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Development and quality mapping of iron fortified jamun (*Syzygium cumini*) leather

Nosheen Naz[1,*], Moazzam Rafiq Khan[1], Muhammad Asim Shabbir[1] and M. Naeem Faisal[2]

[1]National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture Faisalabad, 38000, Pakistan; [2] Institute of Pharmacy, Physiology, and Pharmacology, University of Agriculture, Faisalabad, 38000, Pakistan
*Corresponding author's e-mail: noshinaz93@gmail.com

Focused on the iron-fortification of underutilized food sources of Pakistan, jamun was selected as a vehicle fruit for iron supplementation in the form of jamun leather. Iron-fortified jamun leather was prepared from two varieties available in Pakistan i.e., Desi jamun (V1) and Ra jamun (V2) using ferrous sulfate as a fortificant. The treatments prepared were V1T1, V1T2, V2T1 and V2T2 having iron value of 40% (T1) and 60% (T2) recommended daily allowance (RDA). The analyses as physiochemical, phytochemicals, mineral and sensory evaluations were conducted at 0, 30th, 60th, 90th and 120th day. During the study, pH, ascorbic acid, total phenolic contents (TPC) and (2,2-diphenyl-1-picrylhydrazyl) DPPH showed a declining trend, whereas reducing sugar, acidity and brix value increased during storage period. During the study, the highest reduction of pH was observed in V1T1 (3.38±0.021), maximum ascorbic acid was determined in Desi jamun (V1) in a range of 6.81-6.94 mg/100g. Similarly, Desi jamun (V1) had more total phenolic contents i.e., 1372 mg GAE/100g and remarkable DPPH antioxidant activity as 85% as compared to Ra jamun (V2). The sensory parameters such as color, flavor, taste and overall acceptability showed varying preferences of iron fortification among treatments. Based on analyses outcome, V1T1 and V1T2 were most appropriate treatments having the maximum chemical and organoleptic analysis score amongst all the treatments.

Keywords: Jamun, iron deficiency, fortification, jamun leather.

INTRODUCTION

Adequate nutrition plays a pivotal role in proper physical and mental health. Any imbalance may lead to abnormality in body function and growth. It is necessary to obtain the deficient nutrients from the food otherwise body undergoes nutrient deficiency *i.e.*, malnutrition (Asad and Mushtaq, 2012). Iron deficiency anaemia (IDA) is the decrease in total iron content of the body, which may lead to compromised health. It results in poor cognitive and neurological development among children, high maternal mortality and low productivity in adults (Balarajan *et al*., 2011). In Pakistan, the prevalence of IDA women is about 40-60% associated with severe blood loss in chronic cases (Parks *et al*., 2018). The National Nutrition Survey of Pakistan (NNS, 2018) has indicated that approximately 27% of children under 5 are iron deficient whereas 19% of women of reproductive age are unable to achieve required iron level. In present scenario, diet is not only the source to reduce hunger but also to supply basic nutrients to prevent nutrition-related ailments. The development of efficient strategies for control of iron deficiency anaemia is a great challenge in various regions of the world, especially in Pakistan. Such strategies include nutrition education, supplements for vulnerable population as well as food fortification. Among all the strategies, the fortification is the best approach to provide the micronutrient to the targeted segment of community. According to the Codex Alimentarius, fortification is the addition of one or more nutrients in a diet that are mostly present in the diet in low amount to increase the nutritional status of the deficient population (Dwyer *et al*., 2014). The process of fortification is based on standard laws and principles to control malnutrition issues.

Fruits are undoubtedly important for the provision of nutrition to the living beings along with a high potential of value addition and commercialization. In the present world, consumers are becoming conscious about their health and the nutritional profile of the food they consumed. They are preferring to take food from natural resources rather than using chemical and synthetic foods (Viswanath *et al*., 2018). Post-harvest losses of fruits are becoming a serious issue, so it is necessary to transform such fruits in value-added products. Jamun is one of those fruits which are unfortunately not properly stored thus encounters major post-harvest losses.

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Jamun is seasonal, perishable and underutilized indigenous fruits with a lot of medicinal benefits. The fruit contains a varying amount of minerals, vitamin C, phenolic compounds, sugars and antioxidant components (Prabhakaran *et al*., 2011). Mainly, jamun fruit is processed to prepare vinegar, squash, jam and jellies. Jamun product is attractive to consumers due to the eye-appealing purple color contributed by anthocyanins pigments. Moreover, the jamun flavonoids act as both antioxidants and colorant (Bukya and Madane, 2018). Most fruits have a short harvest season and such fruits are sensitive to the deterioration even these are stored in the refrigerator in favorable condition. Fruit leathers are the dehydrated and concentrated fruit based flexible sheet that are consumed as a dessert or snack with rich nutritional profile (Khayum *et al*., 2018). Thus, fruit leather is the most effective way to preserve fruit pulp. Moreover, it is the best way to give fruit solid to children and adolescents. Fruit leathers can be stored for a longer period of time without any undesirable change in texture and the flavor (Basha *et al*., 2018).

The purpose of the present study was to prepare iron fortified jamun leather and use it to combat iron deficiency anemia. During the study, nutritional profiling including the iron level, total phenolic compounds, antioxidant activity using the DPPH assay were carried out. Additionally, the physicochemical and organoleptic evaluation was done.

MATERIALS AND METHODS

Procurement of raw material and sample preparation: The two varieties of Jamun (*Syzygium cumini*), Ra and Desi, were purchased from Ayub Agriculture Research Institute, Faisalabad keeping in view the quality traits for example size uniformity, shape and color followed by washing and grading. The seed was separated from the pulp for the analysis. The fruit pulp samples were preceded for the proximate and mineral analysis.

Nutritional profiling of Jamun varieties pulp

Proximate and mineral analysis: The proximate analysis of jamun varieties including ash, moisture, crude fat, crude fiber and crude protein were carried out according to the standard method of AOAC (2016). Minerals such as K and Na of jamun pulp were quantified by Flame Photometer whilst Ca, Fe and Zn were determined using the Atomic Absorption Spectrophotometer technique (AOAC, 2016). All the tests were performed in triplicates.

Preparation of fortified jamun leather: Jamun varieties were passed through the pulper for the pulp that was further used for the preparation of jamun leather. The jamun pulp was homogenized using the lab homogenizer. During the homogenization, the other ingredients such as pectin, citric acid and sugar were added to the mixture. After homogenization, the mixture was pasteurized and followed by the addition of iron salt and mixed thoroughly to avoid any precipitation of salt. The ferrous sulphate was added in samples to yield 7.2 mg (40% of Recommended Daily Allowance (RDA)) and 10.7 mg/100g (60% of RDA) of jamun leather according to the treatments separately. The mixture was taken in aluminium trays and a thin layer of vegetable oil was smeared in the aluminium trays to avoid sticking of leather. The process of dehydration was done in the cabinet dryer at a temperature of 60°C and the air velocity was set at 3.5 m/sec in cabinet dryer for about 7 to 8 hours. The leather was cut into desired shapes weighing 10g. The jamun leather was wrapped in butter paper and then stored in the polythene bags that were labelled according to the treatments prepared. Fortified jamun leather was prepared using both of the varieties separately using ferrous sulfate as a fortificant.

***Physicochemical analysis*:** The physicochemical analysis including the pH, total soluble solids (TSS), acidity, reducing sugars and ascorbic acid were analyzed by Kaleem *et al.* (2017).

Mineral analysis/Iron determination: Fe level of the fortified jamun leather was determined by using an atomic absorption spectrophotometer as mentioned by AOAC (2016).

***Total Phenolic content*:** The total phenolic content of iron-fortified jamun leather were determined by using the method of Phuong *et al*. (2017).

DPPH radical scavenging activity: The *in vitro* antioxidant activity was assessed by using DPPH assay according to the method mentioned by Ahmad *et al*. (2018).

Sensory evaluation: The sensory properties of iron-fortified leather including taste, flavor, color and overall acceptability were assessed by the 20 volunteers by using a 9-point hedonic scale.

Statistical Analysis: The data obtained were subjected to statistical analysis using a two-way factorial completely randomized design (CRD) and the means were compared using LSD (least significant difference) test at 0.05% significant level using the Statistix software and following the methods explicated by Montgomery (2008).

Table 1. Treatment plan of iron-fortified jamun leather (10g).

Treatments	Pulp %	$FeSO_4.7H_2O$ (%RDA)
V_1T_1	100	40
V_1T_2	100	60
V_2T_1	100	40
V_2T_2	100	60

V_1=Desi jamun pulp; V_2,= Ra jamun pulp; 40% and 60% RDA- Fe requirement of adult females (18mg/day)

RESULTS AND DISCUSSION

Compositional profiling of jamun varieties pulp: Proximate analysis plays an important role in examining the qualities of the raw material. The results of the present study for

proximate analysis of jamun varieties pulp are mentioned in Table 2. The values of the proximate analysis including moisture, ash, protein, fiber, fat and nitrogen-free extract in desi jamun were 84.08±0.03, 2.09±0.08, 2.14±0.02, 1.77±0.02, 0.157±0.02 and 9.77±0.29 g/100g whilst in Ra jamun 82.11±0.04, 2.15±0.08, 2.09±0.02, 2.06±0.07, 1.51±0.04 and 10.07±0.32 g/100g. The present results of the proximate assay are in corroboration with the findings of Suradkar *et al*. (2017), who evaluated crude fat, moisture, ash, crude protein, crude fiber as 0.29, 81.25, 0.85, 1.26 and 1.05% respectively. The current outcomes are also following the same pattern reported by Ghosh *et al.* (2017) as 79.25% moisture in jamun pulp whilst the remaining contents ash, fat and protein were 1.03, 0.18 and 0.65 g/100g, respectively.

Although minerals are not used as a source of energy, however these are required for the physiological functions of the body. Fruits are considered to be a good source of minerals. Owing to this jamun is considered to be a highly nutritive fruit containing important minerals (Saeed *et al.*,2018). In the present exploration, the minerals like iron (Fe), calcium (Ca), zinc (Zn), sodium (Na) and potassium (K) in desi and Ra jamun pulp were documented as 2.36±0.20, 20.04±0.81, 0.31±0.02, 7.73±0.17, 183.4±0.51 mg/100g and 2.36±0.19, 24.33±0.91, 0.24±0.03, 3.30±0.30 and 172.9±0.55 mg/100g respectively (Table 2). Previously, Ali *et al.* (2013) recorded 8.61, 87.91, 24.30 and 3.04mg of sodium, potassium, calcium and iron in 100g of dry jamun pulp. Moreover, Nawaz *et al.* (2011) observed 0.88mg/100g magnesium in jamun pulp whilst the remaining minerals including 0.88 mg/100g iron, 1.5mg/100g zinc, 19.9 mg/100g sodium and 196.8 mg/100 potassium were also observed. The proximate composition and the mineral contents might deviate due to the changes in geographical conditions, agronomic practices and ripening stage.

Table 2. Compositional profiling of jamun varieties pulp

	Proximate analysis (%)	
	Desi jamun	**Ra jamun**
Moisture	84.08±0.03	82.11±0.04
Ash	2.09±0.08	2.15±0.08
Crude protein	2.14±0.02	2.09±0.02
Crude fiber	1.77±0.02	1.98±0.04
Crude fat	1.57±0.03	1.51±0.04
Nitrogen free extract (NFE)	9.77±0.29	10.07±0.32
	Mineral analysis(mg/100g)	
	Desi jamun	**Ra jamun**
Fe	2.36±0.20	2.36±0.19
Ca	20.04±0.81	24.33±0.91
Zn	0.31±0.02	0.24±0.03
Na	7.73±0.17	3.30±0.30
K	183.40±0.51	172.90±0.55

Storage study of jamun leather: The fortified Jamun leather treatments were stored at room temperature. The leather was stored for 120 days, during this tenure the changes in the jamun leather composition were observed some of those are discussed below.

pH: The mean squares related to pH of the leather predicted that there was a non-significant effect on treatments whilst the storage has a significant effect on pH (Table 3). The maximum reduction of 6% was observed in V_1T_2, which is from 3.46±0.11 (initial day) to 3.25±0.10 (last day). A similar trend of reduction during the storage is observed in other three treatments, such as in V_2T_2 pH calculated at day 0 was 3.42±0.11 which decreased to 3.24±0.10 at the end day of the study. The results of pH are in accordance Kaleem *et al.* (2017). They prepared strawberry leather using different concentrations of sucrose and honey and further analyzed various physicochemical analysis including pH. They reported a decrease in pH value from 3.64 to 3.48 at the end of the study. Similarly, in another research, guava leather was and packed the in different packing material according to the researchers the pH of the leather was decreased during the storage study (Offia-Olua and Ekwunife, 2015). The factors responsible for fall in the values of pH during the storage might be the oxidation or denaturation of protein present in the product (Akhtar *et al*., 2014)

Acidity: The acidity of the fortified jamun leather was significantly affected during storage (Table 3). The maximum increase in acidity was observed in V_2T_2 which was 0.48±0.017 to 0.63±0.025 followed by V_1T_2 that increased from 0.49±0.017 to 0.63±0.021 during the storage of 120 days. Whereas the V_2T_1 showed a less increase in the acidity from 0.46±0.021 (0 day) to 0.59±0.015 (120^{th} day). The present findings are in alignment with the results of Basha *et al.* (2018), noticed a gradual rise in the acidity of the guava leather throughout the storage of 90 days. They prepared guava leather and predicted the acidity 0.55 on day 0 which gradually increases up to 0.563 at the 30^{th} day of the study. A similar trend of increase in acidity was observed by Saranya *et al.* (2017), they prepared papaya fruit rollups. According to their research the acidity of the leather increase during 10 weeks i.e., from 0.36 to 0.65 till the final day of their study. The rise in the acidity might be owing to the breakdown of the pectic bodies which in return increased the chances of the development of the acidic substances (Shakoor *et al*., 2015).

Total Soluble Solids (Brix°): The treatments and the storage time showed a non-significant effect on brix. The mean values of brix showed in Table 3 were 50.78±1.69, 50.98±1.67, 50.17±1.68 and 50.72±1.66 for V_1T_1, V_1T_2, V_2T_1 and V_2T_2 whilst during the storage interval the brix increase from 49.81±1.71 to 51.48±1.65. Depending on the conditions the brix may vary. According to Chavan and Shaik (2015) observed an increase in TSS during the storage of guava leather. In some cases, the increase in brix was linked with the conversion of insoluble polysaccharide starches into soluble

Table 3. Effects of storage and treatment on pH, acidity, TSS, reducing sugars and ascorbic acid of jamun leather.

		Treatments				
Parameter	**Storage Days**	**V_1T_1**	**V_1T_2**	**V_2T_1**	**V_2T_2**	**Means**
pH	0	3.47±0.11^{a}	3.46±0.11^{a}	3.45±0.11^{ab}	3.42±0.11^{abc}	3.45±0.116^{a}
	30	3.43±0.10^{abc}	3.42±0.10^{a-d}	3.41±0.10^{a-d}	3.37±0.10^{a-d}	3.41±0.107^{a}
	60	3.38±0.10^{a-d}	3.38±0.11^{a-d}	3.36±0.11^{a-d}	3.33±0.10^{a-d}	3.37±0.109^{ab}
	90	3.34±0.10^{a-d}	3.32±0.11^{a-d}	3.31±0.11^{a-d}	3.29±0.11^{a-d}	3.32±0.111^{bc}
	120	3.27±0.10^{bcd}	3.25±0.10^{cd}	3.26±0.10^{cd}	3.24±0.10^{d}	3.26±0.103^{c}
	Means	3.38±0.021^{a}	3.37±0.01^{a}	3.36±0.018^{a}	3.34±0.020^{a}	
Acidity	0	0.47±0.01^{j}	0.49±0.01^{hij}	0.46±0.02^{hij}	0.48±0.01^{ij}	0.48±0.019^{e}
	30	0.52±0.02^{fgh}	0.51±0.02^{fgh}	0.51±0.02^{fgh}	0.53±0.02^{fgh}	0.52±0.020^{d}
	60	0.54±0.02^{efg}	0.55±0.01^{def}	0.53±0.01^{def}	0.57±0.02^{cde}	0.55±0.020^{c}
	90	0.58±0.02^{bcd}	0.59±0.01^{bc}	0.57±0.01^{bcd}	0.58±0.02^{bcd}	0.58±0.020^{b}
	120	0.6±0.02^{ab}	0.63±0.02^{a}	0.59±0.01^{ab}	0.63±0.02^{a}	0.61±0.021^{a}
	Means	0.54±0.02^{a}	0.55±0.01^{a}	0.53±0.01^{a}	0.56±0.02^{a}	
TSS (Brix°)	0	50.19±1.70^{a}	50.15±1.70^{a}	49.34±1.70^{a}	49.56±1.60^{a}	49.81±1.70^{a}
	30	50.55±1.60^{a}	50.48±1.60^{a}	49.48±1.60^{a}	49.91±1.60^{a}	50.11±1.60^{ab}
	60	50.92±1.60^{a}	50.95±1.60^{a}	50.90±1.60^{a}	51.06±1.60^{a}	50.96±1.60^{ab}
	90	51.01±1.70^{a}	51.42±1.70^{a}	50.96±1.70^{a}	51.28±1.70^{a}	50.97±1.70^{ab}
	120	51.24±1.60^{a}	51.89±1.60^{a}	50.98±1.60^{a}	51.81±1.60^{a}	51.48±1.60^{b}
	Means	50.78±1.69^{a}	50.98±1.67^{a}	50.17±1.68^{a}	50.72±1.66^{a}	
Reducing	0	13.07±0.52^{e-h}	12.90±0.45^{fgh}	12.48±0.41^{h}	12.77±0.50^{gh}	12.75±0.47^{d}
sugars	30	13.57±0.48^{c-f}	13.27±0.44^{d-g}	12.84±0.48^{fgh}	13.09±0.46^{e-h}	13.19±0.46^{c}
	60	13.82±0.43^{b-e}	13.87±0.52^{bcd}	13.29±0.51^{defg}	13.54±0.52^{c-f}	13.63±0.50^{b}
	90	14.14±0.50^{abc}	14.49±0.45^{ab}	14.25±0.47^{abc}	13.99±0.41^{a-d}	14.28±0.46^{a}
	120	14.52±0.45^{ab}	14.74±0.44^{a}	14.73±0.44^{a}	14.45±0.46^{ab}	14.55±0.45^{a}
	Means	13.82±0.48^{a}	13.81±0.46^{a}	13.75±0.46^{a}	13.57±0.47^{a}	
Ascorbic acid	0	7.15±0.59^{a}	7.09±0.62^{a}	6.55±0.54^{a-d}	6.49±0.65^{a-d}	6.82±0.60^{a}
(mg/100)	30	7.05±0.56^{ab}	6.9±0.58^{a-d}	6.48±0.50^{a-d}	6.38±0.61^{a-d}	6.70±0.56^{ab}
	60	6.93±0.57^{abc}	6.77±0.59^{a-d}	6.39±0.51^{a-d}	6.23±0.62^{a-d}	6.58±0.57^{ab}
	90	6.85±0.58^{a-d}	6.69±0.61^{a-d}	6.25±0.52^{a-d}	6.14±0.62^{bcd}	6.48±0.58^{ab}
	120	6.71±0.54^{a-d}	6.61±0.56^{a-d}	6.03±0.48^{cd}	5.96±0.57^{d}	6.33±0.54^{b}
	Means	6.94±0.57^{a}	6.81±0.58^{a}	6.34±0.51^{b}	6.24±0.61^{b}	

di and mono-saccharides (Shakoor *et al*., 2015). According to Saranya *et al.* (2017), the brix of the papaya leather rollups decreases from 80.60° to 78.34°. Similar findings were mentioned by Vagadia *et al.* (2017), they noticed a decrease in TSS from 84.82° to 83.60° during 6 months of storage. The gradual increase in the brix and the brix to acid ratio of the jamun leather during the storage is due to the decrease of the moisture level and breakdown of polysaccharides into soluble compounds as mentioned by Basha *et al.* (2018).

Reducing sugars: Reducing sugars were also calibrated during the storage study. An increasing trend is observed during the storage at from day 0 to day 120. The maximum rise *i.e.*, 14% was observed in V_2T_1 (12.48±0.41 at day 0 to 14.49 ±0.44 at day 120). Whereas 12% increase was observed in V_1T_2 *i.e.,* 12.90±0.45 to 14.74±0.44. Moreover, a gradual rise in reducing sugars was observed from 12.75±0.47 (0 day), 13.19±0.46 (30th day), 13.63±0.50 (60th day), 14.28±0.46 (90th day), 14.55±0.45 (120th day) as mentioned in Table 3. The results of reducing sugars are similar to the readings of Das *et al.* (2019) prepared a pomegranate leather using different packing material and stored it in the refrigerator as well as in the ambient room temperature for 60 days. During the study, they observed a gradual increase in the level of reducing sugars in the refrigerator kept sample and the sample stored at ambient temperature. They noticed that the reducing sugars at cold temperatures were 8.12 to 10.05% which increased to 12.35 to 13.69. whilst the at ambient temperature reducing sugars ranged between 10.05 to 10.28 which raised to a range of 13.67 to 14.15. Earlier, Kaleem *et al.* (2017), prepared strawberry leather using different concentrations of sucrose and honey and examined the different physicochemical and sensory properties of leather. During the study, they determined that reducing sugars decreased during the storage study. They noticed that the reducing sugars in the leather were 19.08 which was reduced to 19.44 during the study of 90 days. Referring to the literature of Sharma *et al.* (2013), who elaborated the reason

for the rise in the reducing sugars levels as more conversion of non-reducing sugars to reducing sugars.

***Ascorbic acid*:** The ascorbic acid content of jamun leather showed the treatments of the study due to varietal difference whilst during the storage, there was no significant effect on ascorbic acid. The data displayed in Table 3 showed that V_1T_1 (6.94±0.57mg/100g) has the maximum amount of ascorbic acid followed by V_1T_2 (6.81±0.58 mg/100g). The reduction in Vitamin C was observed as from 6.82±0.60 mg/100g to 6.33±0.54 mg/100g during 120 days. Ascorbic acid is a natural antioxidant entity which may reduce due to the interaction with the surrounding environment such as light and air. The same reduction trend was observed by Vagadia *et al.* (2017), during the storage of different papaya and banana leather treatments which was 16.14 to 9.14 mg/100g (treatment having a ratio of papaya and banana as 20% and 80% respectively) during storage of 6 weeks, similarly, another treatment having 60% papaya and 40% banana exhibited a decrease from 35.24 to 24.23 mg/100g. In another study presented by Tontul and Topuz, (2017), the initial value of ascorbic acid was 23.26±10.74 mg/100g which was reduced to 17.57±13.77mg/100g at the end of the study. Saranya *et al.* (2017) mentioned that the decrease in the level of ascorbic acid might be due to the oxidation process of ascorbic acid and the formation of dehydroascorbic acid in an acidic environment.

***Fe determination*:** In the current study, the treatments showed a significant effect on the iron level of the leather whilst the storage has a non-significant effect on the iron level. A decline was observed from 7.25±1.26 to 7.12±1.02 mg/10g in V_1T_1, in V_1T_2 iron level was reduced from 10.75±1.30 to 10.65±1.11mg/10g from the initial day to the termination day of study. Similarly, in V_2T_1 iron value was dropped from 7.22±1.28 to 7.10±1.09 mg/10g and in the last treatment V_2T_2 10.72±1.27 to 10.62±1.05 mg/10g trend was noticed at 0 day and day 120th day (Table 4). A research was conducted by Zahra *et al*. (2020), in which the researchers fortified fruit bar with iron fortificants. They observed a decreasing trend in the iron level during the study of 60 days, such as in a treatment iron level was reduced from 11.56±0.17 to 11.48±0.34 mg. Similarly, in another treatment iron was decreased from 10.78±0.01 to 10.65±0.17 mg during the storage.

Antioxidant activity of iron-fortified jamun leather

Total phenolic contents of iron-fortified jamun leather: The total phenolic contents (TPC) of the iron-fortified jamun leather decline during the storage. Both the treatments and the storage had a significant effect on the phenolic contents of the leather. The mean Table 4 predicted that the total phenolic contents of V_1T_1, V_1T_2, V_2T_1 and V_2T_2 declined from 1377.89±1.96 to 1368.99±1.78, 1375.21±1.97 to 1369.43±1.76, 1299.34±1.81 to 1291.63±1.67 and 1293.36±1.78 to 1283.12±1.60 mg GAE/100g, respectively. Whilst a higher reduction in TPC of all the treatments was recorded as 1336.45±1.88 to 1329.81±1.76 mg GAE/100g throughout the storage. These results are in harmony with the study conducted Torres *et al*. (2015) on the apple and quince leather without the addition of any preservative. They observed a significant reduction of TPC during the storage study such as 31% TPC was reduced in apple leather whereas 49% reduction in quince leather. Similarly, in another research conducted by Tonul and Topuz, (2017) on the pomegranate leather. During the storage of the leather, the researchers observed a reduction in total phenolic contents from 11.78±3.41 to 8.72±3.65 mg GAE/100g. Lafarga *et al.*

Table 4. Effects of storage and treatment on Fe, TPC and DPPH content of jamun leather.

		Treatments				
Parameter	**Storage Days**	**V_1T_1**	**V_1T_2**	**V_2T_1**	**V_2T_2**	**Means**
Fe (mg/10g)	**0**	7.25±1.26^{b}	10.75±1.30^{a}	7.22±1.28^{b}	10.72±1.27^{a}	8.99±1.28^{a}
	30	7.20±1.24^{b}	10.73±1.27^{a}	7.19±1.24^{b}	10.70±1.23^{a}	8.96±1.25^{a}
	60	7.18±1.20^{b}	10.70±1.24^{a}	7.17±1.22^{b}	10.67±1.21^{a}	8.93±1.22^{a}
	90	7.15±1.18^{b}	10.67±1.20^{a}	7.13±1.19^{b}	10.64±1.19^{a}	8.90±1.19^{a}
	120	7.12±1.12^{b}	10.65±1.11^{a}	7.10±1.09 ^{b}	10.62±1.05^{a}	8.87±1.07^{a}
	Means	7.18±1.18^{b}	10.70±1.22^{a}	7.16±1.20^{b}	10.67±1.19^{a}	
TPC (mg	**0**	1375.21±1.97^{ab}	1377.89±1.96^{a}	1299.34±1.81^{f}	1293.36±1.78^{hi}	1336.45±1.88^{a}
GAE/100g	**30**	1374.26±1.96^{bc}	1373.17±1.92^{bc}	1297.23±1.78^{fg}	1290.76±1.75^{ij}	1333.86±1.85^{b}
	60	1372.11±1.88^{cd}	1372.12±1.89^{cd}	1294.67±1.75^{gh}	1288.02±1.69^{j}	1331.74±1.80^{c}
	90	1369.67±1.80^{de}	1371.76±1.85^{cde}	1292.76±1.72	1285.03±1.66^{k}	1329.81±1.76^{d}
	120	1369.43±1.76^{de}	1368.99±1.78^{e}	1291.63±1.67ij	1283.12±1.60^{kd}	1328.29±1.70^{e}
	Means	1372.14±1.87^{a}	1372.80±1.88^{a}	1294.95±1.75^{b}	1288.09±1.70^{c}	
DPPH (%)	**0**	86.78±0.57^{a}	85.36±0.62^{cd}	83.45±0.52^{ghi}	82.76±0.53^{i-l}	84.59±0.56^{a}
	30	86.47±0.55^{ab}	84.94±0.57^{cde}	83.17±0.48^{hij}	82.38±0.49^{j-m}	84.25±0.52^{a}
	60	85.75±0.54^{bc}	84.43±0.57^{ef}	82.82±0.48^{ijk}	81.96±0.48^{lm}	83.74±0.52^{b}
	90	85.06±0.52^{cde}	84.21±0.55^{efg}	82.53±0.47^{jkl}	81.55±0.47^{mn}	83.34±0.51^{b}
	120	84.52±0.48^{def}	83.89±0.50^{fgh}	82.10±0.45^{klm}	80.97±0.44^{n}	82.87±0.47^{c}
	Means	85.72±0.53^{a}	84.57±0.56^{b}	82.81±0.48^{c}	81.92±0.48^{d}	

(2017) stated that the loss of total phenolic contents and their scavenging activity might be due to the deformity of the cells which become more prone to non-enzymatic oxidation during the storage time of the product. Addai *et al.* (2016) quoted that the most common reason is thermal deterioration. During the dehydration process, the polyphenols are more likely to have a deformity in structure as compared to other compounds.

DPPH assay of iron-fortified jamun leather: Depending on the varieties the iron-fortified jamun leather showed different levels of TPC and different antioxidant scavenging activity *i.e.,* DPPH activity. In the present study, there was a significant effect of storage and treatment on the DPPH activity. The mean Table 4 displayed a decrease in DPPH along with the storage interval. The maximum decrease in DPPH was observed in V_1T_1 *i.e.,* 86.78±0.57% to 84.52±0.48% followed by V_2T_2 which was 82.76±0.53% to 80.97±0.44. The overall reduction during along the storage days zero, 30th, 60th, 90th and 120th was 84.59±0.56, 84.25±0.52, 83.74±0.52, 83.34±0.51 and 82.87±0.47. Das *et al.,* (2019), prepared a pomegranate leather using different packing material and stored it in the refrigerator as well as in the ambient room temperature for 60 days. They observed a decline in the DPPH in both the environmental conditions. Such as the DPPH reduced from 78.92% to 66.83% at a cold environment whilst, at the ambient temperature the DPPH declined to 29.93% from 78.52%. The decreased scavenging activity of jamun leather during the storage might be due to the deformity of cells which increased non enzymatic activity (Lafarga *et al*.,2017).

Sensory evaluation of iron-fortified jamun leather: The iron-fortified jamun leather was presented to a panel of 20 judges and evaluation was carried out by using a 9-point hedonic scale. The mean sensory scores of iron-fortified jamun leather treatments are mentioned in Table 5. Colour is one of the most important parameters for the acceptance and success of any food product by the consumers. The storage and treatment have a non-significant effect on the color. The sensory score of color is shown in Table 5, which predicted that maximum color was observed in V_1T_2 which is 7.48±0.25 followed by 7.44±0.27 in V_1T_1. The score gradually reduced from 7.53±0.28 to 7.33±0.23 at the end of the study. The flavor is affected by treatments whilst the storage does not affect the flavor of the leather. The results of flavor in Table 5 showed that the maximum flavor was developed by V_1T_2 *i.e.,* 8.92±0.27 whilst followed by V_1T_1 7.7±0.29. Whilst the scores for V_2T_1 and V_2T_2 were 6.08±0.25 and 6.33±0.25 respectively. The flavor attribute reduced from 7.54±0.28 to 6.85±0.25 during the 120 days. Similarly, the taste of leather the treatments had a significant effect on the taste whilst during the storage, a very non-significant effect was observed.

Table 5. Effects of storage and treatment on sensory evaluation of jamun leather

		Treatments				
Parameter	**Storage days**	**V_1T_1**	**V_1T_2**	**V_2T_1**	**V_2T_2**	**Means**
Color	**0**	7.55±0.28^{a}	7.58±0.28^{a}	7.48±0.29^{a}	7.51±0.27^{a}	7.53±0.28^{a}
	30	7.49±0.27^{a}	7.50±0.25^{a}	7.42±0.26^{a}	7.46±0.24^{a}	7.47±0.26^{a}
	60	7.42±0.27^{a}	7.48±0.28^{a}	7.37±0.26^{a}	7.40±0.24^{a}	7.42±0.26^{a}
	90	7.36±0.26^{a}	7.42±0.25^{a}	7.30±0.25^{a}	7.34±0.24^{a}	7.36±0.25^{a}
	120	7.34±0.25^{a}	7.39±0.23^{a}	7.26±0.23^{a}	7.29±0.22^{a}	7.33±0.23^{a}
	Means	7.44±0.27^{a}	7.48±0.25^{a}	7.37±0.26^{a}	7.40±0.24^{a}	
Flavor	**0**	8.92±0.32^{a}	7.94±0.29^{b}	6.55±0.26^{de}	6.73±0.26^{d}	7.54±0.28^{a}
	30	8.79±0.31^{a}	7.92±0.27^{b}	6.23±0.26^{ef}	6.56±0.25^{de}	7.37±0.27^{ab}
	60	8.74±0.28^{a}	7.64±0.27^{bc}	6.12±0.25^{ef}	6.28±0.25^{ef}	7.17±0.26^{bc}
	90	8.58±0.28^{a}	7.57±0.28^{bc}	6.07±0.25^{f}	6.05±0.24^{f}	7.06±0.26^{c}
	120	8.48±0.27^{a}	7.36±0.26^{c}	6.45±0.27^{f}	6.06±0.23^{g}	6.85±0.25^{d}
	Means	8.68±0.29^{a}	7.67±0.27^{b}	6.08±0.25^{d}	6.33±0.25^{c}	
Taste	**0**	8.93±0.33^{a}	7.92±0.35^{c}	6.54±0.36^{efg}	6.76±0.35^{e}	7.51±0.35^{a}
	30	8.80±0.31^{ab}	7.90±0.33^{c}	6.21±0.34^{fgh}	6.58±0.32^{ef}	7.37±0.33^{ab}
	60	8.67±0.32^{ab}	7.84±0.33^{c}	6.10±0.31^{gh}	6.29±0.33^{fgh}	7.23±0.32^{bc}
	90	8.55±0.32^{ab}	7.77±0.31^{cd}	6.08±0.32^{h}	6.09±0.31^{h}	7.12±0.32^{c}
	120	8.46±0.31^{b}	7.38±0.29^{d}	5.49±0.33^{i}	6.08±0.32^{h}	6.85±0.31^{d}
	Means	8.86±0.32^{a}	7.76±0.32^{b}	6.36±0.33^{c}	6.08±0.33^{d}	
Overall acceptability	**0**	8.92±0.31^{a}	7.94±0.29^{b}	6.55±0.26^{de}	6.73±0.28^{d}	7.53±0.29^{a}
	30	8.79±0.29^{a}	7.92±0.28^{b}	6.23±0.24^{ef}	6.56±0.26^{de}	7.37±0.27^{ab}
	60	8.64±0.29^{a}	7.64±0.27^{bc}	6.12±0.24^{ef}	6.28±0.26^{ef}	7.17±0.27^{bc}
	90	8.58±0.28^{a}	7.57±0.27^{bc}	6.07±0.25^{f}	6.06±0.27^{f}	7.07±0.27^{c}
	120	8.48±0.27^{a}	7.36±0.21^{c}	5.45±0.23^{g}	6.05±0.24^{f}	6.84±0.25^{d}
	Means	8.68±0.29^{a}	7.68±0.27^{b}	6.33±0.24^{c}	6.08±0.26^{d}	

The maximum taste score was exhibited by V_1T_1 which is 8.86±0.32 following the V_1T_2 *i.e.,* 7.76±0.32 (Table 5). The difference in taste and flavor among the treatments may be due to different varieties.

The overall acceptability of jamun leather was maximum in V_1T_1 (8.68±0.29) and V_1T_2 (7.68±0.27) than V_2T_1 (6.33±0.24) and V_2T_2 (6.06±0.26). The overall acceptance was reduced from 7.60±0.29 to 7.41±0.25 during 120 days of study (Table 5). The present study's findings are following Saranya *et al.* (2017), who worked on the papaya fruit rollups. They suggested the sensory attributes were 4.27 to 3.87 for color, 4.47 to 3.67 for flavor, in case of taste and overall acceptability sensory score was 4.20 to 3.80 and 4.47 to 3.92 respectively. Likewise, Zahra *et al.* (2020) developed an iron-fortified fruit bar and conducted the organoleptic analysis of the bar. The sensory analysis was done on a fortnight basis for 60 days. During the research tenure, a decrease in some of the sensory parameters from 0^{th} to 60^{th} day and concluded that the reason behind the decrease in the flavor, taste and overall acceptability score might be the physicochemical changes during the storage. Similarly, Kaleem *et al.* (2016) mentioned that the decline in the color of the leather might be due to the deterioration of the pigment moreover the researchers warned the Millard reaction as a reason for the change in the color during the storage. The maximum rating of all the sensory attributes was observed in V_1T_1 throughout the storage.

Conclusion: Jamun and its derived products have been proposed to have health promoting properties. The present study was carried out to prepare fortified jamun leather for consumption by targeted population using two jamun varieties having specified RDA values of ferrous sulfate to overcome the iron-deficiency anaemia situation. The experiment results related to the fortified jamun leather prepared using different concentration of iron salt was acceptable throughout the 120 days storage period at ambient temperature. In the present study, the iron level of fortified leather remained the same throughout the storage in a range of 7.16-7.18 and 10.67 to 10.70 mg/10g. The highest ascorbic acid was observed in V_1T_1 as 6.94±0.57, similarly, the maximum level of reducing sugars was noticed in V_1T_1 *i.e.,* 13.82±0.48. In case of sensory evaluation, the V_1T_1 and V_1T_2 secured the highest scores in overall acceptability as 8.68±0.29 7.68±0.27 correspondingly. Moreover, on the basis of chemical and organoleptic analysis, the V_1 variety *i.e.,* Desi jamun was considered to be more stable in comparison to the other variety.

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