	**Type 1**	4.20	4.13	3.83	4.03	4.53	4.60	4.70
	Type 2	4.33	4.17	4.70	3.67	3.90	3.90	4.23
	Type 3	2.97	3.67	3.27	3.13	3.13	3.37	3.00
Cookies		4.33	4.37	3.20	3.57	3.53	3.70	3.40
Honey coated bits		3.00	2.53	3.50	3.50	3.27	3.17	3.10
Jaggery coated bits		2.17	2.13	2.50	3.10	2.63	2.27	2.57
Kendall's W test		**0.290**	**0.312**	**0.197**	**0.040**	**0.138**	**0.202**	**0.215**

Type 1- Cashew ball with cashew powder, rice powder and jaggery

Type 2- Cashew ball with cashew powder, rice powder, jaggery and coconut

Type 3- Cashew ball with cashew powder, rice powder, jaggery, dried ginger powder and cumin powder

F. Mean rank scores for organoleptic evaluation of the products prepared from freshly dried kernels

Products from freshly dried kernels		**Appearance**	**Colour**	**Texture**	**Flavour**	**Taste**	**Mouthfeel**	**Overall acceptability**
Cashew balls	**Type 1**	4.70	4.43	4.60	4.13	4.73	4.83	4.87
	Type 2	4.33	4.97	5.00	4.20	4.67	4.50	4.53
	Type 3	2.87	2.80	3.50	3.83	3.57	3.13	3.40
Cookies		4.27	4.53	4.13	4.00	3.93	4.27	4.13
Honey coated bits		3.07	2.70	2.10	2.23	1.53	2.13	1.80
Jaggery coated bits		1.77	1.57	1.67	2.60	2.57	2.13	2.27
Kendall's W test		**0.432**	**0.573**	**0.596**	**0.235**	**0.507**	**0.473**	**0.492**

Type 1- Cashew ball with cashew powder, rice powder and jaggery

Type 2- Cashew ball with cashew powder, rice powder, jaggery and coconut

Type 3- Cashew ball with cashew powder, rice powder, jaggery, dried ginger powder and cumin powder

PRODUCT DEVELOPMENT FROM TENDER CASHEW NUT

By

SHARON JACOB

2018-12-027

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF POST HARVEST TECHNOLOGY

COLLEGE OF HORTICULTURE, VELLANIKKARA,

THRISSUR-680 656

KERALA, INDIA 2019

ABSTRACT

Cashew, an important horticultural crop of India, has great socioeconomic significance in our country. Cashew seed is often considered a nut in the culinary sense and this nut is either eaten on its own or used in different recipes of food preparation. Substantial quantities of cashew nuts are produced during rainy season in Kerala, especially in the late season flowering types, which are inferior in quality and are being wasted. To avoid this loss, harvesting could be carried out in the immature stage and could make value added products. Hence, the present research work was carried out to study the utilisation of immature cashew kernels, its storage methods and potential of value addition.

Six different varieties *viz*., Madakkathara-2, Sulabha, Dhana, Priyanka, Poornima and Kanaka were selected to study the physical and biochemical parameters of the immature cashew kernels. Among the physical characteristics, shelling percentage was highest for Madakkathara-2 (17.88%), the highest kernel weight was for Poornima (2.76g) and the highest kernel size, shell weight and testa weight was observed for the variety Priyanka. Other physical parameters like colour, external appearance and shape of kernel differed with varieties. The estimated range of composition of immature cashew kernels was 0.19-0.23% tannins, 4.88-9.63% carbohydrates, 5.08-9.08% fat and 7.29-12.45% protein, which varied with varieties.

Storage studies of immature kernel were carried out by preserving in different concentrations of brine solution (5%, 10% and 15%), sugar syrup (50°B, 60°B and 70°B) and after drying (2-3% moisture content). Storage period was for four months and the best storage method was preserving in 10% brine and 70°B sugar syrup, which had high organoleptic scoring and acceptable limit of microbial count. Pre-treatments like washing and steam blanching could reduce the tannin content in kernels.

Various value added products were prepared from the stored kernels *viz*., salted bits and pickle from kernels preserved in brine; dried bits and preserve from kernels preserved in sugar syrup; and cashew ball, cookies, jaggery coated cashew bits and honey coated cashew bits from kernels preserved after drying. Most of the value added products showed high acceptability during organoleptic evaluation and was comparable with those

from fresh kernels. Even some of the products like honey coated and jaggery coated cashew bits showed higher acceptability than those from fresh kernels.

The immature cashew kernels are potential raw materials for preparing value added products especially during rainy season to avoid the loss of matured nuts. Also these kernels were observed to contain enough nutrients which makes it a healthy food item.