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Physico-chemical changes during refrigeration storage of osmotic dehydrated coconut

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Abstract
Sugar solution containing 10 and 20º brix were used as osmotic agents for the processing of osmotic dehydrated coconut and stored at ambient and refrigeration condition. The free fatty acid content of ambient temperature stored dehydrated coconuts T_0, T_1, and T_3 were between the range of 0.410 to 1.186, 0.404 to 0.564 and 0.394 to 0.523 per cent, respectively, whereas the refrigeration stored samples were ranged between 0.410 to 0.905, 0.404 to 0.496 and 0.394 to 0.482 per cent. Initially T_0, T_1 and T_2 contained 4.52, 4.45 and 4.38 per cent of peroxide value, respectively. At the end of the storage, the values were between the range of 6.77 to 8.34 (control), 5.13 to 5.79 (T_1) and 4.92 to 5.19 (T_2) per cent. The samples T_1 and T_2 initially had 4.0 x 10^6/g of bacteria and increased into 6.0 and 5.0 x 10^6/g the end of the storage.

Keywords: Coconut, ambient, dehydration, refrigeration, Storage

Introduction
Osmotic dehydration is a method for the partial dehydration of foods by immersing them in a concentrated sugar or salt solution. Osmotic dehydration is done to improve colour and flavour, to reduce shrinkage of the food material and potential energy savings up to 50% of initial moisture is removed from the food material without undergoing a phase change [7]. Dehydrated coconut is the edible, dried-out shredded coconut meat prepared from fresh kernel of fully matured coconut. It is used both in household foods and processed foods particularly in ready-to-cook mixes and in packaged and canned foods. In the bakery and confectionery industry desiccated coconut is a favoured ingredient [5]. The fat content of the desiccated coconut is easily oxidised either by lipase or by the enzymes of microbes during storage. The chain of actions such as oxidation of fatty acids, release of free fatty acids contributed to the development of rancidity and off-flavour in the coconut based products. The oxidation of fatty acids can be prevent by deactivating the enzymes and hinder the growth of microorganism. The enzymes responsible for quality deterioration are active between the temperatures of 40-60 ºC. The temperature maintained at refrigerator are below 4 ºC. So it slows down the enzyme activity and reduce growth rate of microorganisms. The occurrence of spoilage due to the microorganism also reduced. Hence, the study was undertaken to study the effect of refrigeration storage on physico chemical changes during the storage of osmotic dehydrated coconut.

Methods and Materials
Processing of osmotic dehydrated coconut
The process involved in the preparation of osmotic dehydrated coconut are given in the Fig.1. The selected coconuts were broken into two halves and scraped by using a stainless steel scraper. The scraped uniform size coconut was steam blanched for 10 min. Sugar solution containing 10 and 20º brix were prepared. The coconut scrapings and sugar solution were taken in the ratio of 1:2. The blanched coconut scrapings were soaked individually in sugar solutions. To preserve the colour and to prevent the spoilage of coconut samples 250 ppm of SO_2 was added to the soak solution and kept for 24 hours. After osmosis, the solution was drained out from the coconut scrapings and dried separately in the mechanical dryer at 60 ºC for 4 to 5 hours (up to 4.0% moisture). Each dried sample was cooled immediately.

Storage studies

The dehydrated coconut samples were prepared in a large scale and packed in food grade polyethylene bags (300 gauge thickness) and kept in ambient and refrigeration temperature to study the storage quality. The changes in the physico chemical characteristics were analysed once in 30 days during the storage period (6 months).

Physico-Chemical analysis of osmotic dehydrated coconut

Moisture content was determined by weight loss of 5 g sample after heating at 110 ºC for 2 hours[1]. Free fat acid value was expressed as mg of potassium hydroxide required to neutralize free fatty acids of 100 g sample. Peroxide value was determined by titration against thiosulphate in the presence of potassium iodide [11]. Sugar content in the samples was determined by using Lane - Eynon method [1].

Microbial load

The microbial load of osmotic dehydrated coconut samples were enumerated by serial dilution method. The samples were serially diluted. Dilution of 10^{-2}, 10^{-3} and 10^{-6} were taken for all the analysis. One ml of the serial dilutions of the samples were taken in the petri dishes and appropriate media was added for the specific organism. The plates were incubated at room temperature for 48 h for bacteria, 3 days for fungi and actinomycetes and the colonies were counted [2].

Statistical analysis

The analysis of variance of the data obtained was done by using Completely Randomized Design (CRD). Critical differences were worked out at 5% probability level and presented [9].

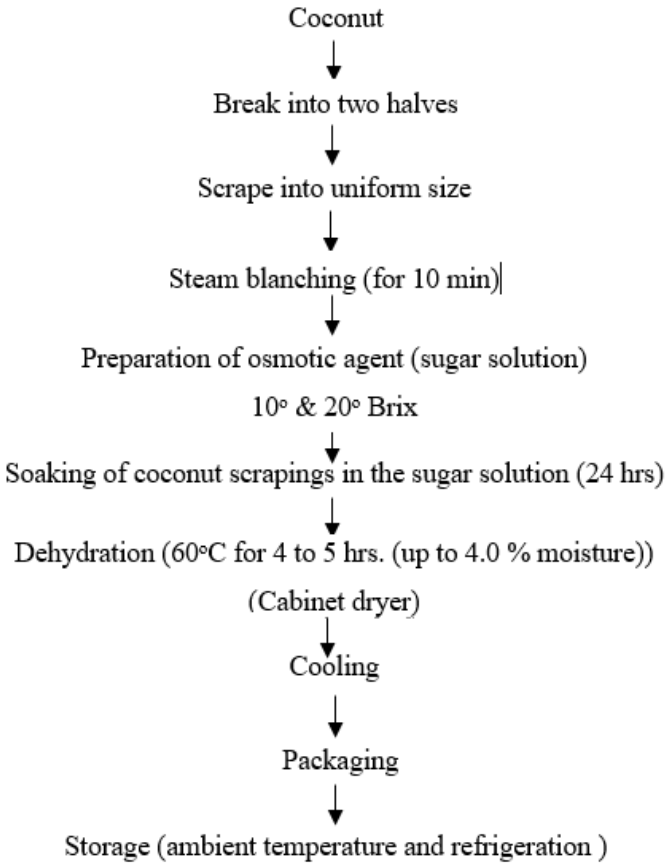

Fig 1: Flow chart for the processing of osmotic dehyrated coconut

Result and Discussion

The ambient temperature and refrigeration stored osmotic dehydrated coconut samples were evaluated for their storage stability. The changes in moisture, total sugar, reducing sugar, free fatty acid, peroxide value and microbial population were analysed.

Moisture content

The moisture content increased gradually in all the samples irrespective of treatment and storage condition (table 1). The control sample had slightly higher moisture content before and after storage than T_1 and T_2. The moisture content of ambient temperature stored osmotic dehydrated coconuts T_0, T_1, and T_3 were between the range of 4.22 to 5.98, 4.18- 5.44 and 4.14 to 5.49 per cent, respectively, whereas the value of refrigeration stored samples were ranged between 4.22 to 5.27, 4.18 to 5.19and 4.14 to 5.28 per cent, respectively. The amount of increment in moisture content during storage of refrigeration stored dehydrated samples are lower than the ambient temperature stored samples.

A significant difference in the moisture content of the dehydrated coconut samples was noted between the treatments, storage condition and storage period. Vennila and Pappiah (1998) found that the stored osmotically dehydrated coconut showed an increase in the moisture content between O and 90 days of storage. Similar increase in the moisture content was observed in the control as well as in the treated samples.

Table 1: Changes in moisture content (%) of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature
0	4.22	4.22	4.18	4.18	4.14	4.14
30	4.41	4.27	4.28	4.23	4.25	4.20
60	4.74	4.34	4.50	4.40	4.46	4.38
90	4.93	4.61	4.71	4.63	4.70	4.65
120	5.15	4.85	4.95	4.81	4.98	4.84
150	5.40	5.12	5.18	4.97	5.25	5.01
180	5.98	5.27	5.44	5.19	5.49	5.28

CD ($P \leq 0.05$) Between Treatment (T) = 0.033, Storage temperature (R) = 0.027, (T X R) = 0.047, Storage period (S) = 0.051, (T X S) = 0.072, (R X S) = 0.080 and (T X R X S) = 0.125.

Total sugar

The control sample contains low total sugar content than the treated samples throughout the study period (table 2). The sample treated with 20° Brix had maintained higher concentration of total sugar than the sample treated with 10° Brix between 0 and 180 days of storage. A gradual reduction in the total sugar content was noted in all the samples irrespective of storage condition and treatments. Initially T_0, T_1 and T_2 contained 8.00, 10.58 and 11.93 per cent of total sugar, respectively. At the end of the storage, the values were between the range of 5.03 to 5.98 (control), 8.17 to 9.56 (T_1) and 9.95 to 11.08 (T_2) per cent. This study shows that reduction in total sugar content is lower in refrigeration stored samples than the ambient temperature stored samples. The statistical analysis of the data revealed a significant difference in the total sugar content of osmotic dehydrated coconut among various treatments, storage condition and storage period.

Vennila and Pappiah (1998) stated that the total sugar content of control and treated coconut pieces had reduced from 8.35 to 5.70 and from 10.88 to 10.05 per cent respectively after 90 days of storage. The reduction noted in the total sugar content of the control resembled similar to the values reported by Vennila and Pappiah (1998).

Table 2: Changes in total sugar content (%) of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature
0	8.00	8.00	10.58	10.58	11.93	11.93
30	7.71	7.92	10.24	10.42	11.51	11.78
60	7.35	7.80	10.08	10.38	11.20	11.62
90	6.29	7.13	9.65	10.17	10.96	11.54
120	5.95	6.84	9.14	9.93	10.40	11.40
150	5.57	6.19	8.50	9.84	10.17	11.29
180	5.03	5.98	8.17	9.56	9.95	11.08

CD ($P \leq 0.05$) Between Treatment (T) = 0.068, Storage temperature (R) = 0.055, Storage period (S) = 0.103, (T X S) = 0.179, (R X S) = 0.146 and (T X R X S) = 0.253.

Reducing sugar

As the storage period increases, the reducing sugar content also increased in all the samples irrespective of storage condition and treatments (table 3). Similar to total sugar content, the control sample shows lesser reducing sugar content throughout the study period than T_1 and T_2. Initially T_0, T_1 and T_2 had 4.40, 7.05 and 7.88 per cent of reducing sugar, respectively. The corresponding values at the end of storage for control ranged between 6.28 and 7.14, 9.68 and 10.15 for T_1 and 9.70 and 10.44 per cent of reducing sugar for T_2 packed in ambient and refrigeration condition. The amount of increase in reducing sugar content of the ambient temperature stored samples are higher than the refrigeration stored osmotic dehydrated coconut samples.

The significant difference in the reducing sugar content of dehydrated coconut was observed between treatments, storage temperature and storage period. The osmotic dehydrated coconut pieces showed an increasing trend in the reducing sugar content from 6.59 to 9.51 per cent after 90 days of storage (Vennila and Pappiah, 1998). Similar observations were noticed in the present investigation too.

Table 3: Changes in reducing sugar (%) content of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature
0	4.40	4.40	7.05	7.05	7.88	7.88
30	4.53	4.54	7.46	7.27	8.21	8.05
60	4.98	4.94	7.87	7.66	8.79	8.41
90	5.27	5.22	8.19	8.01	9.04	8.79
120	6.10	5.45	8.90	8.73	9.63	8.93
150	6.93	5.69	9.38	9.06	9.96	9.24

180	7.14	6.28	10.15	9.68	10.44	9.70

CD ($P \leq 0.05$) Between Treatment (T) = 0.049, Storage temperature (R) = 0.040, (T X R) = 0.070, Storage period (S) = 0.075, (T X S) = 0.130, (R X S) = 0.106 and (T X R X S) = 0.184.

Free fatty acid content changes during storage

The free fatty acid content of control sample was found to be higher than the T_1 and T_2. The control samples showed a drastic change in their free fatty acid content at the end of the storage in both the storage condition (table 4). The samples T_1 and T_2 stored at ambient temperature had slightly higher free fatty acid than the samples stored at refrigeration. The free fatty acid content of room temperature stored osmotic dehydrated coconuts T_0, T_1, and T_3 were between the range of 0.410 to 1.186, 0.404 to 0.564 and 0.394 to 0.523 per cent, respectively, whereas the value of refrigeration stored samples were ranged between 0.410 to 0.905, 0.404 to 0.496 and 0.394 to 0.482 per cent, respectively. The amount of free fatty acid content increased during storage of refrigeration stored dehydrated samples are slightly lower than the samples stored at ambient temperature. The statistical analysis showed that a significant difference in the free fatty acid content of the dehydrated coconut was seen between treatments, storage conditions, and storage period.

Vennila and Pappiah (1998) reported that the osmotically dehydrated control coconut pieces had higher free fatty acid (1.08% of oleic acid) content than the treated one (0.56% of oleic acid) after storing for 90 days. Similar situations were noted in the present study.

The fresh treated coconut grating stored for six months at ambient condition had increased the free fatty acid content from 0.26 to 1.56 per cent of oleic acid (Jayaraman *et al.*, 1998). The test sample selected for the study also exhibited an increase in the free fatty acid during storage.

Table 4: Changes in free fatty acid (% of oleic acid) content of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature
0	0.410	0.410	0.404	0.404	0.394	0.394
30	0.524	0.425	0.421	0.418	0.411	0.404
60	0.741	0.534	0.459	0.428	0.428	0.416
90	0.879	0.592	0.478	0.441	0.450	0.429
120	0.983	0.641	0.497	0.473	0.476	0.452
150	1.114	0.796	0.529	0.485	0.492	0.464
180	1.186	0.905	0.564	0.496	0.523	0.482

CD ($P \leq 0.05$) Between Treatment (T) = 0.004, Storage temperature (R) = 0.003, (T X R) = 0.006, Storage period (S) = 0.006, (T X S) = 0.011, (R X S) = 0.009 and (T X R X S) = 0.015.

Peroxide value changes during storage

The data collected on the peroxide value of the treated osmotic dehydrated coconut samples is presented in table 5. Similar to free fatty acid, the peroxide value also increased as the storage period increases. The control sample exhibited a drastic increase in its peroxide value at the end of the storage than T_1 and T_2. A slight variation in the peroxide value was observed between treatment and storage condition.

The control sample had maintained higher level peroxide value than the sample treated with 10°Brix and 20° Brix between 0 and 180 days of storage. A gradual increase in the peroxide value was noted in all the samples irrespective of storage condition and treatments. Initially T_0, T_1 and T_2 contained 4.52, 4.45 and 4.38 per cent of peroxide value, respectively. At the end of the storage, the values were between the range of 6.77 to 8.34 (control), 5.13 to 5.79 (T_1) and 4.92 to 5.19 (T_2) per cent. This study shows that increase in peroxide value during storage is higher in ambient temperature stored samples than the refrigeration stored samples. The statistical analysis of the data revealed a significant difference in the peroxide value of osmotic dehydrated coconut among various treatments, storage condition and storage period.

Jayaraman *et al.* (1998) reported that the treated preserved fresh coconut gratings showed an increase in the peroxide value from 3.1 to 15.5 mEq/kg after six months of storage. In the present investigation increase in the peroxide value was observed in the stored dehydrated coconut whereas the values obtained were found to be lesser than the reported value.

Table 5: Changes in peroxide value (mEq/kg) of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature
0	4.52	4.52	4.45	4.45	4.38	4.38
30	4.73	4.64	4.52	4.50	4.45	4.42
60	5.54	4.81	4.84	4.61	4.59	4.49
90	5.90	5.14	5.03	4.76	4.73	4.57
120	6.31	5.80	5.28	4.84	4.92	4.71
150	7.15	6.02	5.46	4.98	5.08	4.85
180	8.34	6.77	5.79	5.13	5.19	4.92

CD ($P \leq 0.05$) Between Treatment (T) = 0.036, Storage temperature (R) = 0.029, (T X R) = 0.051, Storage period (S) = 0.055, (T X S) = 0.095, (R X S) = 0.077 and (T X R X S) = 0.134.

Microbial changes during storage

As the storage period progresses an increase in the microbial load was also noted (Table 6). The fungi and actinomycetes count of the samples were found to be less during storage when compared to bacterial count. The control sample had higher microbial population than T_1 and T_2 stored at both the ambient and refrigeration condition. Initially the control sample had 7.0 x 10^6/g of bacteria, which had increased to 29.0 (ambient) and 11.0 x 10^6/g (refrigeration). The samples T_1 and T_2 initially had 4.0 x 10^6/g of bacteria which showed an increase of 6.0 and 5.0 x 10^6/g at the end of the storage, respectively. The control sample initially had 4.0 x 10^2/g of fungi, which had increased to 11.0 (ambient), and 5.0 x 10^2/g (refrigeration) in after 180 days. The samples T_1 and T_2 did not show any increase in the fungal population during the study period stored in both the storage conditions. The actinomycetes level of control was 6.0 x 10^3/g, which had increased to 13.0 (ambient), and 9.0 x 10^3/g (refrigeration) after 180 days. Initially the samples T_1 and T_2 had 2.0 and 1.0 x 10^3/g of actinomycetes, respectively. The both ambient and refrigeration stored 20° brix sugar solution treated sample shows the increase in actinomycetes level from 2.0 to 3.0 x 10^3/g. The result revealed that the osmotic dehydrated coconut treated with sugar solution and refrigeration stored are contains less microbial population the ambient temperatures stored samples.

Vennila (2003) reported that the microbial population of the control and treated dehydrated coconut sample had increased during the study period (90 days). The initial bacterial level of control was noted as 128.0 x 10^6/g and 4.0 x 10^3/g for fungi and 4.0 x 10^3/g for actinomycetes which had increased to 152.0 x 10^6/g, 6.0 x 10^3/g and 8.0 x 10^3/g respectively.

Table 6: Microbial changes in osmotic dehydrated coconut during storage

Treatments	Storage period	Bacteria (x10^6/g)		Fungi (x10^2/g)		Actinomycetes (x10^3/g)	
		Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature	Ambient Temperature	Refrigeration Temperature
Control (T_0)	Initial	7.0	7.0	4.0	4.0	6.0	6.0
	Final	29.0	11.0	11.0	5.0	13.0	9.0
10°Brix (T_1)	Initial	4.0	3.0	1.0	1.0	2.0	1.0
	Final	6.0	6.0	1.0	1.0	4.0	3.0
20° Brix (T_2)	Initial	4.0	3.0	1.0	1.0	2.0	1.0
	Final	5.0	4.0	1.0	1.0	3.0	2.0
CD ($P \leq 0.05$)	Treatment (T)	0.190		0.067		0.073	
	Storage temp. (R)	0.155		0.067		0.073	
	T X R	0.269		0.095		0.103	
	Storage period (S)	0.155		0.083		0.089	
	TXS	0.269		0.117		0.126	
	RXS	0.220		0.117		0.126	
	TXRXS	0.381		0.165		0.178	

Conclusion

The osmotic dehydrated coconut treated with sugar solution along with refrigeration storage prevent the oxidation of fat present in the coconut during storage. So it reduce the formation of free fatty acid and peroxide value of the osmotic dehydrated coconut. It helps in the prevention of rancidity of the products. Osmotic treatment and refrigeration storage hinder the growth of microorganism such as bacteria, fungi and actinomycetes. So shelf life of the dehydrated coconut can be extended by osmotic dehydration and refrigeration storage.

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