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Standardization and Preparation of Guava Leather

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Abstract

The present investigation was carried with the objective to standardize the process for preparation of guava leather of cultivars Sardar and Lalith. Preliminary experiments were conducted to find out the optimum levels of sugar, citric acid and salt for preparation of quality leather. The leather prepared was packed in butter paper and stored at ambient (25±2 ^{0}C) and refrigerated temperature (5±2 ^{0}C) for 90 days to study their storage feasibility. The stored samples were drawn periodically at 30 days interval for analysis. The guava leather (625.76 g/kg pulp) was obtained from treatment V_1T_1 (750g sugar + 5g salt + 2g citric acid), followed by the other treatments (618.06 g/kg pulp) in V_1T_2 (750 g sugar) for Sardar guava variety, (624.00 g/kg pulp) in V_2T_1 (750 g sugar + 5g salt + 2g citric acid) and (617.00 g/kg pulp) in V_2T_2 (750 g sugar) for Lalith guava variety. The treatments V_1T_1, V_2T_1, and V_1T_2, V_2T_2 are same but mainly differ in cultivars of guava white and pink flesh. The production cost of Sardar guava leather was lower as compared to Lalith. The production cost was around (Rs.135–135.55/kg). The chemical composition indicated that the fresh guava leather contained on an average 16.80 per cent moisture, 76.20^{0}Brix TSS, 14.36 per cent reducing sugars, 68.70 per cent total sugars, 0.541 per cent titratable acidity, 127.10 mg/100 g ascorbic acid. The guava leather prepared by using sugar, salt, citric acid (Treatment V_1T_1 and V_2T_1) were superior over the other treatments in respect of sensory properties. The mean score of fresh guava leather for colour and appearance was 8.60, flavor 8.50, texture 8.60, taste 8.30 and overall acceptability 8.50 on 9 point Hedonic scale. The storage studies indicate that there was a gradual decrease in moisture, ascorbic acid, with advancement of storage period. While TSS, reducing sugars and acidity, total sugars were increased continuously. The sensory quality of guava leather decreased at faster rate during storage. However guava leather was found to be acceptable in good condition even after 90 days of storage at ambient and refrigerated temperature.

Keywords: Guava, leather, organoleptic properties, nutritional value, Sardar, Lalith

Introduction

Guava (*Psidium guajava L.*) is a tropical fruit with sweet aroma and pleasant sour sweet taste, good source of vitamin C and dietary fiber. This is a member of the large Myrtaceae or Myrtle family believed to be originated in Central America and Southern part of Mexico (Somogyi *et al*., 1996). It is claimed to be the fourth most important cultivated fruit in area and production after mango, banana and citrus. India is major world producer of guava (Jagtian *et al*., 1998). At present it occupies nearly 1.12 lakh ha land with production of 12.04 lakh tones and productivity 10.77 tones/ha fruit per year in India (Department of Agriculture and co-operation, 2007). Guava is quite hardy, prolific bearer and highly remunerative even without much care. It is widely grown all over the tropics and subtropics including India Viz., Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Andra Pradesh, Tamilnadu, West Bengal, Assam, Orissa, Karnataka, Kerala, Rajasthan and many more states. Main varieties grown in India are Allahabad Safeda, Lucknow - 49, Chittidar, Nagpur Seedless, Bangalore, Dharwar, Akra Mridula, Arka Amulya, Harijha, Allahabad Surkha CISHG -1, CISHG - 2, CISHG - 3., etc. Guava is normally consumed fresh as dessert fruit that is pleasury sweet and refreshing in flavor.

The fruit has about 83% moisture and is an excellent source of ascorbic acid (100 – 260 mg/100 g pulp) and pectin (0.5 – 1.8 %) (Verma and Shrivastava, 1965), but has low energy (66 Cal/100 g) and protein content (1%) (Bose *et al*., 1999). The fruit is rich in minerals like phosphorous (23-37 mg/100 g), calcium (14-30 mg/100 g), iron (0.6-1.4 mg/100 g), as well as vitamins like Niacin, Pantothenic acid, Thiamine, Riboflavin, vitamin A (Bose *et al*., 1999). Whole fruit is edible along with skin, considered as one of most delicious & luxurious fruits, often marketed as " *Super fruits"* which has a considerable nutritional importance in terms of vitamins A and C with seeds that are rich in omega-3, omega-6 poly-unsaturated fatty acids and especially dietary fiber, riboflavin, as well as in proteins, and mineral salts. The high content of vitamin C (ascorbic acid) in guava makes it a powerhouse in combating free radicals and oxidation that are key enemies that cause many degenerative diseases. The anti-oxidant virtue in guavas is believed to help reduce the risk of cancers of the stomach, esophagus, larynx, oral cavity and pancreas. The vitamin C in guava makes absorption of vitamin E much more effective in reducing the oxidation of the LDL cholesterol and increasing the (good) HDL cholesterol. The fibers in guavas promote digestion and ease bowel movements. The high content of vitamin A in guava plays an important role in maintaining the quality and health of eye-sight, skin, teeth, bones and the mucus membranes. With the changing consumer attitudes, demands and emergence of new market products, it has become imperative for producers to develop products, which have nutritional as well as health benefits. In this context, guava has excellent digestive and nutritive value, pleasant flavor, high palatability and availability in abundance at moderate price. The fresh fruit has limited shelf life; therefore, it is necessary to utilize the fruit for making different products to increase its availability over an extended period and to stabilize the price during the glut season. Guava can be consumed fresh or can be processed into juice, nectar, pulp, jam, jelly, slices in syrup, fruit bar or dehydrated products, as well as being used as an additive to other fruit juices or pulps (Leite *et al*., 2006). Excellent salad, pudding, jam, jelly, cheese, canned fruit, RTS, nectar, squash, ice cream and toffees are made from guava (Jain and Asati, 2004).

There has been greater increase in the production rate of these fruits over the years, and this may be due to their increased consumption pattern in the tropics (FAO, 1983). It is common experience that 20-25% of the fruit is completely damaged and spoiled before it reaches the consumer (Yadav, 1997). Therefore, to utilize the produce at the time of glut and to save it from spoilage; the development of low cost processing technology of guava is highly required. It will also generate enough opportunities of self-employment by starting small scale processing unit or cottage industry that will be remunerative to the growers. Thus the preparations of guava pulp with simple technology and its utilization in the form of pulp and leather have a great scope. Fruit leathers are dehydrated fruit based products. They are a tasty, chewy, dried fruit product. Fruit leathers are made by pouring pureed fruit onto a flat surface for drying. When dried the fruit is pulled from the surface and rolled, it gets the name "Leather" from the fact that when the pureed fruit is dried, it is shiny and has the texture of leather. Due to its novel and attractive structure, and for being products that do not require refrigeration, they constitute a practical way to incorporate fruit solids, especially for children and adolescents. Fruit leathers allow leftover ripe fruits to be preserved. Therefore standardization and preparation of guava leather from two kinds of fully ripened guava fruits one is of white flesh of Sardar variety and another of pink flesh Lalith fruits considered in this study.

Materials and Methods

The well-matured, healthy, uniform sized over ripen guava fruits of local *Lalith* of pink and *Sardar (Lucknow* - 49*)* of white flesh cultivars were collected from the Department of Horticulture and progressive farmers of the Rahuri, Nasik, and Yeola Tahashils.

Packaging material: Butter paper of 9 x 10 cm size was used for packaging of individual leather which was obtained from local market and LDPE pouches were used as secondary packaging of leather for safety purpose.

Ingredients: Citric acid, salt, sugar and hydrogenated fat were obtained from local market and used as ingredients for preparation of guava leather.

Physical characteristics of fresh fruits

Skin and flesh colour: Skin and flesh colour of ripen fruits was recorded by visual observations.

Length (height): The length of ten fruits from stalk base to apex was determined with the help of Vernier Caliper and mean value (cm) was recorded.

Diameter (breadth): The diameter of ten fruits at mid-point was determined with the help of Vernier caliper and mean value (cm) was recorded.

Weight: Ten fruits were weighed with electronic balance and average weight (g) was recorded.

Pulp recovery: Cleaned and graded over ripen guava fruits were used for extraction of pulp. The pulp was extracted by using multipurpose home scale pulper machine, the seeds were separated from pulp with the help of sieve and pulp obtained was reported on per cent basis.

Waste material (losses): The waste material (seed material) losses were calculated on weight basis and expressed in per cent.

Chemical analysis of guava fruit pulp and leather:

The over ripen guava fruit pulp was analyzed for the moisture, TSS, titratable acidity, reducing sugars, total sugars, and vitamin C using standard methods of AOAC (2005).

Standardization of ingredient levels for guava leather: Preliminary experiments were conducted to select the optimum level of each ingredient like sugar, salt, citric acid (**Table 1**). The optimum levels of ingredients were finalized by sensory evaluation of guava leather by a panel of minimum ten semi-trained judges using 9 points Hedonic Scale (Amerine *et al*., 1965).

Table 1 Ingredient levels for guava leather

Treatments	Pulp (%)	Sugar (%)	Salt (%)	Citric acid (%)
T_1	100	500	5	2
T_2	100	750	5	2
T_3	100	1000	5	2
T_4	100	750	5	4
T_5	100	750	-	-
T_6	100	750	5	-
T_7	100	750	-	4

Preparation of guava leathers: The guava fruit pulp was used for the preparation of fruit leather. In the pulp sugar, salt as per the formula added, mixed well and then smeared on the aluminium or stainless steel trays. Spread the pulp in thin layer (0.5 to 1.0 cm thick). Then the pulp was dried in hot air oven at 50 ^{0}C for 8-10 hrs. After that dried pulp sheets were cut into desired size and again dried for 8-10 hrs. After drying three layers of sheets were kept together and pressed properly to form one sheet. Then desired size (3 x 4 cm) cutting was done and dried under fan for 2-3 hrs and then wrapped into a metalized polyester wrapper and then kept in plastic bag for storage study (**Plate 1**).

Packaging and storage of guava leathers: Butter paper was used as a packaging material. The guava leather prepared was packed and stored at both ambient (25$\pm$2ºC) and refrigerated (5$\pm$2ºC) temperature safely in laboratory at the middle compartment of the refrigerator for 3 months storage study. Chemical analysis, organoleptic evaluation and microbial analysis of stored guava leathers were carried out at an interval of one month storage period.

Microbial count of guava leather (Colony forming unit): Microbial count was recorded as colony forming units (CFU). One colony was counted as microbe. The potato dextrose agar media was used as growth medium and inoculated petridish were incubated at 25$\pm$2 ºC for 48 hrs. For counting bacterial colonies, a colony counter with magnifying lenses and an automatic counter were used. Total count was taken along with pin point size colonies.

Organoleptic evaluation of guava leathers: The organoleptic evaluation of guava leather samples were carried out according to the standard method of Amerine *et al*. (1965) on 9 point Hedonic Scale. The samples were evaluated for colour and appearance, flavour, texture, taste and overall acceptability by a panel of 10 semi trained judges. The average scores of all the sensory parameters were recorded.

Statistical analysis: The data obtained for changes in chemical constituents and various sensory parameters during storage were analyzed for statistical significance according to the procedure given by Panse and Sukhatme (1967). All the experiments were planned and carried out using Factorial Completely Randomized Design (FCRD) using three to ten replications.

Cost of production of guava leather: The cost of production of guava leather was calculated after consideration of the cost of raw material required, labour, processing cost and miscellaneous charges at prevailing rates during experimental period. The cost was worked out by using standard economic procedure (Lal *et al.*, 1980).

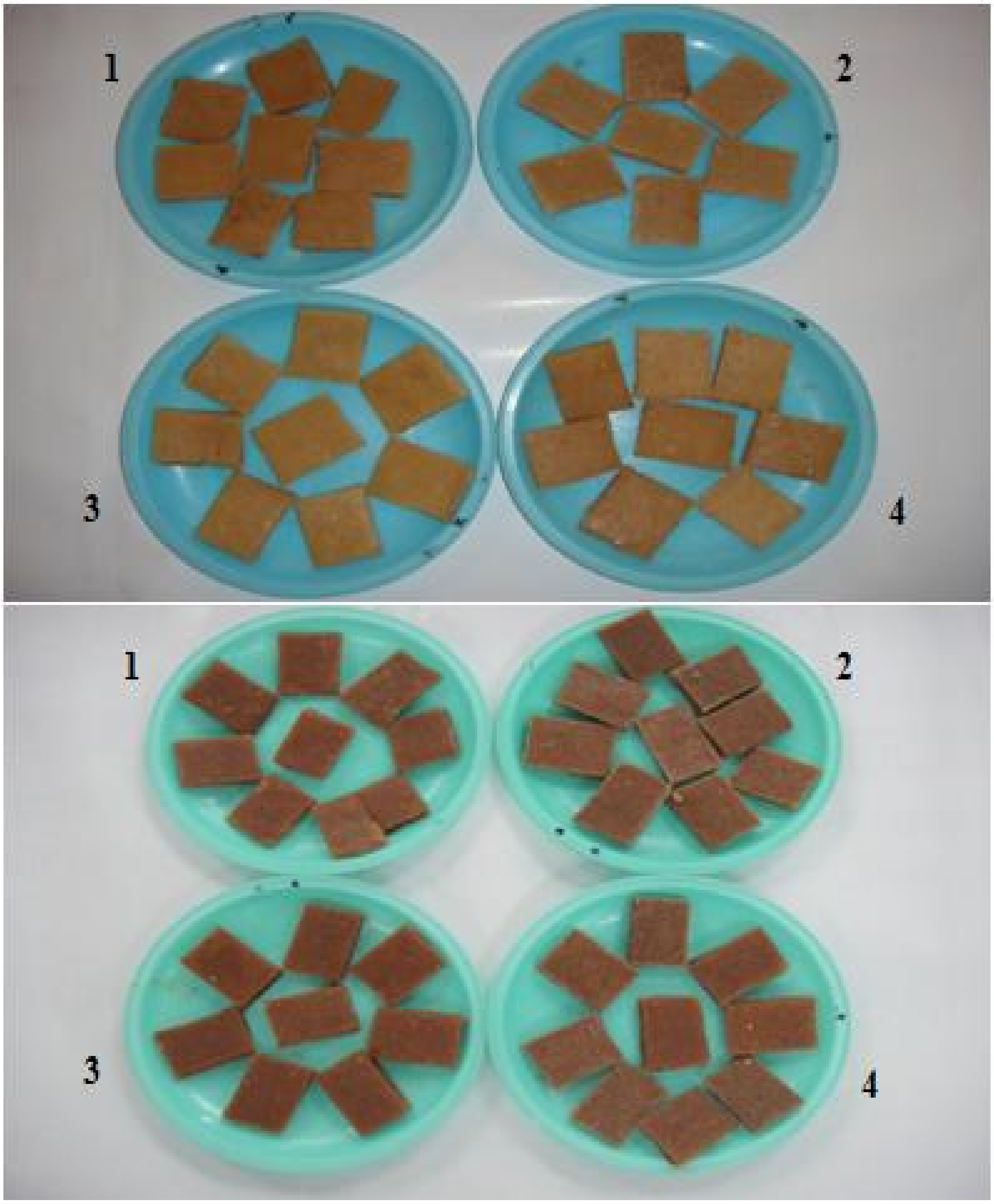

Plate 1 Sardar (above) and Lalith (down) guava leather after 90 days storage
1-2 at ambient temperature (25±2°C) and
3-4 , at refrigerator temperature (5± 2°C)

Results and Discussion

Physio-chemical characteristics of *Sardar* and *Lalith* guava fruit and pulp: The physio-chemical composition of fruit plays a very important role in processing technology of guava as well as final quality of the product. The over ripened fruits were round, yellowish in colour. The average weight of fruit was 139g/fruit. The average values for recovery of pulp and processing losses were 92.60 and 7.40 per cent, respectively (**Table 2**). Lalith fruits were attractive, saffron yellow with occasional red blush and medium sized with firm pink coloured flesh. It has good blend of sugar, acid and suitable for both processing and table purpose. The over ripen fruits of Lalith were round, yellowish in colour. The average weight of fruit was 126 g/fruit. The average values for recovery of pulp and processing losses were 91.0 and 9.0 per cent, respectively (**Table 2**). The recovery of pulp from Sardar guava variety was 92.60 %, while recovery of pulp for Lalith guava variety was 91.0 %.

Table 2 Physio-chemical composition of Sardar guava fruit and its pulp

Parameters	Sardar (white flesh)	Lalith (pink flesh)
Physical parameters of fruits		
Shape	Round	Round
Colour	Yellow	Saffron yellow
Average length (cm)	6.20	04.10
Average fruit weight (g)	139.0	126
Diameter (cm)	6.20	6.2
Per cent of pulp recovery (%)	92.60	91.0
Waste material/Seed content losses (%)	7.40	9.0
Chemical constituents of Pulp		
TSS (^{o} Brix)	9.20	9.10
Acidity (%)	0.450	0.380
Total sugars (%)	7.70	5.10
Reducing sugars (%)	5.30	7.40
Vitamin C (mg/100 g)	210	130
Moisture (%)	82.56	83.60

Organoleptic properties of preliminary trials of guava leathers: The treatments T_2 and T_5 were selected as best among the 7 various treatments for both Sardar and Lalith guava leathers. Selected treatments T_2 and T_5 were renamed as V_1T_1 and V_1T_2 in Sardar guava leather and for Lalith guava leather as V_2T_1 and V_2T_2 (**Table 3 and 4**).

Table 3 Organoleptic evaluation of fresh Sardar variety guava leather[a]

Treatments	Colour and appearance	Flavor	Taste	Texture	Overall accept ability	Selected for further study
V_1T_1	7.60	8.00	8.00	7.90	7.87	Not selected
V_1T_2	8.80	8.30	8.20	8.30	**8.40**	V_1T_1 selected
V_1T_3	8.00	7.70	7.60	8.10	7.85	Not selected
V_1T_4	7.90	7.50	7.60	7.60	7.65	Not selected
V_1T_5	8.40	7.80	8.00	7.80	**8.00**	V_1T_2 selected
V_1T_6	6.50	6.40	6.50	6.90	6.57	Not selected
V_1T_7	6.70	6.90	6.90	6.80	6.82	Not selected

Whereas, a = Ten replications with 9 point Hedonic Scale; V_1 = Sardar guava variety (white flesh).

Table 4 Organoleptic evaluation of fresh Lalith variety guava leather[a]

Treatments	Colour and appearance	Flavor	Taste	Texture	Overall accept ability	Selected for further study
V_2T_1	7.5	8.0	7.5	7.6	7.65	Not selected
V_2T_2	8.7	8.2	8.2	8.7	**8.45**	V_2T_1 selected
V_2T_3	8.5	8.2	8.5	8.0	8.30	Not selected
V_2T_4	7.8	8.0	8.0	7.9	7.92	Not selected
V_2T_5	8.5	8.2	8.2	8.4	**8.33**	V_2T_2 selected
V_2T_6	7.6	7.9	8.3	7.6	7.85	Not selected
V_2T_7	7.7	8.0	8.0	7.8	7.87	Not selected

Whereas, a = Ten replications with 9 point Hedonic Scale; V_2 = Lalith guava variety (pink flesh).

Organoleptic properties of fresh guava leathers (selected treatments): During organoleptic evaluation, V_1T_1 and V_2T_1 found similar and better than V_1T_2 and V_2T_2 for overall acceptability (**Table 5**). So again T_2 and T_5 samples of guava leather (both varieties) are prepared and kept for storage of 3 months at ambient and refrigerated conditions. Guava leather samples were analyzed for organoleptic, physical, chemical, microbiological tests at a regular interval of 30 days, for 3 months storage period.

Table 5 Organoleptic properties of fresh guava leathers[a]

Treatments	Colour and appearance	Flavor	Texture	Taste	Overall acceptability
V_1T_1	8.59	8.46	8.39	8.64	8.53
V_1T_2	8.14	8.03	8.14	8.12	8.07
V_2T_1	8.65	8.52	8.66	8.32	8.56
V_2T_2	8.05	7.80	7.90	8.13	8.37
SE$\pm$	0.022	0.019	0.022	0.016	0.018
CD at 5 %	0.068	0.059	0.068	0.049	0.055

Whereas, a = Ten replications with 9 point hedonic scale. V_1: Sardar guava variety (white flesh); V_2: Lalith guava variety (Pink flesh); T_1: 750 g sugar + 5 g salt + 2 g citric acid per kg guava pulp; T_2: 750 g sugar per kg guava pulp.

Yield and chemical properties of fresh guava leathers: The yield of guava leathers ranged from 617-625 g/kg of pulp (**Table 6**). The yield of guava leather V_1T_1 was slightly higher as compared to V_1T_2, V_2T_1, and V_2T_2. There was no much difference in yield between four treatments as the levels of ingredients are same.

Table 6 Yield and chemical properties of fresh guava leathers[a]

Treatments	Yield (g/kg Pulp)	Moisture (%)	TSS (°Brix)	Titratable acidity (%)	Reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100g)	Total cost
V_1T_1	625.76	15.29	76.10	0.541	14.32	68.72	125.28	135.55
V_1T_2	618.06	15.12	76.00	0.462	14.12	68.23	127.30	135.00
V_2T_1	624.00	16.75	75.85	0.490	14.19	68.47	71.81	155.55
V_2T_2	617.00	16.27	75.85	0.412	12.92	68.28	73.34	155.00
SE$\pm$	1.711	0.024	0.036	0.0011	0.014	0.010	0.127	-
CD at 5 %	NS	0.073	NS	NS	0.045	0.032	NS	-

Whereas, a = Four replications. V_1: Sardar guava variety (white flesh); V_2: Lalith guava variety (Pink flesh); T_1: 750 g sugar + 5 g salt + 2 g citric acid per kg guava pulp; T_2: 750 g sugar per kg guava pulp.

Changes in chemical composition of guava leathers during storage: Guava leather prepared from selected treatments from both varieties was kept for storage study at ambient (25$\pm$2ºC) and refrigerator (5$\pm$ 2ºC) temperatures (**Table 7**).

Moisture: The moisture content was reduced from 15.85 to 14.67 per cent at ambient temperature and 15.85 to 15.07 per cent at refrigerated temperature when stored for three months. It was observed that reduction in moisture content at refrigerated condition was lower than at ambient condition. The moisture content in guava leathers stored at ambient condition was reduced at higher rate than in the refrigerated condition. This might be due to the higher temperature of the ambient condition than the refrigerated temperature which is responsible for removal of moisture from guava leather samples. Among the best two treatments, V_2T_1 was found more suitable to maintain the moisture level at higher value in guava leathers than the other treatments in present investigation. In consistent with these results the decrease in moisture content during storage was reported in mango leather (Rao and Roy, 1980a), sweet potato leather (Collins and Hutsell, 1987), dried fig, guava-papaya fruit bar (Vennilla *et al.*, 2004), mango leather (Gill *et al.*, 2004), fig leather (Kotlawar, 2008) tamarind leather (Kharche, 2012), mixed fruit toffee from fig and guava fruits (Kohinkar *et al.*, 2012), mixed toffee from guava and strawberry (Chavan, 2015). The results obtained in present investigation are parallel with literature.

Table 7 Effect of storage period on chemical composition of guava leather after 3 months storage

Treatments	Moisture (%)		TSS (%)		Acidity (%)		Reducing sugars (%)		Total sugars (%)		Ascorbic acid (mg/100g)		Standard plate count (log cfu/g)	
	A	R	A	R	A	R	A	R	A	R	A	R	A	R
Variety														
V_1	14.09	14.56	77.20	76.94	0.55	0.53	17.24	16.61	69.08	68.76	98.46	112.02	0.10	0.02
V_2	15.25	15.60	77.17	76.68	0.49	0.48	15.48	15.42	68.95	68.71	49.18	58.38	0.13	0.04
SEm (±)	0.011	0.010	0.026	0.015	0.001	0.001	0.009	0.009	0.014	0.013	0.013	0.013	0.001	0.001
CD at 5%	0.035	0.032	NS	0.046	0.004	0.004	0.030	0.028	0.042	0.042	0.042	0.041	NS	NS
Treatments														
T_1	14.71	15.24	77.23	76.86	0.56	0.55	16.72	16.05	69.17	68.87	72.84	84.78	0.11	0.01
T_2	14.63	14.92	77.14	76.76	0.47	0.47	15.99	15.99	68.87	68.61	74.80	85.62	0.13	0.03
SEm (±)	0.011	0.010	0.026	0.015	0.001	0.001	0.009	0.009	0.014	0.013	0.013	0.013	0.001	0.001
CD at 5%	0.035	0.032	NS	0.046	0.004	0.004	0.030	0.028	0.042	0.042	0.042	0.041	NS	NS
Two factor interaction														
V_1T_1	14.05	14.59	77.28	77.01	0.59	0.57	17.28	16.73	69.32	68.98	97.87	111.52	0.10	0.02
V_1T_2	14.13	14.50	77.13	76.88	0.49	0.49	17.20	16.50	68.86	68.54	99.05	112.52	0.13	0.04
V2T1	15.38	15.90	77.19	76.72	0.53	0.52	16.16	15.37	69.02	68.76	47.81	58.04	0.11	0.01
V_2T_2	15.12	15.31	77.15	76.65	0.45	0.44	14.79	15.48	68.88	68.67	50.55	58.73	0.13	0.03
Mean	14.67	15.07	77.20	76.81	0.51	0.51	16.35	16.02	69.02	68.73	73.82	85.20	0.12	0.02
SEm (±)	0.016	0.014	0.036	0.021	0.002	0.002	0.014	0.013	0.019	0.019	0.019	0.019	0.001	0.000
CD at 5% (n=4)	0.050	0.045	NS	NS	0.005	NS	0.043	0.040	0.060	0.060	0.060	0.058	NS	NS

A=Ambient (25±2 ^{0}C), R=Refrigerated (5±2 ^{0}C)

Total soluble solids TSS (^{0}Brix): The TSS content of guava leathers ranged from 75.95 to 77.20 per cent from which sample V_1T_1 stored at ambient temperature had the highest content of total soluble solids. While other treatments had lower results for TSS. The increase in TSS content might be due to decrease in moisture content. The increase in TSS content during storage period was reported in fig (Gawade and Waskar, 2003) dried fig leather (Kotlawar, 2008), changes in guava leather packed in different packaging materials and stored at different storage conditions (Muhammad, 2014) and (Chavan, 2015) mixed toffee from guava and strawberry also increased TSS level due to reduction in moisture content. The results obtained in present investigation showed similar trend as shown in literature.

Titratable acidity: The acidity of guava leathers increased in all samples. It increased from 0.476 to 0.518 per cent at ambient temperature and from 0.476 to 0.506 per cent at refrigerated temperature during storage period of 3 months. Acidity was at higher level in treatment V_1T_1 and V_2T_1 than in V_1T_2 and V_2T_2, it may be due to the addition of citric acid in treatments V_1T_1 and V_2T_1. Whereas, in other two treatments citric acid was not added. Changes in titratable acidity statistically were non-significant up to 30 days but after that there was significant change. The increase in titratable acid content was reported in mango leather (Rao and Roy, 1980), mango fruit bars (Mir and Nirankarnath, 1993), jackfruit bar (Krishnaveni *et al*., 1999), papaya–guava fruit bar (Vennilla *et al*., 2004), fig leather (kotlawar, 2008), high protein tamarind leather (Kharche, 2012) and changes in guava leather packed in different packaging materials, at different storage conditions (Muhammad, 2014). The results obtained in present investigation are parallel to earlier reports.

Reducing sugars: A significant variation in reducing sugar content of guava leathers was observed during storage. The content of reducing sugars in guava leathers increased with progress of storage period. It might be due to more inversion of added sugars in guava leather samples during storage. The mean values of reducing sugar content increased from 13.88 to 16.35 per cent at ambient temperature and from 13.88 to 16.02 per cent at refrigerated temperature during 3 months storage. The increase in reducing sugars at ambient temperature was more than at refrigerated temperature. These results indicated that the increase in storage temperature is the responsible factor for increase in reducing sugars while storing the guava leathers at two different storage temperature conditions. Similar results of increase in reducing sugars were also reported in mango leather sugars during were reported in mango leather (Rao and Roy, 1980), mango fruit bars (Mir and Nirankarnath, 1993), jackfruit bar (Krishnaveni *et al*., 1999), papaya–guava fruit bar (Vennilla *et al.*, 2004), fig leather (kotlawar, 2008), and high protein tamarind leather (Kharche, 2012), mixed fruit toffee from fig and guava fruits (Kohinkar, 2014) and Muhammad (2014) also reported that when guava leather packed in different packaging materials and stored at different storage conditions also increased reducing sugar levels.

Total sugars: The results on changes in total sugar content of guava leathers during storage are presented in Tables 17 and 18. There was gradual increase in total sugar content of guava leathers during storage. This may be due to higher storage temperature at ambient temperature and reduction in moisture content from guava leather samples. The total sugars of guava leather samples ranged from 68.42 to 69.02 per cent at ambient temperature and from 68.42 to 68.73 per cent at refrigerated temperature during 3 months storage. Similar results were reported that total sugar content also increased in sweet potato leather (Collins and Hutsell, 1987), jack fruit leather (Che Man and Taufik, 1995), fig and other fruit products (Doreyappa Gowda *et al*., 1995), mango fruit bar with respect to storage temperature (Doreyappa Gowda *et al*., 1995), guava–papaya fruit bar (Vennilla *et al*., 2004), mixed fruit toffee from fig and guava fruits (Kohinkar, 2014), changes in guava leather packed in different packaging materials stored at different temperature conditions (Muhammad, 2014) and mixed toffee from guava and strawberry (Chavan, 2015). The results obtained in the present investigation are comparable to those reported in the literature.

Ascorbic acid: Significant difference in the ascorbic acid content was observed in guava leather samples during storage with two different temperature conditions with respect to storage period of 3 months. The ascorbic acid content of guava leather samples gradually decreased with the advancement of storage period. It decreased from 99.36 to 73.79 mg/100 g at ambient temperature and from 99.36 to 60.16 mg/100 g at refrigerated temperature. It was observed that ascorbic acid content of guava leather samples was higher level when stored at refrigerated temperature than at ambient temperature. The ascorbic acid content of guava leather samples were successfully maintained when stored at refrigerated temperature. The decrease in the ascorbic acid content at ambient condition might be due to oxidation of ascorbic acid at high storage temperature. The decrease in ascorbic acid content during storage was also reported in dried figs (Pawar *et al*., 1992), mango fruit bar (Mir and Nirankarnath, 1993 and Doreyappa Gowda *et al*., 1995), dried figs (Thonta and Patil, 1998), guava-papaya fruit bar (Vennilla *et al*., 2004), fig leather (Kotlawar, 2008), storage of guava leather packed in different packaging materials, stored at different storage conditions (Muhammad, 2014) and mixed toffee from guava and strawberry (Chavan, 2015).

Microbial spoilage: The microbial studies (cfu count) of guava leathers were enumerated at 0, 30, 60 and 90 days of storage period. Microbial count at zero days' storage was observed as nil. It may be due to high amount of sugar. Less microbial growth was observed in the leather samples stored at refrigerated temperature than at ambient temperature. This indicated that the cold condition of storage controlled the microbial growth in refrigerator.

Changes on organoleptic properties of guava leathers during storage

Colour and appearance: A gradual decrease in score from 8.35 to 7.45 at ambient temperature and from 8.35 to 7.80 at refrigerated temperature was observed for 90 days of storage (**Table 8**). The score 8.35 was observed in V_1T_1 guava leather sample stored at refrigerated condition. Similar trend for colour and appearance of guava leathers was observed at ambient condition but the values were at lower level than the refrigerated storage. The colour deterioration was more in guava leathers stored at ambient condition. This may be due to degradation of pigments that might have occurred at ambient temperature. Similar observations were reported in sweet potato leather (Collins and Hutsell, 1987), jack fruit leather (Che Man and Taufik, 1995), fig and other fruit products (Doreyappa Gowda *et al*., 1995), mango fruit bar with respect to storage temperature (Doreyappa Gowda *et al*., 1995), dried figs, guava–papaya fruit bar (Vennilla *et al*., 2004), fig leather (Kotlawar, 2008) and high protein tamarind leather (Kharche, 2012). The results obtained in the present investigation are in concurrent with the literature.

Flavor: A gradual decrease in score for flavor from 8.20 to 7.55 at ambient temperature and from 8.20 to 7.62 at refrigerated temperature was observed. The flavor retention was higher at refrigerated condition than the ambient condition. In both storage conditions treatment V_2T_1 produced highest flavor score when stored at refrigerated condition. The flavoring compounds may be lost at higher rate at higher storage temperature (thus causing lower flavor score) at ambient condition than at refrigerated condition. A gradual decrease in flavor score was reported with increase in storage period of guava leathers. Dried figs, guava-papaya fruit bar (Vennilla *et al*., 2004), fig leather (Kotlawar, 2008) and high protein tamarind leather (Kharche, 2012). The results obtained in the present investigation are similar to earlier reports.

Texture: A gradual decrease in texture score was observed in guava leathers from 8.27 to 7.56 at ambient temperature and from 8.27 to 7.80 at refrigerated temperature. The maximum score 8.27 was observed in V_2T_1 sample stored at refrigerated temperature. The score for texture decreased significantly during storage at ambient temperature than stored at refrigerated temperature. A gradual decrease in texture score is due to hardening effect resulting from loss of moisture during storage. Similar results were obtained in various experiments performed earlier on sweet potato leather (Collins and Hutsell, 1987), jack fruit leather (Che Man and Taufik, 1995), fig and other fruit products (Doreyappa Gowda *et al*., 1995). Guava–papaya fruit bar (Vennilla *et al.*, 2004), fig leather (Kotlawar, 2008) and high protein tamarind leather (Kharche, 2012). The results obtained in the present investigation for guava leathers are in agreement with literature.

Taste: The gradual decrease in score for taste of guava leathers from 8.30 to 7.49 at ambient temperature and from 8.30 to 7.49 at ambient temperature and from 8.30 to 7.98 at refrigerated temperature was observed. The taste deterioration was more in guava leathers at ambient condition than at refrigerated temperature. The guava leather samples of V_2T_1 at refrigerated temperature gave maximum taste score 8.60 in comparison with other treatments. This might be due to proper blending of sugar and acidity as well as consistency of the guava leather. Both conditions of storage for guava leather samples gave acceptable taste score. It is reported that the taste score decreased during storage with respect to storage condition and period of storage., in sweet potato leather (Collins and Hutsell, 1987), jack fruit leather (Che Man and Taufik, 1995), guava–papaya fruit bar (Vennilla *et al*., 2004) and fig leather (Kotlawar, 2008). The results obtained in the present investigation for taste score in guava leathers are in agreement with literature.

Overall acceptability: The gradual decrease in overall acceptability score from 8.38 to 7.53 at ambient temperature and from 8.38 to 7.78 at refrigerated

Table 8 Sensory quality of guava leather after 3 months storage*

Treatments	Colour and appearance		Flavour		Texture		Taste		Overall acceptability		Ranks	
	A	R	A	R	A	R	A	R	A	R	A	R
Variety												
V_1	7.33	7.72	7.24	7.43	7.40	7.64	7.52	8.13	7.40	7.73	2	2
V_2	7.58	7.87	7.87	7.82	7.72	7.97	7.47	7.83	7.67	7.83	1	1
SEm (±)	0.012	0.009	0.013	0.011	0.012	0.019	0.009	0.012	0.014	0.014	-	-
CD at 5%	0.039	0.030	0.041	0.035	0.038	0.059	0.027	0.038	0.043	0.044	-	-
Treatments												
T_1	7.68	8.02	7.73	7.78	7.65	7.99	7.71	8.28	7.72	8.00	1	1
T_2	7.23	7.57	7.39	7.47	7.47	7.62	7.28	7.68	7.35	7.56	2	2
SEm (±)	0.012	0.009	0.013	0.011	0.012	0.019	0.009	0.012	0.014	0.014	-	-
CD at 5%	0.039	0.030	0.041	0.035	0.038	0.059	0.027	0.038	0.043	0.044	-	-
Two factor interaction												
V_1T_1	7.64	8.03	7.43	7.62	7.47	7.74	7.90	8.63	7.66	7.98	2	2
V_1T_2	7.03	7.42	7.06	7.24	7.34	7.53	7.14	7.64	7.13	7.47	4	4
V2T1	7.72	8.02	8.02	7.94	7.84	8.23	7.52	7.92	7.78	8.02	1	1
V_2T_2	7.44	7.73	7.72	7.70	7.60	7.70	7.42	7.73	7.56	7.65	3	3
Mean	7.45	7.80	7.55	7.62	7.56	7.80	7.49	7.98	7.53	7.78	-	-
SEm (±)	0.018	0.013	0.019	0.016	0.017	0.027	0.012	0.017	0.020	0.020	-	-
CD at 5% (n=10)	0.055	0.042	NS	0.049	0.054	0.083	0.039	0.054	0.062	0.062	-	-

A=Ambient (25±2 ^{0}C), R=Refrigerated (5±2 ^{0}C); *Nine point Hedonic Scale, Ten semi-trained judges were used for sensory evaluation temperature. It was observed that decrease in overall acceptability score at ambient temperature was faster than at refrigerated temperature. The maximum score of 8.00 was observed in treatment V_2T_1 stored at refrigerated temperature. The maximum score of 8.00 was observed in treatment V_2T_1 stored at refrigerated temperature. The highest overall acceptability score was observed in guava leathers stored at refrigerated temperature than at ambient temperature. It may be due to faster deterioration in terms of colour, flavor, texture and taste at higher temperature during ambient condition. It is reported that the overall acceptability score decrease during storage with respect to the storage condition and period. Previous researchers have shown that the decrease in overall acceptability in case of papaya leather (Harvey and Cavaletto, 1978), mango fruit bar (Doreyappa Gowda *et al*., 1994), jack fruit leathers (Che Man and Taufik, 1995), guava-papaya fruit bar (Vennilla *et al*., 2004) and mango leather (Gill *et al*., 2004).

Texture analysis of guava leathers: The Texture analysis of guava leathers was done at initial 0 days storage and final after 90 days storage by using the available Shimazdu Texturometer. The force in (N) used to break down the individual leather is recorded separately. Results obtained stated that more force was used to break the fresh leather and less force was used after 90 days storage (**Table 9**). It may be all due to increase in crystallization of sugar within increase in storage period.

Table 9 Texture analysis of guava leathers

Sr. No	Treatments	Force required (N)		
		Fresh	After 90 days	
			AT	RT
1	V_1T_1	42.55	35.97	32.17
2	V_1T_2	41.76	35.11	31.72
3	V_2T_1	37.65	32.17	27.54
4	V_2T_2	36.69	31.74	26.11

Whereas, AT= Ambient temperature, RT= Refrigerated temperature; V_1: Sardar guava variety (white flesh); V_2: Lalith guava variety (Pink flesh); T_1: 750 g sugar + 5 g salt + 2 g citric acid per kg guava pulp; T_2: 750 g sugar per kg guava pulp.

Economics for making guava leathers: The cost of production of 1 kg guava (white flesh) leather of treatment T_1 was Rs.135.55 and for treatment T_2 Rs.135.00 only. Whereas, the cost of production of 1 kg guava (pink flesh) leather was of treatment T_1 was Rs.155.55 and for treatment T_2 Rs.155.00 only. These costs did not include rent, transport charges, sale commission, local taxes etc. However, there was no significant difference in cost of guava leathers making among the treatments. The costs are for laboratory (small scale) preparation of guava leathers. These may be still reduced during mechanization of the process for mass production.

Conclusion

From these results it is concluded that the guava leather prepared with sugar 750 g, salt 5 g and citric acid 2 g per kg of guava pulp showed better organoleptic properties as well as good storage stability at both storage (ambient and refrigerated) conditions up to 3 months storage period.

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