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Storage stability of osmotic dehydrated coconut

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Abstract
Acidified salt solution and sugar solution were used as osmotic agents for the processing of osmotic dehydrated coconut. The free fatty acid content of control sample was 0.410 per cent (% of oleic acid) and increased to 1.186 per cent (% of oleic acid) between 0 and 180 days. The oleic acid content of T_1 and T_2 were ranged between 0.401 to 0.581 and 0.381 to 0.483 per cent of oleic acid, respectively. The rancid flavour was felt in the control sample and a drastic changes in the taste was also found, which reduced its score value from 4.0 to 2.0 during the storage. The microbial load of bacteria, fungi and actinomycetes present in the dehydrated coconut were between the ranges of 3.0 to 7.0 CFU/g x 10^6, 1.0 to 4.0 CFU/g x 10^2 and 1.0 to 6.0 CFU/g x 10^3, respectively.

Keywords: Coconut, osmotic, dehydration, sensory, storage

Introduction
Coconut is one of the major plantation crops in India with a total cultivated area of 2,178.74 thousand hectares with a production of 21,384 million nuts which makes India stand 3rd in the world. Out of which the contribution of Kerala is 35.7 per cent (7,631 million nuts) followed by Karnataka with 23.9 per cent (5,123 million nuts) and Tamil Nadu with 24.8 per cent (5,311 million nuts) of the total coconut available in India [13]. The processed products made out of coconut include desiccated (dehydrated) coconut, edible copra, coconut cream, coconut powder, coconut milk, coconut syrup and coconut honey. These products occupied an important place in the confectionary, bakery and other food industries. Dehydrated coconut is the edible, dried-out shredded coconut meat prepared from fresh kernel of fully matured coconut. Dehydrated coconut is the most important processed product of coconut and its annual production is estimated as 10,000 metric tonnes[9]. Annual export of desiccated coconut from India is1638.18 metric tonnes which worth of 1419.69 lakhs rupees [14]. 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 [4]. 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. But osmotic dehydration prevents the oxidation and enhance the shelf life of the product. The 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 [6]. Hence, the study was undertaken to study the physico chemical changes during the storage of osmotic dehydrated coconut.

Methods and Materials
Procurement of Coconut
Coconuts used in this study were purchased from the local market of Madurai district, Tamil Nadu. Matured coconuts containing only small quantity of water were selected for the study. The maturity was judged by the metallic sound when tapped with the finger nail.

Preparation of Osmotic Agents
A. Acidified Salt Solution (Without Antioxidant)
Acidified salt solution containing 1 per cent salt with 1.0 per cent of acetic acid were prepared. For the preparation of acidified salt solution, desired volume of acetic acid was added to the sterilized vessel and boiled distilled water was added to make up the correct concentration. The solution was filtered through a clean muslin cloth and cooled.

B. Acidified Salt Solution (With Antioxidant)
The soak solution (acidified salt solution) was prepared as mentioned above. A portion of soak solution (200ml) was taken. Butylated hydroxy toluene (0.1% BHT) and glycerol mono sterate (0.5% GMS) were added and heated to 95ºC for 10 min to melt, cooled and whipped for 3.0 min. The whipped antioxidant emulsion was added to the remaining portion of the soak solution. The contents were mixed well and filtered through a clean muslin cloth.

C. Sugar Solution
Sugar solution containing 10 and 20º brix were prepared. For the preparation of sugar solution, desired quantity of sugar was taken in a sterilized vessel and distilled water was added and boiled to make up correct concentration. The solution was filtered through a clean muslin cloth and cooled.

Processing of Osmotic Dehydrated Coconut
The process involved in the preparation of osmotic dehydrated coconut are preparation of sample, Preparation of osmotic agents, Osmosis of coconut scrapings and dehydration (Fig.1). The selected coconuts were broken into two halves and scraped by using a stainless steel scraper (without testa). The scraped uniform size coconut was selected and steam blanched for 10 min. The coconut scrapings and soak solution were taken in the ratio of 1:2. The blanched coconut scrapings were soaked individually in glass bottles in soak 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 60º C for 4 to 5 hr (up to 4.0 % moisture). Each dried sample was cooled immediately.

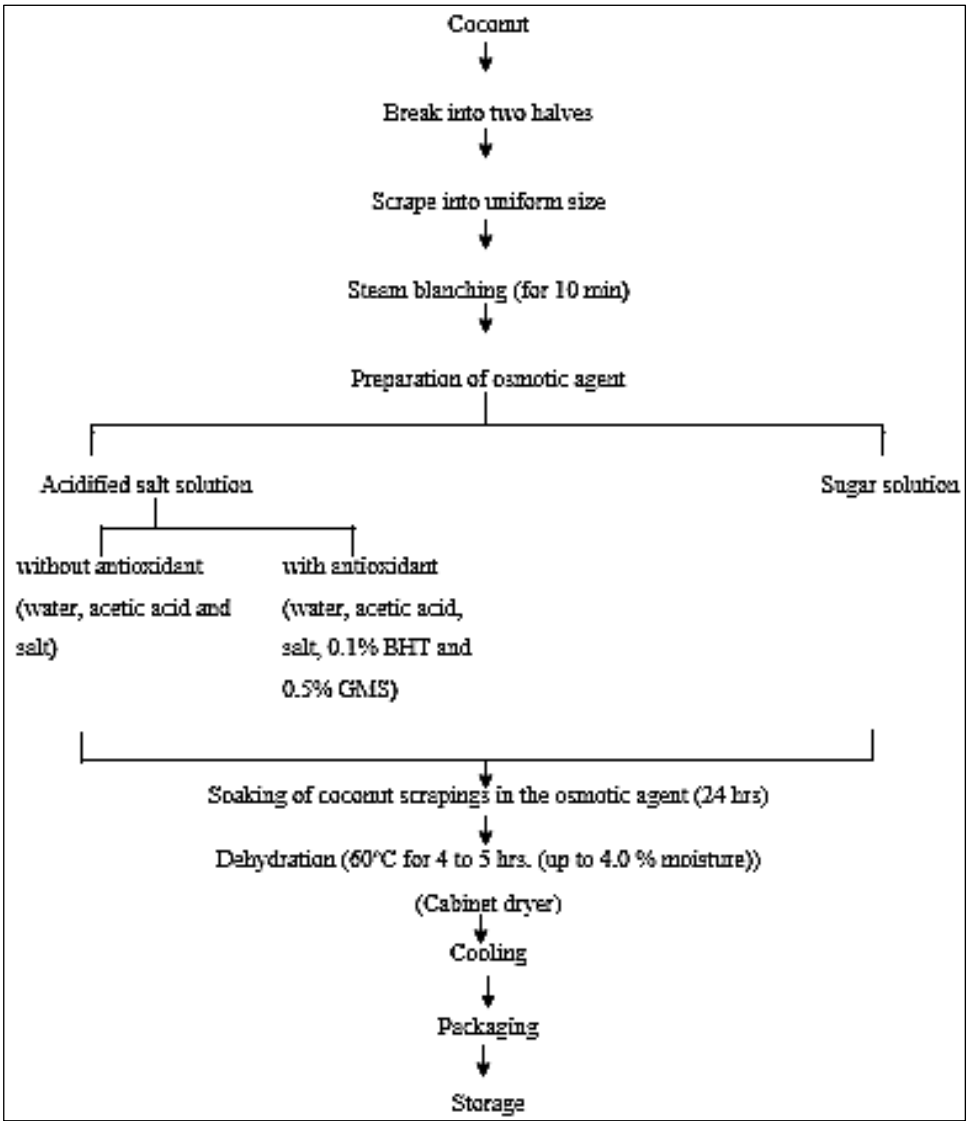

Fig 1: Flow chart for the processing of osmotic dehydrated coconut

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

Physico-Chemical Analysis of *Jhol*
The free fatty acid and peroxide value were determined by titration method [10]. The pH was determined with the help of pH meter calibrated with the standard buffer solutions. The titrable acidity was calculated by titrate the samples against 0.1 N sodium hydroxide by using phenolphthalein as indicator [1]. Moisture content was determined by weight loss of 5g sample after heating at 110 ºC for 2 hours[1]. The ash content

was measured by weight loss of 5 g of moisture free sample for heating at 550 ºC for 5 hours [1]. The crude fat content in the samples was determined by ether extraction using glass soxhlet. The crude protein was determined by using Micro Kjeldhal method. Sugar content in the samples was determined by using Lane-Eynon method [1]. Calcium, Iron and phosphorus were determined by using flame photometer [7].

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 48h 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 [8].

Result and Discussion

Free Fatty Acid Content

The coconut belongs to the food group of nuts and oil seed. The coconut rich in fat showed an increasing trend in the free fatty acid content as the storage period increases (Table 1). The influence of treatment had also noted in the stored sample. The control sample showed a drastic changes in the free fatty acid content at the end of the storage. The initial free fatty acid content (0.410% of oleic acid) of control sample had changed to 1.186 per cent of oleic acid between 0 and 180 days. A slight variation in the oleic acid content was noted between T_1 and T_2 before and after storage and their values ranged between 0.401 to 0.581 and 0.381 to 0.483 per cent of oleic acid, respectively. The oleic acid content of T_4 and T_5 were increased from 0.404 to 0.564 and 0.381 to 0.523 per cent, respectively.

A significant difference in the oleic acid content of the dehydrated coconut samples was observed between treatment and storage period. The increase in the free fatty acid content of control sample indicate the occurrence of oxidation reaction and rancidity. The result of this study indicates that the osmotic dehydration prevent the oxidation of fat present in the sample and arrest the formation rancidity. Kumar (1993) [5] found that the stored coconut treated with antioxidant had lesser oleic acid content than the one without antioxidant. Similar situation was observed in the present study too.

Table 1: Free fatty acid (% of oleic acid) content changes in osmotic dehydrated coconut during storage (6 months)

Storage period (days)	Control (T_0)	Acidified salt solution		Sugar solution	
		Without antioxidants (T_1)	With antioxidants (T_2)	10º Brix (T_3)	20º Brix (T_4)
0	0.410	0.401	0.381	0.404	0.394
30	0.524	0.429	0.392	0.421	0.411
60	0.741	0.464	0.431	0.459	0.428
90	0.879	0.491	0.438	0.478	0.450
120	0.983	0.521	0.443	0.497	0.476
150	1.114	0.552	0.451	0.529	0.492
180	1.186	0.581	0.483	0.564	0.523

CD ($P \leq 0.05$) between storage period (S) = 0.006, Between Treatments (T) = 0.005,
Interaction (S x T) = 0.015

Peroxide Value

A steady increase was noted in the peroxide value of the osmotic dehydrated coconut stored at room temperature (Table 2). Similar to free fatty acid content, a drastic increase was observed in the control sample at the end of the storage period than the treated samples. The influence of treatment and storage period was noticed in the peroxide value among each sample selected for the study. The peroxide values of the samples were 4.5052 (T_0), 4.3031 (T1), 4.2022 (T2), 4.45 (T3) and 4.38 mEq/kg (T4) at initially and changed to 8.34 (T0), 5.96 (T1), 5.14 (T2), 5.79 (T3) and 5.19 mEq/kg (T4) after 180 days.

The statistical analysis showed that a significant difference in the peroxide value of the dehydrated coconut was seen between treatments and storage period. The oxidative change index as represented by peroxide value of the product during storage indicated an increase from the initial value of 39.2 mEq of O_2/kg of fat, reacting a maximum of 207.1 at the end of 80 days of storage in *Kodbale*-a popular Indian spicy savoury (Kumar *et al.*, 1993) [5]. Similar trend was noticed in the present study among the stored sample.

Table 2: Peroxide value (mEq/kg) Changes in osmotic dehydrated coconut during storage (6 months)

Storage period (days)	Control (T_0)	Acidified salt solution		Sugar solution	
		Without antioxidants (T_1)	With antioxidants (T_2)	10º Brix (T_3)	20º Brix (T_4)
0	4.5052	4.3031	4.2022	4.45	4.38
30	4.73	4.44	4.25	4.52	4.45
60	5.54	4.93	4.37	4.84	4.59
90	5.90	5.18	4.43	5.03	4.73
120	6.31	5.45	4.65	5.28	4.92
150	7.15	5.71	4.89	5.46	5.08
180	8.34	5.96	5.14	5.79	5.19

CD ($P \leq 0.05$) between storage period (S) = 0.064, between treatments (T) = 0.054, interaction (S x T) = 0.143

Physico-Chemical Changes of the Osmotic Dehydrated Coconut during Storage

The physico-chemical changes were observed during the storage of osmotic dehydrated coconut. The changes noted in the osmotic dehydrated coconut are given in table 3.

Moisture and Sugar Contents

The initial moisture content of osmotic dehydrated coconut T_0, T_1, T_2, T_3 and T_4 were 4.22, 4.07, 4.30, 4.18 and 4.14 per cent, respectively and increased into 5.98, 5.25, 5.20, 5.44 and 5.49 per cent**.** The initial total sugar content of osmotic dehydrated coconut T_0, T_1, T_2, T_3 and T_4 were 8.00, 8.25, 8.26, 10.58 and 11.93 per cent, respectively and decreased into 5.03, 5.92, 6.18, 8.17 and 9.95 per cent at the end of storage period. The reducing sugar content was between the ranges of 4.40 to 7.88 per cent before storage and increased up to the range of 5.63 to 10.44 per cent during storage period. A significant difference in the moisture and sugar content of the osmotic dehydrated coconut samples was noted between the treatments and storage period. An increase in the reducing sugar content of the coconut scrapings was observed by Kumar (1993) [5] during storage.

Acidity and pH

A significant difference in the acidity and pH of the osmotic dehydrated coconut samples was noted between the treatments and storage period. The acidity content was between the ranges of 0.241 to 0.402 per cent before storage and slightly decreased up to the range of 0.238 to 0.399 per cent. The initial pH value was ranged between 5.20 to 8.05 and slightly increased into 5.25 to 8.14 at the end of storage period.

Protein, Fiber and Ash Content

The protein, fiber and ash content at initially were between the ranges of 10.21 to 10.44, 11.50 to 11.88 and 2.36 to 2.42 per cent, respectively. At the end of the storage period, the value were ranged between 10.07 to10.30, 11.41 to 11.75 and 2.33 to 2.39 per cent. During the study period a negligible changes in the protein, fiber and ash content was observed in all the treated samples.

Table 3: Physico-chemical Changes in osmotic dehydrated coconut during storage (6 months)

Treatments	Storage	Moisture (%)	Total Sugar (%)	Reducing sugar (%)	Acidity (%)	pH	Protein (%)	Crude fiber (%)	Ash (%)
Control (T_0)	Initial	4.22	8.00	4.40	0.241	6.27	10.21	11.5	2.36
	Final	5.98	5.03	7.14	0.238	6.36	10.07	11.41	2.33
Acidified salt solution									
Without antioxidants (T_1)	Initial	4.07	8.25	4.45	0.399	5.20	10.36	11.85	2.4
	Final	5.25	5.92	5.92	0.395	5.25	10.22	11.7	2.36
With antioxidants (T_2)	Initial	4.30	8.26	4.41	0.402	5.21	10.32	11.88	2.42
	Final	5.20	6.18	5.63	0.399	5.26	10.21	11.75	2.39
Sugar solution									
10^0 Brix (T_3)	Initial	4.18	10.58	7.05	0.243	7.43	10.44	11.54	2.39
	Final	5.44	8.17	10.15	0.239	7.56	10.3	11.46	2.34
20^0 Brix (T_4)	Initial	4.14	11.93	7.88	0.243	8.05	10.39	11.57	2.41
	Final	5.49	9.95	10.44	0.241	8.14	10.27	11.5	2.36
CD ($P \leq 0.05$)	Treatment (T)	0.089	0.129	0.096	0.005	0.098	N.S	N.S	N.S
	Storage (S)	0.056	0.081	0.061	0.003	0.062	N.S	N.S	N.S
	T x S	0.126	0.182	0.135	0.007	0.138	N.S	N.S	0.057

N.S- Non significant

Organoleptic Characteristics of Osmotic Dehydrated Coconut during Storage (6 Months Period)

The organoleptic characteristics such as appearance, colour, texture, flavour, taste and overall acceptability were analysed for each samples before and during storage at regular intervals (once in 30 days) for 6 months. The organoleptic score for the dehydrated coconut has been presented in table 4.

The control had the score value as 3.8 for appearance up to one month after that it had reduced to 2.5, whereas T_1 and T_4 have maintained the maximum score (4.0) up to 6 months. The freshly prepared T_1 sample had milky white in colour (4.0) which had changed to dull white during storage. The colour of the control was changed from dull white to yellow tint.

The crisp texture of the T_1, T_2, T_3 and T_4 were maintained throughout the study period, whereas the control changed into moderately crisp texture during storage. The rancid flavour was felt in the control sample from 2nd month onwards. A drastic change in the taste was found in the control sample which had reduced its score value from 4.0 to 2.0. The changes noted in each quality attribute had influenced the overall acceptability score of the stored sample. The overall acceptability of were ranked in the order of T_2, T_4, T_1, T_3 and T_0.

Vennila and Pappiah (1998) [12] reported that the osmotically dehydrated coconut pieces had maintained its original colour, flavour and texture even after storing for 3 months. In the present study T_2 had maintained all the quality attributes throughout the storage study whereas control showed a change in colour, texture, flavour, taste and overall acceptability at the end of the storage at room temperature.

Table 4: Organoleptic characteristics of osmotic dehydrated coconut during storage (6 months period)

Quality attributes	Control (T_0)	Acidified salt solution		Sugar solution	
		Without antioxidants (T_1)	With antioxidants (T_2)	10^o Brix (T_3)	20^o Brix (T_4)
Appearance	Acceptable-Moderately acceptable (3.8-2.5)	Highly acceptable-Acceptable (4.0-3.8)	Highly acceptable (4.0-4.0)	Highly acceptable-Acceptable (4.0-3.9)	Highly acceptable (4.0-4.0)

Colour	Dull white-Yellow tint (3.7-2.4)	Milky white-Dull white (4.0-3.7)	Milky white (4.0-4.0)	Milky white (4.0-4.0)	Milky white (4.0-4.0)
Texture	Crisp-Moderately crisp (4.0-3.6)	Crisp (4.0-4.0)	Crisp (4.0-4.0)	Crisp (4.0-4.0)	Crisp (4.0-4.0)
Flavour	Natural coconut flavour-Rancid (4.0-2. 2)	Natural coconut flavour -Slightly rancid flavour (4.0-3.8)	Natural coconut flavour -Very slight rancid flavour (4.0-3. 9)	Natural coconut flavour -Slightly rancid flavour (4.0-3. 9)	Natural coconut flavour-Very slight rancid flavour (4.0-4.0)
Taste	Highly acceptable-Moderately acceptable (4.0-2.0)	Highly acceptable-Acceptable (4.0-3.9)	Highly acceptable (4.0-4.0)	Highly acceptable-Acceptable (4.0-3.9)	Highly acceptable (4.0-4.0)
Overall acceptability	Highly acceptable-Moderately acceptable (4.0-2.0)	Highly acceptable-Acceptable (4.0-3.9)	Highly acceptable (4.0-4.0)	Highly acceptable-Moderately acceptable (4.0-3. 9)	Highly acceptable (4.0-4.0)

Microbial Changes in the Dehydrated Coconut

The changes in the microbial population was observed before and after storage of osmotic dehydrated coconut. The microbial load of the control sample was found to be higher before and after storage than T_1, T_2, T_3 and T_4 (Table 5). Initially the bacterial population of the T_0, T_1, T_2, T_3 and T_4 were 7.0, 3.0, 3.0, 4.0, 4.0 CFU x 10^6 /g which had increased to 29.0, 9.0, 7.0, 6.0 and 5.0 CFU x 10^6 /g, respectively. The fungi population of control sample at initial was 4.0 and increased to 11.0 CFU x 10^2/g at the end of storage. No changes was noticed in the fungal population in T_1, T_2, T_3 and T_4 during the study period. The actinomycetes showed an increasing trend in the control (6.0-13.0 x 10^3/g) whereas a slight increase in population was observed in T_1, T_2, T_3 and T_4. There was a significant difference in the microbial population in the osmotic dehydrated coconut samples was noted between the treatments and storage period. Vennila (2003) [11] reported that the microbial population of the control and treated dehydrated coconut. The 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.

Table 5: Changes in microbial population of osmotic dehydrated coconut during storage (6 months)

Treatments	Storage	Bacteria (x10^6/g)	Fungi (x10^2/g)	Actinomycetes (x10^3/g)
Control (T_0)	Initial	7.0	4.0	6.0
	Final	29.0	11.0	13.0
Acidified salt solution				
Without antioxidants (T_1)	Initial	3.0	2.0	1.0
	Final	9.0	2.0	3.0
With antioxidants (T_2)	Initial	3.0	1.0	1.0
	Final	7.0	1.0	1.0
Sugar solution				
10^0 Brix (T_3)	Initial	4.0	1.0	2.0
	Final	6.0	1.0	4.0
20^0 Brix (T_4)	Initial	4.0	1.0	2.0
	Final	5.0	1.0	3.0
CD ($P \leq 0.05$)	Treatment (T)	0.183	0.060	0.140
	Storage (S)	0.116	0.038	0.089
	T x S	0.259	0.085	0.198

Conclusion

The samples treated with acidified salt solution with antioxidant and 20° Brix sugar solution had secured highest score for overall acceptability during the storage study. The antioxidant added with acidified salt solution and sugar solution prevent the oxidation of fat present in the coconut during storage and reduce the formation of rancidity. So it reduce the free fatty acid and peroxide value of the dehydrated coconut. The shelf life of the dehydrated coconut can be extended by osmotic dehydration. The osmotic dehydrated coconut and ready-to-use products are having high potential for commercialisation and marketability.

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