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Quality of tamarind leathers as affected by drying systems and storage period

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Abstract
The present study was conducted to evaluate the quality of tamarind leathers dried by two different food dehydrators. It also aimed at assessing the quality of tamarind leathers stored at room temperature. Cabinet and solar driers were used to dry the tamarind leathers, the dried leathers were stored for six months at room temperature. Microbial and physicochemical analysis for leathers was carried out. The results revealed that, the leathers were free from any contamination caused by microorganisms during the storage period. The moisture content of leathers was increased during storage period, also the texture values of the leathers were increased during storage period thus the leathers became tender at the end of the storage period.
As the storage period proceeds, the leathers color became darker. The change of color values was from 1.38 to 1.869 for leathers dried by cabinet, while for leathers dried by solar drier was from. 0043 to 1.859. The rehydration ratio values was decreased at the end of the storage period, the decreasing percent was 9.7% and 23.6% for tamarind leathers dried by cabinet and solar driers respectively.
The same trend for pH values was observed for all tamarind leathers, they were from 2.78 to 2.12 and from 2.8 to 1.98 for cabinet and solar driers respectively. The rate of change of tirerable acidity of all tamarind leathers was increased during storage period, the percent changes was 30.32% and 10.06 for tamarind leathers dried by cabinet and solar driers respectively.
There was a highly significant decrease ($P \leq 0.05$) of sucrose in the cabinet dried leathers (from 21.16 to 1.02).likewise the same trend has been observed with the solar dried leathers (from 19.42 to 1.83).There was a significant difference ($P \leq 0.05$) between the two drying systems.
As the storage period proceed, there was a significant decrease ($P \leq 0.05$) in reducing sugars content of the cabinet dried leathers (from 55.52 to 36.83) and also in the solar dried leathers (from 55.52 to 36.83).

Keywords: cabinet, drying, leather, tamarind, solar and storage

Introduction

Tamarind (*Tamarindus indica* L.) is a tropical seasonal bearing fruit species grown in relatively dry regions in the tropics (Amararathna, *et al.*, 2015) [1]. It is possesses great potential to address various nutritional, health, socioeconomic and environmental constraints (National Research Council, 2008, Gunasena, H. P.M.; Hughes, 2000 and Morton. J. F. 1987) [13, 7, 11].
Tamarind fruits were found in different regions of Sudan, where in eastern part of Sudan tamarind fruits are reported to be longer than fruits from central Sudan. In addition, the fruits from central region have been reported to be sweeter than those from eastern Sudan (Gebauer *et al.*, 2002) [6]
Tamarind pulp is valued and widely used in food, beverages and also has medicinal uses. It has therapeutic uses for constipation, abdominal pains, bowel obstruction, pregnancy vomiting and intestinal disorders among others (Nacoulma, 1999) [12]. While in India where many studies have been carried on tamarind seeds which are used as cattle feed because of the high protein content, (Krithika and Radhai, 2007) [9].
Dried fruits and vegetables have been regarded as alternative fat free snacks and received more attention from the food industry during past decade (Devahastin and Niamnucy, 2010) [5]. So the objective of current study is to investigate the quality of tamarind leathers as affected by drying methods and storage period.

Materials and Methods

Tamarind fruits from local cultivars were purchased from Elobiud market (Sudanese market). The tamarind fruits were fully ripe, brown in colour and have very strong sour taste. Other ingredient used in this study was sucrose sugar which obtained from local market of Khartoum State. All chemical reagents used for the analysis were of analytical grade.

Samples preparation

Tamarind fruits were sorted, washed and soaked in water (the ratio of water to tamarind fruits was 1: 4) for two hours and then passed through a pulper (Model: Reeves, size: IVIF-18) to get tamarind pulp. Fifteen percent of sucrose (by weight of tamarind pulp) was added to the recovered pulp and then the pulp was cooked in an open double jacketed kettle till it became puree (Mircea, 1995) [5].

Drying of tamarind leathers

One kilogram of the tamarind puree was spreaded on fabricated stainless steel drying trays with a solid base (51cm length x 39 x cm width x 3 cm depth). The tamarind leathers were dried in solar and cabinet driers. Solar drying was carried out using a prototype solar cabinet dryer (average drying temperature was 54±4 °C). Drying in the cabinet dryer (Gallenkamp, Model, O. V – 160) was done at 70 °C. The tamarind leathers were packed in polyethylene bags and stored for six months at ambient temperature.

Microbiological and Physico-chemical analysis

The microbiological parameters studied were included, total viable count, yeasts and moulds, coliform bacteria, lactic acid bacteria, *Staphylococcus* sp., sporformer and salmonella.

Where the physic-chemical parameters were moisture, texture, non-enzymatic browning, rehydration ratio and pH of tamarind leathers were determined according to A.O.A.C, 2005 methods. While titerable acidity was determined according to Ranganna (2003).

Sucrose and inverted sugars content were determined by using High Pressure Liquid Chromatography (HPLC) instrument.

Results and Discussion

The results showed that, all tamarind leathers dried by different drying systems were free from contaminated microorganisms throughout the storage period at ambient temperature, this may be due to the presence of tartaric acid in the tamarind pulp which acts as a preservative. These findings were agreed with Chattopadhyay (2016) [4] who reported that, the growth of microorganisms was not detected through the storage period of dehydrated jackfruit cubes which stored at ambient temperature for six months.

Table 1 showed changes in moisture content (MC) of tamarind leathers, there was significant increased ($P \leq 0.05$) in MC of leathers for both drying systems during storage. The MC of cabinet dried leathers increased from 5.52 to 7.44%, while of solar dried leathers increased from 7.95 to 9.63. The increased in MC of leathers may be due to permeability to moisture of polyethylene bags.

The texture of tamarind leathers from both drying systems (Table 2) underwent slight toughness in the first month of storage and then eventually leathers started to show tenderness towards the end of the storage period (from 3.49 to 2.72 Kg/ N and from 4.10 to 2.64 Kg/ N for cabinet and solar dries dried tamarind leathers respectively). However, there was no significant difference ($P \leq 0.05$) in the textures of both products at the end of the storage period irrespective of the drying system used. The tenderness may be due to pick up of moisture (Kaushal *et al.* 2013) [8].

The nonenzymatic browning increased (Table 3) significantly during storage from 0.127 to 1.869 for the cabinet dried leathers and in the solar dried leathers from 0.043 to 1.859. Non enzymatic browning was significantly ($P \leq 0.05$) increased during storage period for both leathers dried in different driers. The leathers had become slightly darker during the storage, this phenomena may attributed mainly to non- enzymatic chemical reactions.

The data in table 4 showed changes in rehydration ratio (RR) of tamarind leathers during storage, there was no significant changes ($P \leq 0.05$) observed in the rehydration property of the cabinet dried leathers (from 1.44 to 1.30). Also there was no significant changes ($P \leq 0.05$) observed in RR of the solar dried one (from 1.78 to 1.36). There were no significant differences ($P \leq 0.05$) in RR between the two drying systems. The slight decreased in RR of tamarind leathers during storage may be due to the increase of moisture content of tamarind leathers during storage Chattopadhyay (2016).

The tamarind leathers from both driers, their pH values (Table 5) have significantly ($P \leq 0.05$) decreased during storage (from 2.78 to 2.12, cabinet dryer) and (from 2.81to 1.98, solar dryer).

Table 1: Changes in moisture content (%) of tamarind leathers during storage as affected by two drying systems and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	5.52^{l}±0.11	5.21^{m}±0.11	5.72^{k}±0.03	5.92^{j}±0.0.06	6.25^{i}±0.0.09	6.81^{h}±0.10	7.44^{g}±0.11
Solar drier	7.95^{f}±0.05	7.35^{g}±0.15	8.24^{e}±0.10	8.54^{d}±0.11	8.92^{c}±0.03	9.30^{b}±0.11	9.63^{a}±0.11
$Lsd_{0.05}$	0.1587						
SE±	0.05477						

Means ±SD bearing different superscript letters within columns and rows are significantly different ($P \leq 0.05$).

Table 2: Changes in texture (Kg/ N) of tamarind leathers during storage as affected by drying systems and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	3.29^{bc}±0.31	3.49^{b}±0.23	3.12^{bcd}±0.19	3.00^{bcde}±0.08	2.83^{cde}±0.14	2.73^{de}±0.07	2.72^{de}±0.24
Solar drier	2.52^{e}±0.36	4.10^{a}±0.70	3.07^{bcd}±0.03	3.03^{bcde}±0.09	2.93^{cde}±0.09	2.75^{de}±0.22	2.64^{de}±0.26
$Lsd_{0.05}$	0.4519						
SE±	0.1560						

Means ±SD bearing different superscript letters within columns and rows are significantly different ($P \leq 0.05$).

Table 3: Changes in non-enzymatic browning of tamarind leathers during storage as affected two drying systems and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	0.138^{g}±0.01	1.271^{e}±0.07	1.438^{d}±0.08	1.596^{c}±0.05	1.707^{b}±0.02	1.733^{b}±0.02	1.869^{a}±0.01
Solar drier	0.043^{h}±0.00	0.886^{f}±0.03	1.547^{c}±0.02	1.598^{c}±0.04	1.688^{b}±0.01	1.704^{b}±0.06	1.859^{a}±0.00
$Lsd_{0.05}$	0.07480						
SE±	0.02582						

Means ±SD bearing different superscript letters within columns and rows are significantly different ($P \leq 0.05$).

Table 4: Changes in rehydration ratio of tamarind leathers during storage as affected by drying system and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	1.44^{cd}±0.16	1.39^{cd}±0.03	1.36^{cd}±0.06	1.35^{d}±0.05	1.33^{d}±0.04	1.31^{d}±0.05	1.30^{d}±0.05
Solar drier	1.78^{a}±0.26	1.69^{ab}±0.20	1.59^{abc}±0.14	1.49^{bcd}±0.06	1.44^{cd}±0.18	1.39^{cd}±0.04	1.36^{cd}±0.09
$Lsd_{0.05}$	0.2048						
SE±	0.07071						

Means ±SD bearing different superscript letters within columns and rows are significantly different ($P≤0.05$).

Table 5: Changes in pH-values of tamarind leathers during storage as affected by drying system and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	2.78^{ab}±0.03	2.76^{ab}±0.23	2.71^{ab}±0.08	2.50^{abc}±0.02	2.31^{cd}±0.05	2.30^{cd}±0.41	2.12^{de}±0.10
Solar drier	2.81^{a}±0.03	2.74^{ab}±0.03	2.69^{ab}±0.23	2.56^{abc}±0.11	2.48^{bc}±0.02	2.12^{de}±0.04	1.98^{e}±0.25
$Lsd_{0.05}$	0.2748						
SE±	0.09487						

Means ±SD bearing different superscript letters within columns and rows are significantly different ($P≤0.05$).

It seemed that, there was similarity in the trend of the pH decreased between the two drying systems.
The results were similar to those reported by Saranya *et al.* (2017) [14] that, the pH of papaya fruit rollup decreased as the storage period proceed at the ambient temperature.
The decrease in pH might be due to interconversion of sugars and other chemical reactions which were accelerated at high ambient temperature.
There was significant increased ($P≤0.05$) in titerable acidity values of tamarind leathers (Table 6) dried in both drying system and during storage.
Comparing the two systems of drying, the titerable acidity of both products was more or less similar towards the end of storage period. The results were similar with the findings of Saranya *et al* (2017) [14] who reported that, the titerable acidity of jack fruit rollup was increased during storage. Bash (2015) [3] reported that, the acidity of guava leather increased during storage for 90 days at ambient temperature. The increment of titerable acidity may be due to hydrolysis of sucrose.

Regard to the changes in sucrose values in for the tamarind leathers (Table 7), there was a highly significant decrease ($P≤0.05$) of sucrose in the cabinet dried leathers (from 21.16 to 1.02).Similarly, the same trend has been observed with the solar dried leathers (from 19.42 to 1.83).There was a significant difference ($P≤0.05$) between the two drying systems.
The decrease in sucrose level could be attributed to its hydrolysis to fructose and glucose by the action of organic acids in different dried foods (Bash 2015) [3].
There was a high increased of inveredt sugars level (Table 8) of cabinet dried leathers from zero time to the first month of storage (from 34.53 to 55.52) and this may be due to conversion of sucrose to glucose and fructose.
As the storage proceed, there was a significant decrease ($P≤0.05$) in inverted sugars of the cabinet dried leathers (from 55.52 to 36.83) and also in the solar dried leathers (from 55.52 to 36.83). The decreased in inverted sugars level may be attributed to some degree of non

Table 6: Changes in titerable acidity (as tartaric acid %) of tamarind leathers during storage as affected by drying system and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	6.86^{d}±0.03	7.03^{d}±0.09	7.77^{c}±0.25	7.99^{c}±0.27	8.19^{bc}±0.07	8.26^{bc}±0.08	8.94^{a}±0.22
Solar drier	7.85^{c}±0.39	7.86^{c}±0.11	7.95^{c}±0.72	8.05^{bc}±0.15	8.09^{bc}±0.68	8.35^{bc}±0.23	8.64^{ab}±0.23
$Lsd_{0.05}$	0.5420						
SE±	0.1871						

Means ±SD bearing different superscript letters within columns and rows are significantly different ($P≤0.05$).

Table 7: Changes of sucrose level (%) of tamarind leathers during storage as affected by two drying systems and storage time

Drying system	Storage time (months)						
	0	1	2	3	4	5	6
Cabinet drier	21.16^{a}±0.00	4.37^{e}±0.00	3.88^{f}±0.00	3.72^{g}±0.00	2.68^{j}±0.00	2.40^{k}±0.00	1.02^{n}±0.00
Solar drier	19.42^{b}±0.00	4.71^{c}±0.00	4.62^{d}±0.00	3.25^{h}±0.00	2.78^{i}±0.00	1.87^{l}±0.00	1.83^{m}±0.00
$Lsd_{0.05}$	0.0005289						
SE±	0.0001826						

Means ± SD bearing different superscript letters within columns and rows are significantly different ($P≤0.05$).

Table 8: Changes in inverted sugars level (%) (Glucose and fructose) of tamarind leathers during storage as affected by two drying systems and storage time

Drying system	Storage time (months)						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Cabinet drier	$34.53^{l}\pm0.00$	$55.52^{b}\pm0.00$	$49.55^{d}\pm0.00$	$45.25^{f}\pm0.00$	$41.18^{h}\pm0.00$	$39.93^{i}\pm0.00$	$36.84^{k}\pm0.00$
Solar drier	$33.91^{m}\pm0.00$	$55.67^{a}\pm0.02$	$52.93^{c}\pm0.00$	$45.73^{e}\pm0.00$	$42.96^{g}\pm0.00$	$38.13^{j}\pm0.00$	$27.83^{n}\pm0.00$
$Lsd_{0.05}$	0.0005289						
SE±	0.0001826						

Means± SD bearing different superscript letters within columns and rows are significantly different ($P\leq0.05$).

Enzymatic browning reaction (Maillard reaction) that took place between the invert sugars and the total free amino acids.

Conclusion

The current study revealed that, the tamarind leathers dried by cabinet and solar driers and stored at room temperature for six months were free from microbes, became tender and dark in color.

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