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Studies on Individual Quick Freezing of Mature Raw Cashew (*Anacardium Occidentale* L.) Kernels

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HIGHLIGHTS

- Cashew is one of the important dollar-earning plantation crop of India.
- The mature raw cashew kernel is nutritious having main components are total fat, carbohydrates and proteins.
- Individual Quick Freezing may help to preserve the mature raw cashew kernels and also maintains the nutritive value of kernels.

Abstract: The present experiment aims to preserve mature cashew kernels by Individual Quick Freezing (IQF). The mature cashew kernels were peeled, blanched and dipped in liquid nitrogen for different time intervals (0, 25, 50, 75, 100 and 125 seconds). After the completion of dipping time, it was packed in LDPE (Low-Density Polyethylene) pouches and subjected to storage in deep freezing (-20°C). The samples were taken out periodically at the time interval of 2 months and physicochemical analysis was done. The study investigated that, after 180 days of storage, the frozen mature raw cashew kernels immersed in liquid nitrogen for 75 seconds reported the best overall quality compared to other treatments. These findings suggest that treatment T4 (75 sec) is the preferred method for preserving the nutritional quality during Individual Quick Freezing.

Keywords: Cashew; IQF; Liquid Nitrogen; Mature Cashew kernels; Preservation.

INTRODUCTION

Cashew is one of the important dollar-earning plantation crop of India belonging to the genus *Anacardium* of the family *Anacardiaceae* [1]. The cashew tree is grown around the world, especially in Brazil, Vietnam, India, Nigeria, Indonesia, Philippines, Benin, Guinea-Bissau, and Ivory Coast [2]. It is an important nut crop that provides food, employment and hard currency to many developing countries. There is great scope to

expand the area under cashew by about 7.1 lakh ha in both traditional and non-traditional areas including Gujarat, Jharkhand, North Eastern Hilly (NEH) Regions, Andaman and Nicobar Islands, Chhattisgarh and plains region of Karnataka in addition to the present area [3].

The major five raw cashew nut-producing countries are Cote d'Ivoire, India, Vietnam, Burundi, Philippines with production of 848700 MT, 738009 MT, 348504 MT, 300910 MT, 255915 MT and productivity 417 kg/ha, 684 kg/ha, 1241 kg/ha, 1084 kg/ha, 8626 kg/ha respectively [4]. Recently, India is the world's biggest producer, processor, and exporter of cashew kernel [5]. Maharashtra state contributes 170 thousand ha area under cashew and production is about 199.70 thousand MT [6]. Konkan region on the west coast of Maharashtra is one of the largest cashew growing belts occupying 173,601 ha area under cashew cultivation. The Konkan region of Maharashtra including Thane, Raigad, Ratnagiri and Sindhudurg districts is the major territory of cashew cultivation in the state [7].

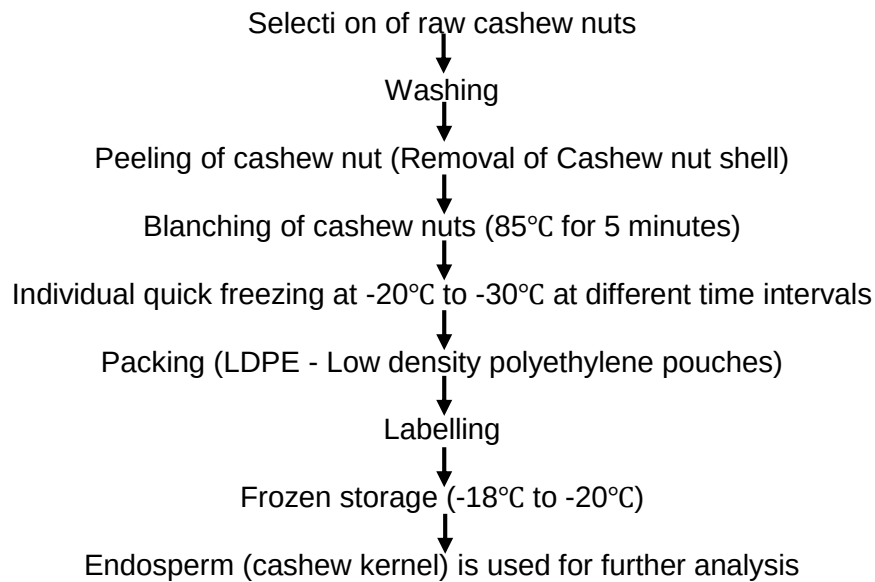
Vengurla – 4 is a hybrid variety of cashew nuts with the parentage of Midnapore Red x Vetore 56 and was released in 1981. It is a cluster-bearing type with a percentage of perfect flowers 35 and a fruit set of 6 %. The yield of nuts is 17.2 kg tree⁻¹. The nut weight is 7.7 g and the shelling percentage is 31. The colour of the apple is red. Kernel grade is 210 (export grade) [8]. The apple or false fruit and the nut or true fruit are the two components of the cashew fruit. A cashew nut is a real fruit of the cashew, inside of which the seed is found called a kernel. The kernel and shell together make up the nut. About 45–50 % of the weight of the kernel is made up of the 3 mm-thick shell [9]. The kernel, which is slightly curled on itself and made up of two cotyledons accounts for 20–25 % of the nut's weight and is covered by a thin, flexible membrane-like peel called testa, which makes up about 5 % of the total weight of nut [10]. The mature raw cashew kernel is nutritious having main components are total fat, which makes up 48.3 % of the overall weight having 79.7 % unsaturated fatty acids, 20.1 % saturated fatty acids and 0.2 % trans fatty acids, carbohydrates 20.5 g/100 g, followed by proteins with 21.3 g/100g is present on average [11].

Individually Quick Frozen, also known as IQF, is the term used to describe products that have undergone the process [12]. All kinds of berries, fruits, vegetables, diced or sliced seafood, small fish, squid, meat, poultry, even pasta, cheese, and grains are examples of common food items that are frequently frozen using IQF technologies. The most recent advancement in freezing technology is liquid nitrogen freezing which makes it possible to preserve and store fruit slices and cubes in their original farm-fresh condition for up to a year. Fruit and vegetables are frozen in liquid nitrogen using the fluidization method, which takes only 45 to 60 seconds as opposed to at least 3 to 4 hours or even longer in a blast freezer. The key component of this process is ultra-rapid freezing at extremely low temperatures (-20°C to -30°C), which is intended to stop the activities of the microorganisms that deteriorate food. Better texture and free-flowing, lump- and block-free products are the outcomes of this. One does not have to thaw or defrost the whole packet to take out only a portion, and the rest will remain frozen till required again [13]. The mature raw cashew kernels are available in the Konkan region from March to May. It is mainly used for vegetable purposes due to its immense taste and nutritional value. Due to the seasonality of mature raw cashew kernels, the use of IQF technology will boon to make it available around the year during the off-season.

MATERIAL AND METHODS

The research was conducted from April to September 2023. The fresh well mature raw cashew kernels (Vengurla – 4) were harvested during morning hours from the orchard at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India. The harvested cashew nuts were brought to Sahyadri Farms, Nashik, Maharashtra, India. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications. The cashew nuts were peeled, blanched and then directly treated with liquid nitrogen at various time intervals. There were six treatments viz., T1: Control, T2: 25 sec, T3: 50 sec, T4: 75 sec, T5: 100 sec and T6: 125 sec. After the treatment, the cashew kernels were stored for the storage of 6 months. The procedure for Individual Quick Freezing of mature raw cashew kernels applied in this study is presented in Flowchart 1.

Observations were done on the chemical characteristics of the samples, including moisture, ash, protein, fat, carbohydrates, fatty acids, and minerals like calcium, potassium, magnesium, and phosphorus by using methods described in AOAC. [14], physical quality of the colour using a colour reader (make Konica Minolta, Japan CR-10), total number of microbial contaminants using the plate count method of APHA (2001) [15], and organoleptic evaluation of the flavour, taste, colour and overall performances of the product based on hedonic scale 1 to 9.



Flow chart 1. Procedure for Individual quick freezing of Fresh mature raw cashew kernels at -20 °C

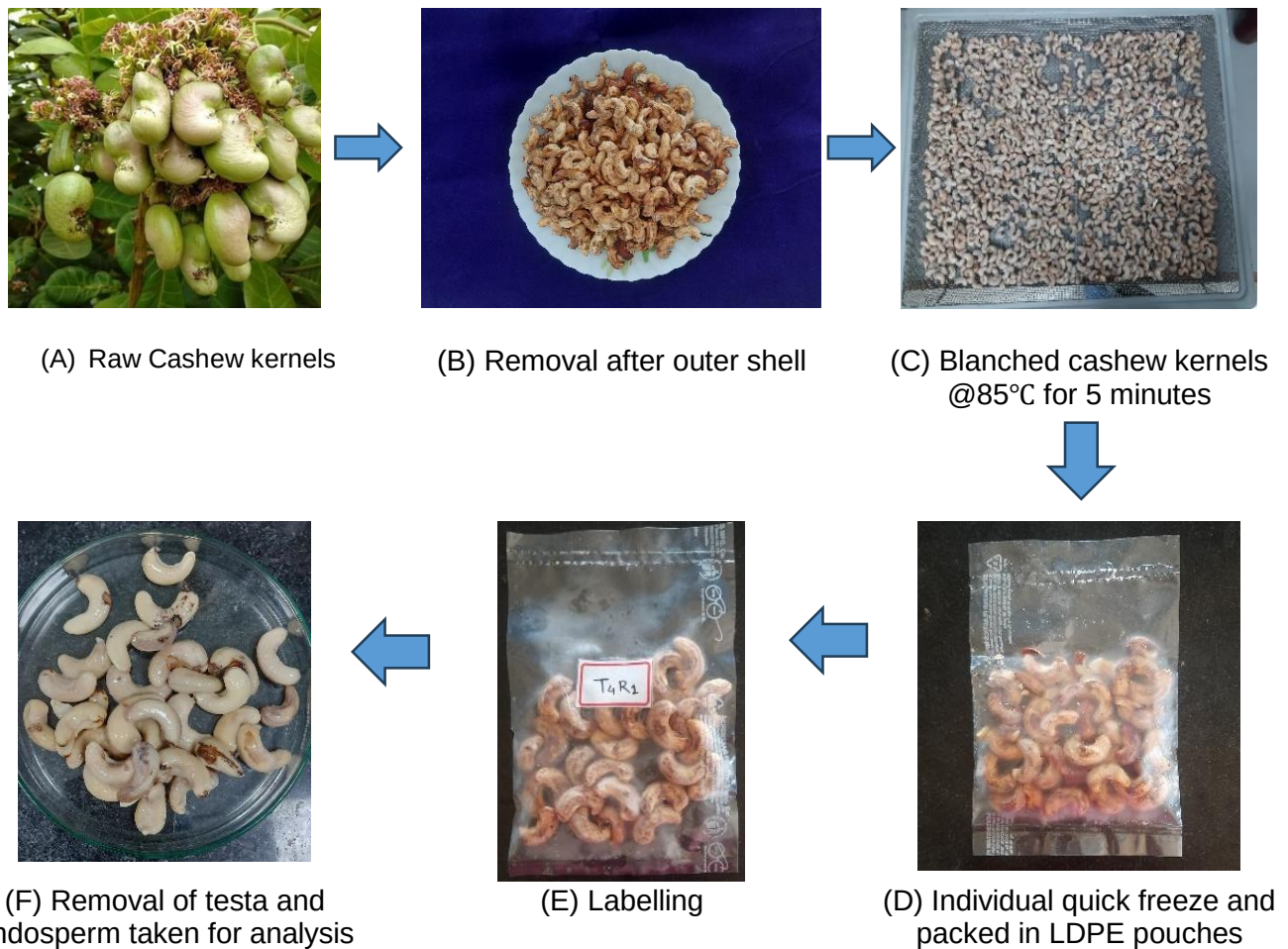


Figure 1. (A) Raw Cashew kernels (B) Removal after outer shell (C) Blanched cashew kernels @85°C for 5 minutes (D) Individual quick freeze and packed in LDPE pouches (E) Labelling (F) Removal of testa and endosperm taken for analysis.

RESULTS AND DISCUSSION

The changes in moisture, ash, protein content during frozen storage is shown in Table 1; carbohydrates, fat and fatty acids are shown in Table 2; minerals in Table 3 total plate count in Table 4 and colour value in Table 5.

MOISTURE

Among the treatments, the maximum moisture content was observed in treatment T4 (46.79 %) whereas treatment T1 recorded the lowest moisture content (45.97 %). The moisture content at the initial stage was 47.13 % and 45.69 % after 180 days. The mature raw cashew kernels dipped in the liquid nitrogen for a period of 75 seconds showed a minimum decrease than the control sample. Hashem and coauthors (2012) studied the long-term freezing storage study toward safety, nutritive value and chemical changes of pistachio nuts, it was observed after two years of storage at freezing conditions were shrinking as there was a decrease in moisture content resulting in the level of relative humidity around the nuts [16].

ASH

Treatment T4 (1.448 %) recorded the highest mean ash content whereas minimum ash content was observed in the treatment T1 (1.333 %). As regards the storage, the highest ash content was recorded at the initial stage irrespective of treatments. An ash content decreased from 1.457 to 1.338 per cent was noticed up to 180th days of storage. The mature raw cashew kernels dipped in liquid nitrogen for the period of 75 seconds recorded a minimum decrease in mean ash content as compared to the control. The blanching applied before seed preservation in broad beans caused a decrease in the levels of ash [17].

PROTEIN

The data revealed that the different immersion periods in liquid nitrogen exerted significant effects on protein content. Among the treatments, the maximum protein content was observed in treatment T4 (13.91 %) which was significantly superior to all the treatments. However, treatment T1 (12.50 %) recorded the lowest protein content. There was an increase in protein content with regards to the storage at -20°C temperature. The increase in protein content may be due to the decrease in moisture and ash content. The quick-freezing treatment after blanching reduced the degradation of soluble protein in celery during storage [18].

CARBOHYDRATES

The carbohydrate during storage at -20°C was significantly impacted by the different liquid nitrogen immersion periods. The treatment T2 (26.25 %) showed the significantly highest mean carbohydrate and minimum carbohydrate was observed in the treatment T1 (16.35 %). The highest mean carbohydrate content was seen in dipping time 25 seconds while control had the lowest carbohydrate content. In terms of storage conditions, 180 days of -20°C storage resulted in decrease in the content of carbohydrate. Nuts lose moisture during frozen storage, and can also lead to decrease in carbohydrate content. Carbohydrates are hydrophilic so they attract and bind to water molecules. When nuts lose some of water molecules that are bound to carbohydrate which can make carbohydrate more susceptible enzymatic breakdown and the Millard reaction in pistachio nuts [16].

Table 1. Changes in moisture, ash protein content of frozen mature raw cashew kernels immersed in liquid nitrogen for different immersion periods and stored at -20 °C temperature

Treatments	Moisture (%)					Ash (%)					Protein (%)				
	Storage period (Days)					Storage period (Days)					Storage period (Days)				
	0	60	120	180	Mean	0	60	120	180	Mean	0	60	120	180	Mean
T1	47.13	45.96	45.51	45.27	45.97	1.45	1.36	1.29	1.23	1.333	12.43	12.49	12.51	12.57	12.5
T2	47.15	46.66	45.53	45.26	46.15	1.46	1.41	1.38	1.32	1.393	12.6	12.78	12.84	12.94	12.79
T3	47.11	46.88	46.63	45.83	46.61	1.45	1.41	1.4	1.38	1.41	12.56	13.37	13.93	14.95	13.7
T4	47.17	47.1	46.66	46.24	46.79	1.47	1.45	1.44	1.43	1.448	12.68	13.25	14.23	15.5	13.91
T5	47.09	46.31	45.99	45.83	46.31	1.46	1.4	1.34	1.3	1.375	12.52	13.6	13.9	14.11	13.53
T6	47.11	47.05	46	45.7	46.47	1.45	1.4	1.38	1.37	1.4	12.48	12.97	13.21	13.97	13.16
Mean	47.13	46.66	46.05	45.69		1.457	1.405	1.372	1.338		12.55	13.08	13.44	14.01	
	S.Em±		CD 5 %			S.Em±		CD 5 %			S.Em±		CD 5 %		
Treatment(T)	0.17		0.47			0.003		0.008			0.05		0.14		
Storage(S)	0.13		0.38			0.002		0.007			0.04		0.12		
Interaction (T×S)	0.3		NS			0.005		0.015			0.09		NS		

Data based on mean of three replications (p < 0.05)

Table 2. Changes in carbohydrates, fat, fatty acids content of frozen mature raw cashew kernels immersed in liquid nitrogen for different immersion periods and stored at 20 °C temperature.

Treatments	Carbohydrate (%)					Fat (%)					Fatty acid (%)				
	Storage period (Days)					Storage period (Days)					Storage period (Days)				
	0	60	120	180	Mean	0	60	120	180	Mean	0	60	120	180	Mean
T1	15.28	16.34	16.80	16.96	16.35	12.377	11.187	11.127	10.967	11.414	23.71	23.85	23.89	23.97	23.85
T2	25.82	25.93	26.93	26.32	26.25	12.967	13.217	13.317	14.157	13.414	23.80	24.10	24.28	24.53	24.18
T3	26.74	25.42	24.80	24.32	25.32	12.137	12.917	13.237	13.517	12.952	23.53	24.66	25.62	26.11	24.98
T4	26.52	24.83	23.92	22.00	24.32	12.157	13.367	13.747	14.827	13.524	23.77	25.06	26.15	26.93	25.48
T5	26.47	25.15	24.93	24.71	25.32	12.457	13.537	13.837	14.047	13.469	23.44	23.89	24.33	24.85	24.13
T6	26.74	25.88	26.47	25.46	26.14	12.217	12.697	12.937	13.497	12.837	23.28	24.15	24.85	25.13	24.35
Mean	24.60	23.93	23.98	23.30		12.385	13.217	13.450	13.972		23.59	24.29	24.85	25.25	
		S.Em±		CD 5 %				S.Em±		CD 5 %		S.Em±		CD 5 %	
Treatment(T)		0.58		1.64				0.012		0.033		0.08		0.22	
Storage(S)		0.47		NS				0.01		0.027		0.06		0.18	
Interaction (T×S)		1.05		NS				0.021		0.06		0.14		0.4	

Data based on mean of three replications (p < 0.05)

Table 3. Changes in calcium, magnesium, potassium, and phosphorus content of frozen mature raw cashew kernels immersed in liquid nitrogen for different immersion periods and stored at -20°C temperature

Treatments	Calcium (mg/100)					Magnesium (mg/100g)					Potassium (mg/100g)					Phosphorus (mg/100g)				
	Storage period (Days)					Storage period (Days)					Storage period (Days)					Storage period (Days)				
	0	60	120	180	Mean	0	60	120	180	Mean	0	60	120	180	Mean	0	60	120	180	Mean
T1	28.18	27.77	27.21	26.77	27.48	212.31	211.51	210.17	209.97	210.99	358.35	353.5	351.19	350.13	353.29	359.61	354.76	350.46	347.4	353.06
T2	28.47	29.75	30.87	31.52	30.15	212.61	215.38	217.12	220.38	216.37	357.75	370.98	385.85	395.19	377.44	359.19	373.87	383.38	397.49	378.49
T3	28.65	30.05	30.97	31.00	30.17	211.64	223.2	235.64	243.29	228.44	358.24	375.56	395.12	399.71	382.16	359.71	380.29	388.32	399.15	381.87
T4	28.05	30.55	31.8	32.68	30.77	212.17	222.05	239.7	242.4	229.08	357.71	382.62	393.24	404.41	384.5	359.69	380.82	399.58	406.04	386.54
T5	28.91	30.72	31.68	31.42	30.68	211.87	220.42	232.9	238.32	225.87	358.04	369.29	375.59	380.62	370.89	359.51	370.9	376.49	382.63	372.39
T6	29.26	30.64	30.77	31.04	30.43	211.97	219.31	229.4	234.73	223.85	358.11	368.78	371.18	375.69	368.44	359.29	368.77	371.08	373.82	368.24
Mean	28.59	30.08	30.88	31.24		212.09	219.31	229.16	233.48		358.03	370.12	381.03	387.29		359.5	373.24	380.89	388.09	
	S.Em±		CD 5 %			S.Em±		CD 5 %			S.Em±		CD 5 %			S.Em±		CD 5 %		
(T)	0.015		0.04			0.1		0.28			0.2		0.56			0.12		0.35		
(S)	0.012		0.03			0.08		0.23			0.16		0.46			0.1		0.29		
(T×S)	0.027		0.08			0.18		0.51			0.36		1.02			0.22		0.64		

Data based on mean of three replications (p < 0.05)

Table 4. Changes in total plate count of frozen mature raw cashew kernels immersed in liquid nitrogen for different immersion periods and stored at -20°C temperature

Treatments	TPC (cfu/g)				
	Storage period (Days)				
	0	60	120	180	Mean
T1	ND	ND	12 x 10 ³	30 x 10 ³	10.5 x 10 ³
T2	ND	ND	10 x 10 ³	28 x 10 ³	9.5 x 10 ³
T3	ND	ND	9 x 10 ³	25 x 10 ³	8.5 x 10 ³
T4	ND	ND	7 x 10 ³	15 x 10 ³	5.5 x 10 ³
T5	ND	ND	8 x 10 ³	18 x 10 ³	6.5 x 10 ³
T6	ND	ND	9 x 10 ³	20 x 10 ³	7.25 x 10 ³
Mean	ND	ND	9.17 x 10 ³	22.67 x 10 ³	
	S.Em±			CD 5 %	
Treatment (T)	0.2			0.58	
Storage (S)	0.17			0.47	
Interaction (T x S)	0.37			1.05	

Data based on mean of three replications (p < 0.05)

Table 5. Changes in Colour L* a* and b* value of frozen mature raw cashew kernels immersed in liquid nitrogen for different immersion periods and stored at -20 °C temperature

Treatments	L* value of colour					a* value of colour					b* value of colour				
	Storage period (Days)					Storage period (Days)					Storage period (Days)				
	0	60	120	180	Mean	0	60	120	180	Mean	0	60	120	180	Mean
T1	87.20	76.83	65.25	55.23	71.13	-16.50	-11.23	-5.73	0.10	-8.34	42.60	44.35	46.68	48.93	45.64
T2	87.40	77.46	66.85	58.56	72.57	-16.70	-12.16	-6.48	-1.10	-9.11	42.40	44.06	45.77	47.68	44.98
T3	87.30	76.80	65.54	56.93	71.64	-16.60	-12.88	-6.94	-1.40	-9.46	42.60	43.90	44.97	46.27	44.44
T4	87.60	76.90	67.50	61.37	73.34	-16.80	-13.57	-8.07	-1.80	-10.06	42.20	43.78	44.83	46.54	44.34
T5	87.20	78.43	67.13	60.98	73.44	-16.50	-13.04	-7.58	-1.70	-9.71	42.40	43.99	45.19	47.02	44.65
T6	87.40	77.16	66.04	55.87	71.62	-16.80	-11.75	-6.01	-0.50	-8.77	42.20	44.21	46.37	48.36	45.29
Mean	87.35	77.26	66.39	58.16		-16.65	-12.44	-6.80	-1.07		42.40	44.05	45.64	47.47	
		S.Em±		CD 5 %		S.Em±		CD 5 %		S.Em±		CD 5 %			
Treatment(T)		0.07		0.21		0.037		0.11		0.03		0.09			
Storage(S)		0.06		0.17		0.031		0.09		0.02		0.07			
Interaction (T×S)		0.13		0.38		0.068		0.19		0.05		0.16			

Data based on mean of three replications (p < 0.05)

FAT

It was observed that there was a significant difference among the treatments with respect to the fat content. Treatment T4 (13.524 %) recorded the highest mean fat content and minimum was observed in the treatment T1 (11.414 %). The mature raw cashew kernels immersed in liquid nitrogen for period of 75 seconds showed the maximum increase in fat content. It is also noted that the fat content showed increasing trend with increase in the storage period. The increase in fat content of mature raw cashew kernels may be due to the initial oxidation of fat which is usually slow and at a relatively uniform rate. This is known as induction period. At the end of the induction period, the oxidation process accelerates very rapidly [19].

FATTY ACID

It was observed from the data that there was increasing trend in fatty acid content of mature raw cashew kernels dipped in liquid nitrogen at different periods during storage. Among the treatments, the significantly maximum fatty acid content was observed in treatment T4 (25.48 %) however, treatment T1 (23.85 %) recorded lowest fatty acid content. With respect to storage, increasing trend in fatty acid content was observed. An increase in free fatty acid percentage with increasing storage time because of the degradation of large lipid molecules, which produced smaller molecules including free fatty acids by lipase and oxidation [20].

CALCIUM

There was a significant difference among the treatments with respect to calcium content in frozen mature raw cashew kernels. The treatment T4 (30.77 mg/100g) showed the significantly highest mean calcium and minimum mean was observed in the treatment T1 (27.48 mg/100g). As regards the storage, an increasing trend in calcium content was observed during storage. The increase of calcium content was probably due to the presence of calcium in water used for blanching, an increase in its concentration is typically noticed. Furthermore, because of its structural connection to plant tissues, it is not as readily removed [21].

MAGNESIUM

The treatment T4 (229.08 mg/100g) showed the significantly highest mean of magnesium while lowest was observed in the treatment T1 (210.99 mg/100g). The magnesium content was increased from 0 to 180th day of storage. The possible reason for increasing the magnesium content in frozen mature raw cashew kernels during storage at -20°C would be because of the greater amount of magnesium content in frozen vegetables than that of canned vegetables. Lee (1949) asserts that frozen peas can maintain a higher nutritional quality than any other processed pea when they are thawed to a low enough temperature (-10°F) [21].

POTASSIUM

The treatment T4 showed significantly highest (384.50 mg/100g) mean potassium content whereas minimum was observed in the treatment T1 (353.29 mg/100g). At 0 day the potassium content was 358.03 mg/100g and it was increased up to 387.29 mg/100g 180 days during storage. The increasing trend in potassium content was observed. According to the nutritious contents of processed vegetables, frozen products had a greater mineral Potassium concentration than canned vegetables. Lee (1949) claims that frozen peas can maintain a higher nutritional quality than any other processed pea when they are thawed to a low enough temperature (-10°F) [21].

PHOSPHORUS

The treatment T4 (386.54 mg/100g) showed the significantly highest mean of phosphorus and lowest phosphorus content was observed in the treatment T1 (353.06 mg/100g). As regards, storage conditions, an increase in phosphorus content was observed during 180 days. The phosphorus significantly increased from 359.50 mg/100g at the initial stage to 388.09 mg/100g at 180 days of storage. In terms of storage conditions, 180 days of -20°C storage resulted in an increase in the content of phosphorus. The present study also confirms the results of Wyatt and Ronan (1983) in green beans and broccoli [22].

TOTAL PLATE COUNT

The minimum significant total plate count content was observed in treatment T4 (5.50×10^3 cfu/g) while maximum was found in treatment T1 (10.50×10^3 cfu/g). As regards to the storage, there was significant increase in the total plate count content was observed during 180 days of storage period after 120 days. The initially up to 60 days total plate count was not detected. The minimum total plate count content was observed at 9.17×10^3 cfu/g on 120 days of storage while maximum was found on 180 day of storage (22.67×10^3 cfu/g). Microbial count of all the treatments after 180 days of storage was far below the permissible limits (1,00,000 colonies/ml) in food material. Along with rapid freezing, defrosting also had a significant impact on microbiological life, and rapid heating would result in the death of the microorganisms. Additionally, rapid cooling of microbe cells below their optimal temperature might lead to cold shock, which would kill the bacteria. Kumalaningsih and Hidayat (1995) reported the condition was associated with liquid changes in the cell membrane, such as ribonuclease inhibitors that inhibit microbial growth or disrupt cell permeability [23].

COLOUR (L^* , a^* , b^* values)

Colour is one of the major visual attributes of fruits. The Hunter value of colour L^* is a measure of lightness on a scale ranging from zero (black) to 100 (white). a^* value of colour value is negative, it indicates greenness; when a value is positive, it indicates redness. A color's Hunter b^* value indicates its blueness when it's negative and its yellowness when it's positive. The changes in L^* , a^* and b^* value of colour is presented in Table 5. The maximum average L^* value was observed in the treatment T5 (73.44). The minimum mean L^* value was observed in the treatment T1 (71.13) i.e. control. The present data shows that the lightness of cashew kernels significantly decrease in the L^* value for colour was observed during six months of storage period. The mean maximum L^* value was observed at the initial stage (87.35) irrespective of treatments while minimum was noticed on the 180th day (58.16) of storage period. The maximum mean a^* value for mature raw cashew kernels observed in the treatment T1 (-8.34) which was followed by treatment T6 (-8.77) and T2 (-9.11). The average minimum a^* value was recorded in treatment T4 (-10.06) which was followed by treatment T5 (-9.71). The average minimum a^* value was observed at initial stage (-16.65) while average maximum a^* value was recorded on 180th day (-1.07) of storage. There was a significant effect of treatment on b^* value for the mature raw cashew kernels showed an increasing trend during storage. It was observed from the data that maximum mean b^* value was observed in the treatment T1 (45.64) which was followed by treatment T6 (45.29). The minimum was recorded in treatment T4 (44.34) i.e., 75 seconds dipping time followed by T3 (44.44) and T5 (44.65). As regard the storage, there was significant increase in the b^* value for colour during 180th day of storage period. The average significantly minimum b^* value was observed at initial stage (42.40) while it was maximum on 180th day of storage (47.47). The change was probably occurred due to browning reactions that proceeds oxidative and enzymatically controlled process as reported by Calligaris and coauthors (2002) [24].

ORGANOLEPTIC EVALUATION

The colour of the mature raw cashew kernels under all the treatments showed difference among the treatments and the different dipping time in liquid nitrogen showed decreasing trend for colour, texture, flavour and overall acceptability Y. The colour scores of frozen mature raw cashew kernels immersed in liquid nitrogen at varying immersion times agree with research on mango cv. Arumanis done by Mulyawanti and Dewandari (2010) [25]. The quick breakdown or ester diffusion process that occurs after freezing has an impact on the frozen mature raw cashew kernels flavour. According to Talens and coauthors (2003) [26], dehydration that happened during the freezing of the kiwi fruit changed the process of ester compound synthesis and decreased the amount of aldehyde and alcohol compounds. This led to changes in the volatile component profiles. Research on apple slices by Fennema (1973), mango cv. Arumanis by Mulyawanti and Dewandari (2010) [25]. The reduction in scores for the texture of frozen mature raw cashew kernels was observed. The different immersion period of liquid nitrogen and storage periods exhibited significant influence on the overall acceptability of mature raw cashew kernels stored at -20°C temperature. The frozen mature raw cashew kernels dipped in liquid nitrogen for 75 seconds obtained a maximum mean score for overall acceptability which was superior to that of dipping for 25 seconds and 125 seconds. At storage conditions, a significant decline in the scores for overall acceptability was observed at the end of storage condition of 180 days but frozen mature raw cashew kernels all the treatments were acceptable throughout the storage at -20°C of 180 days. This indicates that the mature raw cashew kernels immersed in liquid nitrogen for 75 seconds and stored at -20°C temperature was found to be superior with respect to overall acceptability of

frozen mature raw cashew kernels with either 25 seconds, 50 seconds, 100 seconds and 125 seconds at -20°C storage temperature.

CONCLUSION

Dipping periods in liquid nitrogen and storage period at -20°C affected quality of mature raw cashew kernels. Dipping for 75 seconds in the liquid nitrogen gave the best quality when the frozen mature raw cashew kernels were stored for 6 months. It had moisture 46.79 %, ash 1.448 %, protein 13.91 %, fat 13.524 %, carbohydrates 24.32 %, fatty acid 25.48%, calcium 30.77mg/100g, magnesium 229.08 mg/100g, potassium 384.5 mg/100g, phosphorus 386.54 mg/100g and colour value were L* 73.3, a* -10.0, b* 44.34.

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Conflicts of Interest: The authors declare that there is no conflict of interest.

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