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Storage stability of Jamun fruit bar with respect to different temperature and packaging material

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Abstract
The objective of present investigation was to study the effect of different storage temperature and packaging material on moisture, TSS, acidity and total sugar of jamun fruit bar during storage period. Jamun bar was prepared from fruits of Konkan Bahadoli variety. The bar was standardized by using different level of sugar and citric acid. The selected bar sample of best combination i.e. CC2 (50 per cent sugar and 0.40 per cent citric acid) were packed in butter paper or vegetable parchment paper (VPP), low density polyethylene pouch (LDPE) and aluminium foil (AlF). These packets were stored for a period of 180 days at refrigerated temperature (6±1℃) and ambient temperature (28±1℃) and changes in moisture, TSS, acidity and total sugar were recorded and elaborated.

Keywords: Jamun, TSS, acidity, temperature, butter paper, aluminium foil

Introduction
Jamun, *Syzygium cumini* (L.) Skeels, the Indian blackberry is called the fruit of gods, belonging to family Myrataceae. The other names are Jamun, Jambul, Black plum, Java plum, Indian blackberry and Jamblang. It is fruit from a very large ever green tropical tree with property of astringent and purple-skinned fruit, native to India, Nepal, Pakistan, Sri Lanka, Indonesia, Bangladesh, and Philippines (Menka and Venkatasubramanian, 2017) [12]. Drying of agricultural produce is the oldest and most widely used preservation method. It involves the reduction of as much water as possible from the fresh fruit to arrest enzyme and microbial activities, hence, stopping deterioration (Teshome, 2010) [22]. Fruit bar is a confectionery product, prepared by drying of fruit pulp after mixing with appropriate quantities of sugar, citric acid and other ingredients. It is also called fruit slabs or fruit leather. It can be prepared from a wide variety of fruits including guava, banana, papaya, mango, sapota, apple, jackfruit etc. Most of the commercially available fruit bars (except mango leather) are synthetic in nature and without fruit pulp. Natural fruit pulp-based fruit bars are more nutritious and organoleptically acceptable since substantial quantities of dietary fibers, minerals and vitamins are the constituents of finished product (Sharma *et al.*, 2013) [19]. Hence by keeping these points in mind present investigation was carried out to prepare and analyze jamun bar.

Materials and Methods
Fresh jamun Cv. Konkan Bahadoli was obtained from Central Nursery Scheme, VNMKV Parbhani. The other raw materials like sugar, citric acid and packaging material such as low density polyethylene pouch (LDPE-50 micron thickness), vegetable parchment paper (VPP) and aluminium foil (AlF-11 micron thickness) were procured from the local market. The jamun bar was standardized by using different level of sugar and citric acid as per the treatment details given in table 1.

Table 1: Treatment details for jamun bar

Sample	Treatment Details
A	A1 (Pulp +30% sugar +0.30% citric acid)
	A2 (Pulp +30% sugar +0.40% citric acid)
	A3 (Pulp +30% sugar +0.50% citric acid)
	A4 (Pulp +30% sugar +0.60% citric acid)
B	B1 (Pulp +40% sugar +0.30% citric acid)
	B2 (Pulp +40% sugar +0.40% citric acid)
	B3 (Pulp +40% sugar +0.50% citric acid)
	B4 (Pulp +40% sugar +0.60% citric acid)
C	C1 (Pulp +50% sugar +0.30% citric acid)
	C2 (Pulp +50% sugar +0.40% citric acid)
	C3 (Pulp +50% sugar +0.50% citric acid)
	C4 (Pulp +50% sugar +0.60% citric acid)
D	D1 (Pulp +60% sugar +0.30% citric acid)
	D2 (Pulp +60% sugar +0.40% citric acid)
	D3 (Pulp +60% sugar +0.50% citric acid)
	D4 (Pulp +60% sugar +0.60% citric acid)
Control	Pulp without sugar and citric acid

Where, A=30% sugar, B=40% sugar, C=50% sugar, D=60% sugar

Procedure for preparation of Jamun bar from Jamun Cv. Konkan Bahadoli

Jamun fruits Cv. Konkan Bahadoli were steamed for 2-3 min. and pulp was separated manually. Pulp passed through blender to obtain fine pulp and obtained fine pulp was passed through muslin cloth (with added water 100ml/kg fine pulp) to reduce pomace content. Then heating was carried out at low flame till the volume reduced to half followed by continuous mixing to avoid burning at the bottom of pan. Further, sugar and citric acid were added as per treatment details given in table 1 and spreading on aluminium trays (smeared with glycerin) to a thickness of 1.5cm followed by drying at 55±5 ℃ for 6-7 hrs in Tray dryer were conducted. After cooling, cutting of fruit bar sheet into rectangular pieces (7cm x 3cm). The best combination (CC2) of 50.00 percent sugar and 0.40 percent citric acid selected on the basis of sensory evaluation. The selected bar samples of best combination i.e. CC2 were packed in low density polyethylene pouch (LDPE), vegetable parchment paper or butter paper (VPP) and aluminium foil (AlF). These packets were stored for a period of 180 days at refrigerated temperature (6±1℃) and ambient temperature (28±1℃) under study. Stored samples were analyzed periodically at each interval of 30 days to record the changes in moisture (A.O.A.C., 2007) [1], TSS (Ranganna, 2007) [17], acidity (A.O.A.C., 2007) [1] and total sugar (A.O.A.C., 2007) [1].

Result and Discussion

The results obtained are presented under suitable headings as follows

Changes in moisture content of Jamun bar during storage

Changes in moisture content of jamun bar during storage are presented in table-2. As regards storage studies, there was a gradual decrease in moisture content of jamun bar throughout the storage period in all samples. The decreasing trend was more pronounced in sample stored at ambient temperature as compare to refrigerated temperature. This might be due to high temperature at ambient condition than refrigerated condition.

The moisture content of freshly prepared jamun bar was recorded as 23.20 percent which is safe for the storage of fruit products. Fruit products with moisture content of 13-25 percent have water activity less than 0.8, below which most of the microbial growth especially bacteria, is impeded (Jay *et al.*, 2005) [12].

While studying the moisture content of sample stored at refrigerated temperature, the decreasing trend was higher in sample packed in vegetable parchment paper (13.14, 19.91 and 25.86 percent decrease) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the decreasing trend was minimum in sample stored in aluminium foil (1.89, 5.17 and 8.83 percent decrease) during 60, 120 and 180 days of storage, respectively.

As regards the moisture content of sample stored at ambient temperature, the moisture loss was higher in sample packed in vegetable parchment paper (14.87, 25.43 and 33.40 percent) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the decreasing trend was less in sample stored in aluminium foil (1.29, 9.05 and 17.58 percent) during 60, 120 and 180 days of storage, respectively. This might be due to aluminium foil was comparatively better barrier to moisture than parchment paper and low density polyethylene packing (Safdar *et al.*, 2014) [18].

The moisture loss was higher in bar stored at ambient condition as compared to the refrigerated condition. This might be due to the higher temperature of the ambient condition than the refrigerated condition which is responsible for removal of moisture (Chavan and Shaik, 2015) [5].

Similar to the present investigation decrease in moisture content during storage were reported by Shere *et al.* (2014) [20], Khan *et al.* (2014) [10] and Chavan and Shaik (2015) [5] in jamun mango bar, guava bar and guava leather, respectively.

Changes in TSS of jamun bar during storage

Changes in TSS of jamun bar during storage are presented in table- 3. Data regarding changes in total soluble solids of jamun bar during storage reveals that there was a gradual increase in TSS throughout the storage period in all packing materials.

The increasing trend of TSS was more pronounced in sample stored at ambient temperature as compare to refrigerated temperature. This might be due to loss of moisture was higher during storage at ambient temperature resulting in the concentration of product (Nanjudaswamy *et al.*, 1976, Mir and Nath, 1993) [14, 13].

The TSS of freshly prepared jamun bar was calculated as 34.40 percent. While studying the TSS of sample stored at refrigerated temperature, the increasing trend was higher in sample packed in vegetable parchment paper (4.94, 8.16 and 8.19 percent increase) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the increasing trend was minimum in sample stored in aluminium foil (2.90, 3.13 and 2.73 percent increase) during 60, 120 and 180 days of storage, respectively.

As regards the TSS content of sample stored at ambient condition, the TSS was higher in sample packed in vegetable parchment paper (6.16, 10.81 and 14.91 percent increase) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the increasing trend was minimum in sample stored in aluminium foil (2.55, 6.04 and 6.97 percent increase) during 60, 120 and 180 days of storage, respectively.

The TSS of bar stored at refrigerated condition was increased at slower rate as compared to ambient condition. Since at low temperature storage, the rate of reactions are significantly slower as compared to high temperature storage (Safdar *et al.*,

2014) [18]. Increase in TSS during storage might be due to acid hydrolysis of polysaccharides especially gums and pectin into soluble sugars (Safdar *et al.*, 2014) [18]. Also an increase in TSS during storage were reported by Phimpharian *et al.* (2011) [15], Shere *et al.* (2014) [20], Khan *et al.* (2014) [10], Kuchi *et al.* (2014) [11] and Prasanth and Mishra (2017) [16] in pineapple leather, jamun mango bar, guava bar and guava jelly bar and guava bar, respectively.

Table 2: Changes in moisture (percent) content of jamun bar during storage

Packaging material	Fresh Jamun bar	Storage (days) at Refrigerated temperature						Storage (days) at Ambient temperature					
		30	60	90	120	150	180	30	60	90	120	150	180
VPP	23.20	22.13	20.51	19.40	18.58	17.66	17.20	21.10	19.75	18.68	17.30	16.80	15.45
LDPE	23.20	23.04	22.35	22.11	21.19	20.87	19.30	22.57	21.51	20.22	19.48	18.30	17.88
AlF	23.20	23.18	22.76	22.52	22.00	21.58	21.15	22.15	22.90	21.40	21.10	20.80	19.12
SE±	-	0.005	0.019	0.002	0.017	0.003	0.005	0.007	0.020	0.003	0.018	0.005	0.009
CD @ 5%	-	0.017	0.057	0.008	0.051	0.011	0.015	0.022	0.062	0.010	0.055	0.016	0.028

Each value is an average of three replications, *LDPE: Low density polyethylene pouch, VPP: Vegetable parchment paper, AlF: Aluminium foil

Table 3: Changes in TSS (percent) of jamun bar during storage

Packaging material	Fresh Jamun bar	Storage (days) at Refrigerated temperature						Storage (days) at Ambient temperature					
		30	60	90	120	150	180	30	60	90	120	150	180
VPP	34.40	35.68	36.10	36.90	37.21	37.45	37.22	35.32	36.52	37.87	38.12	38.95	39.53
LDPE	34.40	35.75	35.97	36.08	36.27	36.48	36.70	35.68	35.91	36.46	36.85	37.21	37.65
AlF	34.40	35.40	35.40	35.40	35.48	35.34	35.34	34.92	35.28	35.85	36.48	36.65	36.80
SE±	-	0.004	0.002	0.005	0.003	0.004	0.003	0.008	0.010	0.032	0.026	0.022	0.018
CD @ 5%	-	0.012	0.008	0.017	0.010	0.013	0.010	0.025	0.031	0.098	0.079	0.067	0.055

Each value is an average of three replications, *LDPE: Low density polyethylene pouch, VPP: Vegetable parchment paper, AlF: Aluminium foil

Changes in acidity of jamun bar during storage

Changes in acidity of jamun bar during storage are presented in table-4. Percent acidity of jamun bar in different packing materials exhibited a gradual increase during the storage period. The increasing trend was more pronounced in sample stored at ambient temperature as compare to refrigerated temperature. The acidity of freshly prepared jamun bar was recorded as 1.72 percent. While studying the acidity of sample stored at refrigerated temperature, the increasing trend was higher in sample packed in vegetable parchment paper (2.32, 6.39 and 8.13 percent increase) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the increasing trend was minimum in sample stored in aluminium foil (1.16, 3.48 and 6.39 percent increase) during 60, 10 and 180 days of storage, respectively.

As regards the acidity content of sample stored at ambient temperature, the higher acidity shown by the sample packed in vegetable parchment paper (5.81, 8.13 and 10.46 percent increase) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the increasing trend was minimum in aluminium foil packed sample (3.48, 6.39 and 7.55 percent increase) during 60, 120 and 180 days of storage, respectively.

However, the rate of increase in acidity content was relatively slower at refrigerated storage as compared to ambient storage, this may be due to at refrigeration temperature the rate of degradation of polysaccharides and oxidation of reducing sugars was at slower rate which would be higher if stored at room temperature The increase in acidity might be ascribed to rise in the concentration of weakly ionized acids and their salts during storage. Increase in acidity might also be due to formation of acids by degradation of polysaccharides and oxidation of reducing sugars or by breakdown of pectic substances and uronic acid (Iqbal *et al.*, 2001; Hussain *et al.*, 2008) [8, 7]. Similar types of observations regarding acidity were reported by Singh *et al.* (2006) [21] during storage of dehydrated aonla products, Safdar *et al.* (2014) [18] during storage of guava leather, Deepika *et al.* (2016) [6] during storage of aonla bar, Anita and Dhaliwal (2017) [3] during storage of crab apple bar and Prasanth and Mishra (2017) [16] during storage of guava bar.

Table 4: Changes in acidity (percent) of jamun bar during storage

Packaging material	Fresh Jamun bar	Storage (days) at Refrigerated temperature						Storage (days) at Ambient temperature					
		30	60	90	120	150	180	30	60	90	120	150	180
VPP	1.72	1.75	1.76	1.80	1.83	1.85	1.87	1.77	1.82	1.85	1.86	1.88	1.90
LDPE	1.72	1.74	1.75	1.78	1.80	1.83	1.86	1.76	1.80	1.83	1.84	1.86	1.88
AlF	1.72	1.73	1.74	1.76	1.78	1.81	1.83	1.75	1.78	1.80	1.83	1.84	1.85
SE±	-	0.003	0.002	0.004	0.012	0.001	0.005	0.009	0.007	0.008	0.010	0.012	0.014
CD @ 5%	-	0.010	0.007	0.013	0.037	0.003	0.017	0.028	0.022	0.025	0.032	0.037	0.043

Each value is an average of three replications, *LDPE: Low density polyethylene pouch, VPP: Vegetable parchment paper, AlF: Aluminium foil

Changes in total sugar content of jamun bar during storage

Changes in total sugar content of jamun bar during storage are presented in table-5. Data regarding changes in total sugars of jamun bar showed decreasing trend throughout the storage period. The decreasing trend was more pronounced in sample stored at ambient temperature as compare to refrigerated temperature.

The total sugar of freshly prepared jamun bar was recorded as 52.26 percent. While studying the total sugar of sample stored at refrigerated temperature, the decreasing trend was higher in sample packed in vegetable parchment paper (0.51, 3.40 and 9.81 percent decrease) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch.

However, the decreasing trend was minimum in sample stored in aluminium foil (0.24, 1.37 and 3.78 percent decrease) during 60, 10 and 180 days of storage, respectively.

As regards the total sugar content of sample stored at ambient storage, the higher decrease in total sugar showed by the sample packed in vegetable parchment paper (3.53, 7.06 and 11.02 percent decrease) during 60, 120 and 180 days of storage respectively, followed by low density polyethylene pouch. However, the decreasing trend was minimum in sample stored in aluminium foil (0.88, 3.86 and 5.07 percent decrease) during 60, 120 and 180 days of storage, respectively.

However, the rate of decreasing in total sugar content was relatively slower in refrigerated storage as compared to ambient storage of packed jamun bar, this may be due to the rate of reactions are significantly slower at low temperature as compared to high temperature storage. Total sugar exhibited gradual decrease during storage which may be due to increase in reducing sugar by acid hydrolysis of total and non-reducing sugar and thereby inversion of total and non-reducing sugar to reducing sugar. Similar patterns of decreasing trend in total sugar were reported by Akhila (2014) [2] during storage of jamun jam, Shere (2014) [20] during storage of jamun-mango bar, Bhatt and Jha (2015) [4] during storage of wood apple bar and Anita and Dhaliwal (2017) [3] during storage of crab apple bar.

Table 5: Changes in total sugar (percent) content of jamun bar during storage

Packaging material	Fresh Jamun bar	Storage (days) at Refrigerated temperature						Storage (days) at Ambient temperature					
		30	60	90	120	150	180	30	60	90	120	150	180
VPP	52.26	52.10	51.83	51.60	50.78	48.37	47.13	51.63	50.41	49.68	48.57	47.43	46.50
LDPE	52.26	52.00	51.75	51.28	50.73	49.50	48.20	51.78	50.38	49.53	48.75	48.12	47.40
AlF	52.26	52.20	52.13	51.95	51.64	50.86	50.28	52.15	51.80	50.82	50.24	49.32	49.61
SE±	-	0.006	0.004	0.007	0.011	0.016	0.018	0.016	0.017	0.009	0.020	0.018	0.006
CD @ 5%	-	0.019	0.014	0.022	0.034	0.049	0.056	0.041	0.053	0.028	0.061	0.055	0.019

Each value is an average of three replications, *LDPE: Low density polyethylene pouch, VPP: Vegetable parchment paper, AlF: Aluminium foil

Conclusion

The selected bar sample of best combination i.e. CC2 (50 per cent sugar and 0.40 per cent citric acid) were packed in vegetable parchment paper or butter paper (VPP), low density polyethylene pouch (LDPE) and aluminium foil (AlF). These packets were stored for a period of 180 days at refrigerated temperature (6±1℃) and ambient temperature (28±1℃) under study. As regards storage studies, there was a gradual decrease in moisture and total sugar, content of jamun bar. The decreasing trend was more pronounced in sample stored at ambient temperature as compare to refrigerated temperature. On the other hand, there was gradual increase in TSS and acidity during storage period. Sample stored in aluminium foil showed minimum loss of nutrient during storage followed by low density polyethylene pouch and vegetable parchment paper.

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