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Studies on development of guava leather as a novel product

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Abstract
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 case an investigation was carried with the objective to standardize the process for preparation of guava leather of cultivars 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 for 90 days at both ambient (25+2 ℃) and refrigerated temperature (5+2 ℃) to study their storage feasibility. The stored samples were drawn periodically at 30 days interval for analysis. 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, novel product, consumer attitudes

Introduction
Guava (*Psidium guajava* L.) has been cultivated in India since early 17th century and gradually become a crop of commercial importance. At present it occupies nearly 1.12 lakh ha. l and 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, Tamil Nadu, West Bengal, Assam, Orissa, Karnataka, Kerala, Rajasthan and many more states. Main varieties grown in India are Allahabad Safeda, Luck now -49, Chittidar, Nagpur Seedless, Bangalore, Dharwar, Arka, CISHG - 3. etc. Guava is normally consumed fresh as dessert fruit that is pleasure sweet and refreshing in flavor. 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) [39]. 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) [16].

Whole fruit is edible along with skin, considered as one of most delicious & luxuios 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, Oesophagus, 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. 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) [42], but has low energy (66cal/100g) and protein content (1%). The fruit is rich in minerals like phosphorous (23-37 mg/100g),

calcium (14-30 mg/100g), iron (0.6-1.4 mg/100g), as well as vitamins like Niacin, Pantothenic acid, Thiamine, Riboflavin, vitamin A (Bose *et al*., 1999).

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) [24]. Excellent salad, pudding, jam, jelly, cheese, canned fruit, RTS, nectar, squash, ice cream and toffees are made from guava (Jain and Asati, 2004) [17].

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) [11]. 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. Jain and Asati, (2004) [17] found that the cost of production of pulp is only Rs. 11/kg which is a raw material for guava leather. Leathers can also be made from a wide variety fruit including pawpaw, guava, banana and sweet potato (Collins and Hutsell, 1987) [9]. 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. Moreover, fruit pulp left from making jellies, during prolonged time in reduced volumes may also be converted into leathers. In recent years, their popularity has increased, transforming from a homemade preparation into an industrial product. The available literature describes very limited information on guava leather. Therefore guava leather from fully ripened guava fruit pink flesh fruit considered in this study.

Materials and Methods

Raw materials: Well-matured, healthy, uniform sized over ripen fruits of local *Lalith* of pink and *Sardar* or *Lucknow-49* of white flesh cultivars were collected from the Department of Horticulture and progressive farmers of the Rahuri, Nasik, Yeola Tahashils.

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

Chemicals: Most of the chemicals used in this investigation were of analytical grade, obtained from M/s. British Drug House Mumbai, M/s. Sarabhai M. Chemicals, M/s. Baroda, S.D. Fine Chemical Ltd., Mumbai and E. Merck (India), Mumbai.

Preparation of guava leathers: Fine guava fruit pulp was used for the preparation of fruit leather. In this pulp content ingredient like sugar, salt and citric acid as per the formula, which are further mixed well and then smeared with vegetable oil on the aluminum or stainless steel trays into thin layers (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 semi surface-dried pulp sheets were cut into desired size usually of rectangular 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.

Manufacturing process of guava leathers

Left over ripen guava fruits
↓
Thoroughly washing under running water
↓
Extraction of fine pulp by pulp extractor
↓
Addition of Ingredients
↓
Smearing of trays with vegetable oil
↓
Spreading of fine pulp in thin layer
(0.5-1.0 cm on smeared trays)
↓
Initial drying for 8-10 hrs
↓
Cutting surface dried pulp as per required size
↓
Final drying for 8-10 hrs
↓
Triple dried layers pressed together
↓
Cutting dried sheets
↓
Wrapping in butter paper
↓
Filling in dry plastic jars
↓
Sealing and storage

Fig 1: Flow sheet for preparation of guava leather

Standardization of ingredient levels for guava leather: Preliminary experiments were conducted to select the optimum level of each ingredient like sugar, salt, citric acid. 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.

Table 1: Treatment details for experimentation

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

Packaging: The prepared leathers were packed in a butter paper stored at both ambient (25±2ºC) and refrigerated (7±2ºC) temperature safely in laboratory at the middle compartment of the refrigerator for 3 months storage study. Analysis of stored guava leathers was carried out at an interval of 0, 30, 60, 90 day's storage period.

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

Statistical Analysis: Results and experiments were planned and carried out using Factorial Completely Randomized Design (FCRD) using three to ten replications according to methods of the procedure given by Panse and Sukhatme (1967).

Results and Discussion

Physio-chemical characteristics of Sardar 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 Physio-chemical composition of Sardar cultivar of guava is presented in Table 2. The over ripened fruits were round, yellowish in color. The average weight of fruit was 139 g/fruit. The average values for recovery of pulp and processing losses were 92.60 and 7.40 per cent, respectively.

Physio-chemical characteristics of Lalith guava fruit and its pulp: Lalith fruits were attractive, saffron yellow with occasional red blush and medium sized with firm pink color flesh. It has good blend of sugar and acid and suitable for both processing and table purpose. The Physio-chemical composition of Lalith cultivar of guava is presented in Table 2. Its yield was more than 24 per cent than the Allahabad Safeda variety (Yadav P.K. 2007). The over ripen fruits of Lalith were round, yellowish in color. 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: Physio-chemical characteristics of Sardar, Lalith guava fruits

S. No.	Parameters	Sardar (white flesh)	Lalith (Pink flesh)
A.	**Physical parameters of fruits**		
1.	Shape	Round	Round
2.	Color	Yellow	Saffron yellow
3.	Average length (cm)	6.20	4.10
4.	Average fruit weight (g)	139.0	126
5.	Diameter (cm)	6.20	6.2
6.	Per cent of pulp recovery (%)	92.60	91.0
7.	Waste material/Seed content losses (%)	7.40	9.0
B.	**Chemical constituents of Pulp**		
1.	TSS (º Brix)	9.20	9.10
2.	Acidity (%)	0.450	0.380
3.	Total sugars (%)	7.70	5.10
4.	Reducing sugars (%)	5.30	7.40
5.	Vitamin C (mg/100 g)	210	130
6.	Moisture (%)	82.56	83.60

4.3 Extraction and recovery of pulp

The harvested ripe guavas of Sardar and Lalith variety were cleaned thoroughly washed under tap water to remove dust, dirt particles. The pulp was extracted by passing the fruits through the pulp extractor separately. The pulp extracted was used in the preparation of guava leathers. The recovery of pulp from Sardar guava was 92.60 % while recovery of pulp for Lalith guava was 91.0 %.

Recovery of pulp

The recovery of pulp from Sardar guava variety was 92.60 %, while recovery of pulp for Lalith guava variety was 91.0 %.

Organoleptic properties of pre-treatment guava leathers

From the organoleptic evaluation presented in Tables 3, 4 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.

Organoleptic properties of Pre-treatment guava leathers

From the organoleptic evaluation presented in Tables 3, 4 and 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 T_1 and T_2 in Sardar guava leather, and for Lalith guava leather as T_3 and T_4.

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

S. No	Treatments	Colour & appearance	Flavor	Taste	Texture	Overall acceptability	Selected for further study
1	V_1T_1	7.60	8.00	8.00	7.90	7.87	Not selected
2	V_1T_2	8.80	8.30	8.20	8.30	8.40	V_1T_1 selected
3	V_1T_3	8.00	7.70	7.60	8.10	7.85	Not selected
4	V_1T_4	7.90	7.50	7.60	7.60	7.65	Not selected

5	V_1T_5	8.40	7.80	8.00	7.80	8.00	V_1T_2 selected
6	V_1T_6	6.50	6.40	6.50	6.90	6.57	Not selected
7	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]

S. No	Treatments	Color & appearance	Flavor	Taste	Texture	Overall acceptability	Selected for further study
1	V_2T_1	7.5	8.0	7.5	7.6	7.65	Not selected
2	V_2T_2	8.7	8.2	8.2	8.7	8.45	V_2T_1 selected
3	V_2T_3	8.5	8.2	8.5	8.0	8.30	Not selected
4	V_2T_4	7.8	8.0	8.0	7.9	7.92	Not selected
5	V_2T_5	8.5	8.2	8.2	8.4	8.33	V_2T_2 selected
6	V_2T_6	7.6	7.9	8.3	7.6	7.85	Not selected
7	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)

The selected treatments leather was prepared for further study. The organoleptic evaluations of fresh guava leather from both varieties are presented in Table 5. 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. So again T_2 and T_5 samples of guava leather (both varieties) are prepared and kept for storage of 3 months at both ambient and refrigerated conditions.

Yield and chemical properties of fresh guava leathers

The yield and chemical properties of fresh guava leather of both Sardar as well as Lalith cultivars are shown in Table 6. The yield of guava leathers ranged from 617-625 g/kg of pulp. 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 three treatments, as the levels of ingredients are same.

Table 5: Organoleptic properties of selected fresh guava leathers[a]

Treatments	Color & 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
SEm±	0.022	0.019	0.022	0.016	0.018
CD at 5 %	0.068	0.059	0.068	0.049	0.055

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

Treatments	Yield (g/kg Pulp)	Moisture (%)	TSS (° Brix)	Titrable 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
SEm±	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 (27 ± 2ºC) and refrigerator (7 ± 2 ºC) temperatures. The storage study results of guava leather are presented in Tables 7 to 14.

Changes in chemical composition of guava leathers during storage

Guava leather prepared from selected treatments was kept for storage study at ambient (25+2ºC) and refrigerator (5+ 2ºC) temperatures were presented in tables (Table 7 -14).

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. Mean values of moisture content were reduced with the advancement of increase in storage period as shown in Tables 7 to 10. The moisture content in guava leathers stored at ambient condition was reduced at higher rate than in the refrigerated condition, which might be due to the higher temperature of the ambient condition than the refrigerated temperature,

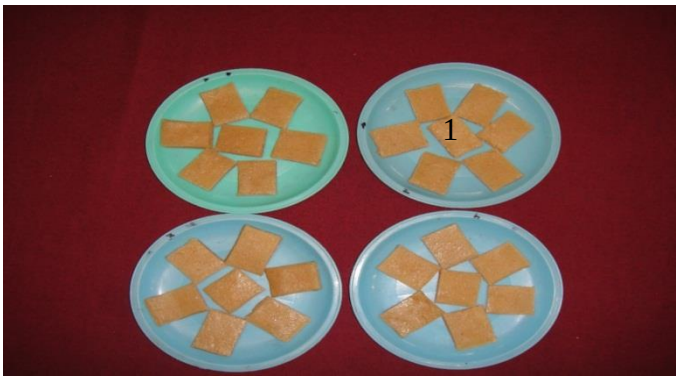

Plate 1: Sardar guava leather at 0 days storage

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1-2, Ambient tempearture (27 ±2 ^{0}C), 3-4, Refrigerated tempearture (7 ±2 ^{0}C)

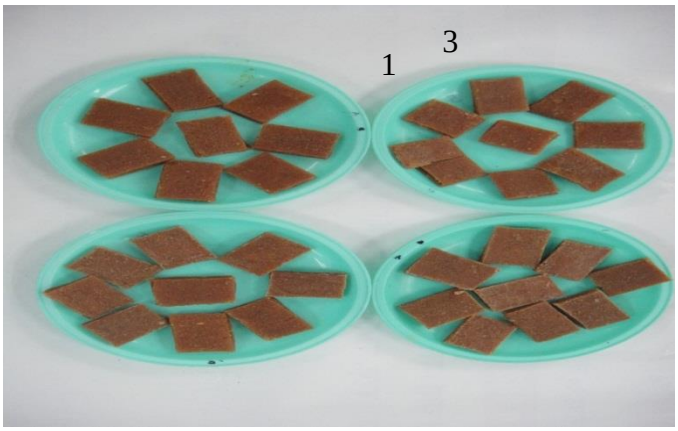

Plate 2: Lalith guava leather at 0 days storage

1-2, Ambient tempearture (27 ±2 ^{0}C), 3-4, Refrigerated tempearture (7 ±2 ^{0}C)

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responsible for removal of moisture from guava leather samples., V_2T_1 treatment was found more suitable to maintain the moisture level at higher value in guava leathers than the other treatments. In consistent with these results, the decrease in moisture content during storage was reported in mango leather (Rao and Roy, 1980) [34], sweet potato leather (Collins and Hutsell, 1987) [9], dried fig (Chandeshwar *et al*., 2004), mango leather (Gill *et al*., 2004) [13], fig leather (Kotlawar, 2008) [21], tamarind leather (Kharche, 2012) [19], the results obtained in present investigation are parallel with literature.

Total soluble solids TSS (º Brix)

Due to decrease in moisture content there was increase in TSS content of guava leathers from 75.95 to 77.20 per cent at ambient temperature, 75.95 to 76.81 per cent at refrigerated temperature. With the advancement of increase in storage period mean values of TSS content were increased as shown in Tables 7 to 10. It was observed that there was gradual increase in TSS content at ambient condition than at refrigerated condition. Sample V_1T_1 stored at ambient temperature had the highest content of total soluble solids.

The increase in TSS content during storage period was reported in fig (Mali, 1997, Palve, 2002, Gawade and Waskar, 2003 and Chandeshwar *et al.*, 2004) [12] dried fig leather (Kotlawar, 2008) [21], 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.

Titrable acidity (%)

The titrable acidity of guava leathers increased in all samples. Mean values of titrable acidity are 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. The changes in titrable acidity of guava leathers are presented in Tables 7 to 10. Changes in titrable acidity statistically were non-significant up to 30 days but after that there was significant change. The increase in titrable acid content was reported in mango leather (Rao and Roy, 1980) [35], fig leather (kotlawar, 2008), high protein tamarind leather (Kharche, 2012) [19] and changes in guava leather packed in different packaging materials, at different storage conditions (Muhammad, 2014) [29]. 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. Due to more inversion of added sugars in guava leather samples during storage. The content of reducing sugars in guava leathers increased with progress of storage period.

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. The changes in reducing sugar content of guava leather samples are presented in Tables 7 to 10. 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) [35], mango fruit bars (Mir and Nirankarnath, 1993), jackfruit bar (Krishnaveni *et al*., 1999) [22], papaya–guava fruit bar (Vennilla *et al.*, 2004) [41], fig leather (kotlawar, 2008), mixed fruit toffee from fig and guava fruits (Chavan, 2012) 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 (%)

There was gradual increase in total sugar content of guava leathers with increase in storage time. 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. The results on changes in total sugar content of guava leathers during storage are presented in Tables 7 to 10.

Similar results were reported that total sugar content also increased in sweet potato leather (Collins and Hutsell, 1987) [9], 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), 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 (mg/100 g)

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 result on changes in ascorbic acid content of guava leathers during storage are presented in Tables 7 to 10.

The decrease in ascorbic acid content during storage was also reported in dried figs (Pawar *et al*., 1992) [6], mango fruit bar (Mir and Nirankarnath, 1993 [26] and Doreyappa Gowda *et al*., 1995) [10], dried figs (Thonta and patil, 1998), guava-papaya fruit bar (Vennilla *et al*., 2004) [41], fig leather (Kotlawar, 2008) [21], storage of guava leather packed in different packaging materials, stored at different storage conditions (Muhammad, 2014) and mixed toffee from guava and strawberry.

Table 7: Effect of storage period on Physio-chemical composition of fresh guava leathers at 0 days storage

Treatments	Moisture (%)	TSS (%)	Acidity (%)	Reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100g)
Variety						
V_1	15.20	76.05	0.501	14.22	68.47	126.29
V_2	16.50	75.85	0.451	13.55	68.37	72.58
SEm(±)	0.017	0.026	0.0007	0.010	0.007	0.090
CD @ 5%	0.052	0.080	0.0024	0.032	0.022	0.278
Treatments						
T_1	16.02	75.97	0.516	14.26	68.60	98.54
T_2	15.69	75.92	0.437	13.52	68.25	100.32
SEm(±)	0.017	0.026	0.0007	0.010	0.007	0.090
CD @ 5%	0.052	NS	0.0024	0.032	0.022	0.278
Two factor interaction						
V_1T_1	15.29	76.10	0.541	14.32	68.72	125.28
V_1T_2	15.12	76.00	0.462	14.12	68.23	127.30
V_2T_1	16.75	75.85	0.490	14.19	68.47	71.81
V_2T_2	16.27	75.85	0.412	12.92	68.28	73.34
SEm(±)	0.024	0.036	0.0011	0.014	0.010	0.127
CD @ 5%	0.073	NS	NS	0.045	0.032	NS

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

V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).

T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp.

Table 8: Effect of storage period on Physio-chemical composition of guava leather at 30 days storage

Treatments	Moisture (%)		TSS (%)		Acidity (%)		Reducing sugars (%)		Total sugars (%)		Ascorbic acid (mg/100g)	
	A	R	A	R	A	R	A	R	A	R	A	R
Variety												
V_1	15.41	15.04	76.75	76.29	0.519	0.512	15.30	14.693	68.73	68.61	114.88	121.03
V_2	16.10	16.26	76.71	76.21	0.481	0.458	14.90	13.62	68.65	68.52	64.76	68.52
SEm(±)	0.010	0.019	0.019	0.013	0.0009	0.0014	0.014	0.009	0.012	0.014	0.086	0.013
CD @ 5%	0.032	0.059	NS	0.042	0.0030	0.0044	0.043	0.028	0.038	0.043	0.266	0.040
Treatments												
T_1	15.71	15.84	76.74	76.39	0.551	0.526	15.28	14.55	68.88	68.74	89.14	94.01
T_2	15.80	15.46	76.72	76.11	0.449	0.444	14.92	13.76	68.52	68.39	90.51	95.55
SEm(±)	0.010	0.019	0.019	0.013	0.0009	0.0014	0.014	0.009	0.012	0.014	0.086	0.013
CD @ 5%	0.032	0.059	NS	0.042	0.0030	0.0044	0.043	0.028	0.038	0.043	0.266	0.040
Two factor interaction												
V_1T_1	15.03	15.15	76.79	76.40	0.562	0.552	15.52	14.83	69.01	68.86	114.41	120.41
V_1T_2	15.80	14.92	76.72	76.17	0.476	0.472	15.08	14.55	68.46	68.36	115.36	121.65
V_2T_1	16.40	16.52	76.70	76.39	0.540	0.500	15.04	14.27	68.75	68.62	63.86	67.60
V_2T_2	15.80	16.01	76.72	76.04	0.422	0.4166	14.76	12.97	68.57	68.42	65.66	69.44
SEm(±)	0.015	0.027	0.026	0.019	0.0014	0.0020	0.019	0.013	0.018	0.020	0.122	0.018
CD @ 5%	0.045	0.083	NS	0.060	0.0043	NS	0.061	0.040	0.054	0.062	0.377	0.056

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

V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).

T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp.

Table 9: Effect of storage period on Physio-chemical composition of guava leather at 60 days storage

Treatments	Moisture (%)		TSS (%)		Acidity (%)		Reducing sugars (%)		Total sugars (%)		Ascorbic acid (mg/100g)	
	A	R	A	R	A	R	A	R	A	R	A	R
Variety												
V_1	14.46	14.84	77.04	76.71	0.528	0.522	16.78	16.12	68.86	68.66	105.33	116.07
V_2	15.84	16.06	76.96	76.45	0.480	0.470	14.98	14.87	68.79	68.59	56.41	62.41
SEm(±)	0.041	0.013	0.014	0.011	0.0014	0.0011	0.010	0.009	0.019	0.007	0.110	0.010
CD @ 5%	0.128	0.041	0.044	0.034	0.0044	0.0034	0.030	0.030	0.059	0.023	0.339	0.033
Treatments												
T_1	15.35	15.60	77.04	76.66	0.546	0.536	16.25	15.48	68.95	68.78	79.91	89.28
T_2	14.96	15.29	76.96	76.50	0.463	0.456	15.51	15.52	68.71	68.46	81.83	89.20
SEm(±)	0.041	0.013	0.014	0.011	0.0014	0.0011	0.010	0.009	0.019	0.007	0.110	0.010
CD @ 5%	0.128	0.041	0.044	0.034	0.0044	0.0034	0.030	0.030	0.059	0.023	0.339	0.033
Two factor interaction												
V_1T_1	14.57	14.92	77.08	76.81	0.577	0.562	16.86	16.15	69.05	68.92	104.63	116.07
V_1T_2	14.36	14.75	77.00	76.61	0.480	0.482	16.70	16.10	68.67	68.41	106.03	116.06
V_2T_1	16.13	16.28	77.01	76.51	0.516	0.510	15.64	14.80	68.84	68.65	55.18	62.48
V_2T_2	15.56	15.84	76.92	76.39	0.4453	0.430	14.32	14.94	68.74	68.52	57.63	62.33
SEm(±)	0.059	0.019	0.020	0.015	0.0020	0.0015	0.014	0.013	0.027	0.010	0.155	0.015
CD @ 5%	0.181	0.058	NS	0.048	0.0063	NS	0.043	0.042	0.083	0.033	0.480	0.047

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

V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).

T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp

Table 10: Effect of storage period on Physio-chemical composition of guava leather at 90 days storage

Treatments	Moisture (%)		TSS (%)		Acidity (%)		Reducing sugars (%)		Total sugars (%)		Ascorbic acid (mg/100g)	
	A	R	A	R	A	R	A	R	A	R	A	R
Variety												
V_1	14.09	14.56	77.20	76.94	0.545	0.522	17.24	16.61	69.08	68.76	98.46	112.02
V_2	15.25	15.60	77.17	76.68	0.493	0.470	15.48	15.42	68.95	68.71	49.18	58.38
SEm(±)	0.011	0.010	0.026	0.015	0.0011	0.0011	0.009	0.009	0.014	0.013	0.013	0.013
CD @ 5%	0.035	0.032	NS	0.046	0.0036	0.0034	0.030	0.028	0.042	0.042	0.042	0.041
Treatments												
T_1	14.71	15.24	77.23	76.86	0.563	0.536	16.72	16.05	69.17	68.87	72.84	84.78
T_2	14.63	14.92	77.14	76.76	0.474	0.456	15.99	15.99	68.87	68.61	74.80	85.62
SEm(±)	0.011	0.010	0.026	0.015	0.0011	0.0011	0.009	0.009	0.014	0.013	0.013	0.013
CD @ 5%	0.035	0.032	0.080	0.046	0.0036	0.0034	0.030	0.028	0.042	0.042	0.042	0.041
Two factor interaction												
V_1T_1	14.05	14.59	77.28	77.01	0.595	0.562	17.28	16.73	69.32	68.98	97.87	111.52
V_1T_2	14.13	14.5	77.13	76.88	0.494	0.482	17.20	16.50	68.86	68.54	99.05	112.52
V_2T_1	15.38	15.90	77.19	76.72	0.532	0.510	16.16	15.37	69.02	68.76	47.81	58.04
V_2T_2	15.12	15.31	77.15	76.65	0.454	0.430	14.79	15.48	68.88	68.67	50.55	58.73
SEm(±)	0.016	0.014	0.036	0.021	0.0016	0.0015	0.014	0.013	0.019	0.019	0.019	0.019
CD @ 5%	0.050	0.045	NS	NS	0.0051	NS	0.043	0.040	0.060	0.060	0.060	0.058

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

V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).

T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp

Table 11: Effect of storage period on Organoleptic properties of fresh guava leathers at 0 days storage

Treatments	Colour and appearance	Flavour	Texture	Taste	Overall acceptability
Variety					
V_1	8.36	8.24	8.27	8.38	8.30
V_2	8.35	8.16	8.28	8.22	8.46
SEm(±)	0.015	0.013	0.015	0.011	0.012
CD @ 5%	NS	0.041	NS	0.035	0.039
Treatments					
T_1	8.62	8.49	8.52	8.48	8.54
T_2	8.09	7.92	8.02	8.13	8.22
SEm(±)	0.015	0.013	0.015	0.011	0.012
CD @ 5%	0.048	0.041	0.048	0.035	0.039
Two factor interaction					
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
SEm(±)	0.022	0.019	0.022	0.016	0.018

CD @ 5%	0.068	0.050	0.068	0.049	0.055

A=Ambient (25±2 ^{0}C), R=Refrigerated (5±2 ^{0}C)
V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).
T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp.

Table 12: Effect of storage period on Organoleptic properties of guava leather at 30 days storage

Treatments	Colour and appearance		Flavour		Texture		Taste		Overall acceptability	
	A	R	A	R	A	R	A	R	A	R
Variety										
V_1	7.89	8.20	7.75	7.90	7.93	8.02	8.00	8.22	7.89	8.03
V_2	7.93	7.93	7.79	7.97	7.86	8.08	8.10	8.18	8.11	8.23
SEm(±)	0.012	0.015	0.019	0.018	0.015	0.010	0.019	0.020	0.016	0.016
CD @ 5%	0.038	0.048	NS	0.058	0.047	0.030	0.061	NS	0.049	0.050
Treatments										
T_1	8.18	8.41	8.05	8.19	8.03	8.23	8.28	8.43	8.14	8.33
T_2	7.64	7.72	7.48	7.67	7.76	7.87	7.81	7.97	7.86	7.93
SEm(±)	0.012	0.015	0.019	0.018	0.015	0.010	0.019	0.020	0.016	0.016
CD @ 5%	0.038	0.048	0.060	0.058	0.047	0.030	0.061	0.063	0.049	0.050
Two factor interaction										
V_1T_1	8.12	8.56	7.97	8.08	8.04	8.12	8.45	8.61	8.13	8.33
V_1T_2	7.66	7.83	7.53	7.71	7.82	7.92	7.54	7.82	7.66	7.73
V_2T_1	8.24	8.25	8.14	8.30	8.02	8.34	8.12	8.25	8.16	8.34
V_2T_2	7.62	7.62	7.44	7.63	7.70	7.82	8.08	8.12	8.06	8.12
SEm(±)	0.017	0.023	0.027	0.026	0.021	0.014	0.028	0.029	0.022	0.023
CD @ 5%	0.054	0.066	0.085	0.082	0.066	0.043	0.086	0.089	0.070	0.071

A=Ambient (25±2 ^{0}C), R=Refrigerated (5±2 ^{0}C)
V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).
T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp.

Table 13: Effect of storage period on Organoleptic properties of guava leather at 60 days storage

Treatments	Colour and appearance		Flavour		Texture		Taste		Overall acceptability	
	A	R	A	R	A	R	A	R	A	R
Variety										
V_1	7.66	8.06	7.22	7.43	7.72	7.90	7.68	8.13	7.59	7.97
V_2	7.78	7.76	7.59	7.73	7.59	7.83	7.95	8.18	7.82	8.06
SEm(±)	0.012	0.014	0.021	0.011	0.008	0.011	0.014	0.011	0.013	0.009
CD @ 5%	0.038	0.045	0.066	0.035	0.025	0.035	0.044	0.036	0.041	0.029
Treatments										
T_1	8.06	8.22	7.63	7.78	7.80	8.00	8.05	8.43	7.87	8.25
T_2	7.38	7.60	7.19	7.39	7.51	7.73	7.58	7.88	7.55	7.79
SEm(±)	0.012	0.014	0.021	0.011	0.008	0.011	0.014	0.011	0.013	0.009
CD @ 5%	0.038	0.045	0.066	0.035	0.025	0.035	0.044	0.036	0.041	0.029
Two factor interaction										
V_1T_1	8.00	8.33	7.39	7.62	7.82	7.98	8.02	8.63	7.84	8.40
V_1T_2	7.32	7.78	7.05	7.24	7.63	7.83	7.35	7.64	7.35	7.55
V_2T_1	8.12	8.11	7.86	7.94	7.79	8.03	8.08	8.24	7.90	8.10
V_2T_2	7.44	7.42	7.32	7.53	7.39	7.64	7.81	8.12	7.75	8.02
SEm(±)	0.017	0.021	0.030	0.016	0.011	0.016	0.020	0.016	0.019	0.013
CD @ 5%	NS	0.064	0.094	NS	0.035	0.049	0.063	0.051	0.059	0.041

A=Ambient (25±2 ^{0}C), R=Refrigerated (5±2 ^{0}C)
V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).
T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp

Table 14: Effect of storage period on Organoleptic properties of guava leather at 90 days storage

Treatments	Colour and appearance		Flavour		Texture		Taste		Overall acceptability	
	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
V_2	7.58	7.87	7.87	7.82	7.72	7.97	7.47	7.83	7.67	7.83
SEm(±)	0.012	0.009	0.013	0.011	0.012	0.019	0.009	0.012	0.014	0.014
CD @ 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
T_2	7.23	7.57	7.39	7.47	7.47	7.62	7.28	7.68	7.35	7.56
SEm(±)	0.012	0.009	0.013	0.011	0.012	0.019	0.009	0.012	0.014	0.014
CD @ 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
V_1T_2	7.03	7.42	7.06	7.24	7.34	7.53	7.14	7.64	7.13	7.47
V_2T_1	7.72	8.02	8.02	7.94	7.84	8.23	7.52	7.92	7.78	8.02
V_2T_2	7.44	7.73	7.72	7.70	7.60	7.70	7.42	7.73	7.56	7.65
SEm(±)	0.018	0.013	0.019	0.016	0.017	0.027	0.012	0.017	0.020	0.020
CD @ 5%	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)
V_1: Sardar guava variety (white flesh), V_2: Lalith guava variety (Pink flesh).
T_1: 750g sugar + 5g salt + 2g citric acid per kg guava pulp, T_2: 750g sugar per kg guava pulp.

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. The results obtained are presented in Table 15. Results obtained stated that more force was used to break the fresh leather and less force was used after 90 days storage. It may be all due to increase in crystallization of sugar within increase in storage period.

Table 15: 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.

4.10 Economics for making guava leathers

The results on production cost of guava leathers are presented in Table 15. 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.

Conclusions

From the results of this research it was concluded that in physicochemical analysis, guava leather prepared with treatment T_1 showed better organoleptic properties as well as good storage stability at both storage (ambient and refrigerated) conditions up to 3 months storage period,

Recommendations

1. Preparation of guava leather on pilot scale needed to undertake for its better utilization.
2. Study should be carried out in the effect of different packaging materials
3. Further studies on preparation of guava leather and preservation using other preservatives
4. Preparation of guava leather on pilot scale needed to undertake for its better utilization.

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