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Standardization and development of tamarind leather with incorporation of liquid jaggery

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Abstract
In the present investigation carried out to standardization and development of tamarind leather with incorporation of liquid jaggery. The liquid jaggery was utilized in development of tamarind leather instead of sugar. It is healthy option to use liquid jaggery instead of sugar. Tamarind leather was prepared by addition of liquid jaggery at different level i.e. 10%, 20%, 30% and 40% respectively. The prepared tamarind leather was analyzed for chemical and sensory properties. Sensory evaluation revealed that the sample T_2 (30% liquid jaggery) secured highest score which has recipe tamarind pulp 100 g, liquid jaggery 30 g, citric acid 0.4 g, pectin 1 g, maltodextrin 1g, guar gum 1 g and for flavor 2 g funnel seed extract was used. Selected T_2 tamarind leather contains moisture 16.96%, protein 4.36%, fat 1.05%, carbohydrate 73.05%, ash 4.14%, pH 3.91, acidity 1.92% of tartaric acid and energy value 319.69 Kcal respectively.

Keywords: Standardization, development, tamarind, liquid jaggery

Introduction
Tamarind (*Tamarindus indica* L.) is a tropical fruit that belongs to the family Leguminosae (Fabaceae) and subfamily Caesalpinioideae. Tamarind is native to tropical Africa (Vuyyala *et al*., 2020) [14]. The fruit of tamarind tree or 'Assam tree' is known as 'imli' or 'Indian date'.
Medicinal uses of tamarind are uncountable. Tamarind pulp is used to aliay thirst and is nutritive and refrigerant; in large quantity laxative. On this account it forms a useful and agreeable drink in febrile and inflammatory diseases and with persons recovering from sickness, to keep their bowels regular, it may form a portion of their diet. Tamrind preparations are universally recognized as refrigerants in fever and as laxatives and carminatives. (Joshi *et al*., 2013) [3].
Liquid jaggery is an important intermediate product obtained during the preparation of jaggery from sugarcane juice. Liquid jaggery is having additional nutritional components which are having wide spectrum of medicinal properties and hence, it is a good nutraceutical. Liquid jaggery is incorporated in many traditional foods and ayurvedic medicinal compositions (Rajendran *et al*., 2020) [8].
Liquid jaggery is a versatile product finding used in various food compositions as that of honey (Nath *et al*., 2015) [6]
India is the largest producer of jaggery in the world and has the share of more than 70% of world production (Rao *et al*. 2007) [9].
Now-a-days, there is an increased demand for the natural sugar like liquid jaggery, due to its nutritional ingredients, unlike the white sugar which is devoid of all nutrients except sucrose (Shrivastav *et al*. 2016) [10].
The non-sugar ingredients include pigments, phenolic compounds, vitamins, amino acids, sterol and minerals containing salts of calcium, potassium, magnesium, phosphorus, iron, zinc, sulphur, etc. Liquid jaggery helps in blood purification, controls acidity, gives instant energy and so it is used in Ayurvedic medicinal preparations (Singh *et al*. 2011) [12].
High content of reducing sugars in liquid jaggery is the instant energy provider on consumption. Hence, it is good for students, sportsmen, children, and aged persons. It is used as ingredient in ice creams, sudharas, fruit salad, ayurvedic medicines & syrups. It is good for patients for energy recovery. It is also useful as dietary supplement for bread, chapatti, jowar Bhakri, millet Bhakri, Puranpoli, roti, etc. With the importance of these versatile properties of LJ, focus has been made to prepare LJ in a simple way which can be augmented for upscale preparation to the market level.

Indiscriminate use of chemical clarificants like hydros, super phosphate, phosphoric acid, etc. by jaggery manufacturers results in the low quality sugarcane products. Quality of the product is slowly degraded on storage due to these chemicals and excess residues of these chemicals are harmful to health (Nagalakshmi and Uma 1999) [5].

Fruit leathers are the restructured fruit made from concentrates of mixture of fruit juices or fruit pulp and other materials after a drying process. The fruit leathers made of pulp are most widely preferred by the consumers as they consist of good quantities of carbohydrates, fibers, vitamins, antioxidants and minerals. Fruit leathers are the dried and dehydrated products. These are chewy, tasty and dried fruit product. These are made by spreading the pulp on the stainless or aluminium trays and then drying or dehydrating them at a particular temperature such that the moisture content reaches up to 15-20%. The drying can be carried out by different methods like solar drying, cabinet drying, hot air drying, microwave oven drying, vaccum drying, freeze drying. After drying the leather is then peeled out from the trays and are then packed. Because of its novelty and being more attractive in its form and on the other hand as it does not require refrigeration and so it was considered as the best way for incorporation of fruit solids and is mostly preferred by all ages especially for kids and adults. The leathers are also prepared from the left over ripe fruits. Basically fruit leather is the fruit without moisture content in it. Many dehydrating techniques eliminates water or moisture content from the fruit pulp so that the product lasts long. It is economical that allows to buy fruits in bulk and ensures that it won't go bad. (Bandaru and Bakshi, 2020) [1].

The mixed fruit bar incorporated with mahua flower was developed by varying concentration of mango pulp, papaya pulp and mahua flower pulp was varied at in each treatment, the ratio 60:20:20 respectively received the highest hedonic score 8.2. (Tathe *et al*., 2023) [2].

Materials and Methods

Materials

The raw materials utilized during present investigation like tamarind, liquid jaggery and packaging materials were procured from local market of Parbhani, Maharashtra.

Methods

Preparation of tamarind pulp

Fresh, mature ripe and sound quality tamarind pods were selected. Break and open the tamarind pods. Fibrous outer shell and any seeds inside was removed. Water in the proportion with flesh 2:1 was added. The addition of water increased the efficiency of pulping. It is found that increase in addition of water up to twice the amount of flesh, the recovered pulp was very convenient for handling, beyond this the pulp becomes unacceptable. This was heated for 70 ^{0}C for 10 min to facilitate the soaking process. This is allowed to soaking process for 6 hours at room temperature. After 6 hours of soaking period maceration and straining process were carried out (Joshi *et al*. 2013) [3]. Finally, tamarind pulp was obtained according to Figure 1.

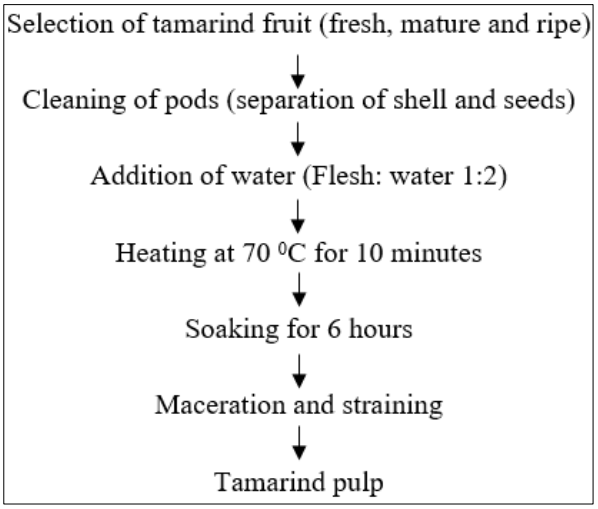

Fig 1: Preparation of tamarind pulp

Formulation of standardization and development of tamarind leather

Tamarind leather was prepared in Department of Food Chemistry and Nutrition of College of Food Technology Parbhani. Recipe for formulation of standardization and development of tamarind leather at different level of liquid jaggery and other ingredients in Table 1.

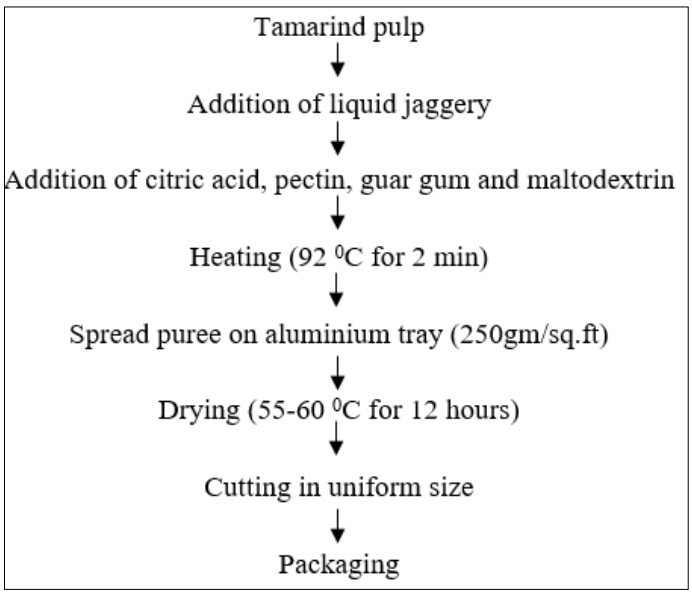

Fig 2: Development of tamarind leather

Table 1: Standardization and development of tamarind leather at different level of liquid jiggery

Ingredients	Control (T_0)	T_1	T_2	T_3	T_4
Tamarind pulp	100	100	100	100	100
Sugar	25	0	0	0	0
Liquid Jaggery	0	15	30	45	60
Citric acid	0.4	0.4	0.4	0.4	0.4
Pectin	1	1	1	1	1
Guar gum	1	1	1	1	1
Maltodextrin	1	1	1	1	1

Tamarind leather was prepared with varying proportion of liquid jaggery, sugar while citric acid, pectin, guar gum, maltodextrin at constant percent, four different treatments were given, such as control (T_1) had 100 g tamarind pulp, 25 g sugar, 0 g liquid jaggery, 0.4 g citric acid and 1 g each of pectin, guar gum, maltodextrin constant.

Treatment given to T_1 had 100 g tamarind pulp, 0 g sugar, 15 g liquid jaggery, 0.4 g citric acid, 1 g each pectin, guar gum and maltodextrin.

Treatment given to T_2 had 100 g tamarind pulp, 30 g sugar, 30 g liquid jaggery, 0.4 g citric acid, 1 g each pectin, guar gum and maltodextrin

Treatment given to T_3 had 100 g tamarind pulp, 0 g sugar, 45 g liquid jaggery, 0.4 g citric acid, 1 g each pectin, guar gum and maltodextrin

Treatment given to T_4 had 100 g tamarind pulp, 0 g sugar, 60 g liquid jaggery, 0.4 g citric acid, 1 g each pectin, guar gum and maltodextrin

Results and Discussion

Chemical composition of tamarind pulp

The chemical composition of tamarind pulp was systematically analysed. Detailed insights into the physicochemical composition of tamarind pulp are provided in Table 3, encompassing essential parameters such as moisture content, protein content, crude fat content, carbohydrate composition, ash content, total soluble solids (measured in degrees Brix), acidity, and pH value. This compositional analysis serves to elucidate the fundamental characteristics and chemical properties of tamarind pulp, thereby contributing to a comprehensive understanding of its nutritional and functional attributes.

Table 2: Chemical composition of tamarind pulp

Chemical Parameters	Value %
Moisture	85±0.02
Crude fat	0.2±0.04
Protein	2.36 ±0.03
Carbohydrates	8.36 ±0.2
Ash	4.08±0.03
Total Soluble Solids ^{0}Brix	15±0.1
Acidity	1.5±0.01
pH	2.6±0.02

Table 2 serves as an informative summary of the chemical composition of tamarind pulp. Specifically, the moisture content was determined to be 85%, while the Crude fat content and protein content were established at 0.2% and 2.36% respectively. The carbohydrate content was assessed using a difference method, revealing a value of 8.36% and ash content was 4.08%.

Moreover, Table 2 provides data on the Total Soluble Solids, indicating a reading of 15°Brix. The acidity level was found to be 1.5%, and the pH value was measured at 2.4 using a digital pH meter. It's noteworthy to mention that similar findings were reported by Joshi *et al*. in 2013 [3].

Chemical composition of liquid jaggery

Table 3 serves as a comprehensive repository of data pertaining to the physicochemical composition of liquid jaggery. This analysis encompasses a range of key parameters, including moisture content, protein content, crude fat content, carbohydrate, ash content, total soluble solids (measured in degrees Brix), acidity, and pH value. These detailed findings offer a profound understanding of the fundamental chemical properties and nutritional attributes of liquid jaggery, which are vital for evaluating its applicability and quality in various contexts.

Table 3: Chemical composition of liquid jiggery

Chemical composition	Value %
Moisture	17.45±0.01
Crude fat	1.04 ±0.02
Protein	0.95±0.001
Carbohydrates	79.66±0.1
Ash	0.9±0.001
Total Soluble Solids ^{0}Brix	78±0.2
pH	5.26±0.2

The objective of this study was to assess the chemical composition of liquid jaggery. Table 3 compiles the data related to the chemical attributes of liquid jaggery. The moisture content within the liquid jaggery was determined to be 17.45% using the hot air oven method. Protein content, established via the micro Kjeldhal method, was found to be 0.95%. In contrast, the liquid jaggery exhibited a minimal presence of crude fat, registering at 0.04%.

The carbohydrate content was assessed through the difference method, revealing a value of 79.66%. Additionally, the liquid jaggery displayed a concentration of 78°Brix, indicating its total soluble solids content. The pH value, measured with a digital pH meter, was recorded as 5.26. These findings comprehensively delineate the essential physicochemical characteristics of liquid jaggery and are instrumental in elucidating its suitability for various applications. Similar results were reported by Patil and Anekar (2014) [17].

Sensory evaluation of prepared tamarind leather

The prepared tamarind leather was evaluated for sensory qualities including colour and appearance, texture, taste, flavour, overall acceptability by semi trained panel, proficient in sensory assessment, was assembled for this purpose. The panel members were presented with five distinct samples, namely the control T_0, T_1, T_2, T_3, and T_4 and were asked with providing their expert sensory judgments using the Hedonic rating system. The detailed results of this sensory evaluation are documented in Table 4, offering valuable insights into the organoleptic attributes and overall acceptability of the tamarind leather products under scrutiny. This assessment is crucial for understanding consumer preferences and the quality of the tamarind leather formulations.

Table 4: Sensory evaluation of developed tamarind leather

Samples	Sensory attributes				
	Colour and Appearance	Texture	Taste	Flavour	Overall Acceptability
Control (T_0)	8.2	8.3	8.5	8.5	8.3
T_1	7.5	7.9	7.5	7.8	7.6
T_2	7.9	8.1	8.0	8.0	8.0
T_3	7.8	8.0	7.8	8.0	7.9
T_4	7.7	8.0	7.5	7.0	7.5
SE	0.0906	0.15055	0.01217	0.1022	0.03333
CD@ 5%	0.2729	3.52389	0.28985	2.53599	0.09777

Where,

Control (T_0): Tamarind pulp: Sugar: Liquid jaggery: Citric acid: Guar gum: Pectin: Maltodextrin (100:25:0:0.4:1:1:1)

T_1: Tamarind pulp: Sugar: Liquid jaggery: Citric acid: Guar gum: Pectin: Maltodextrin (100:0:15:0.4:1:1:1)

T_2: Tamarind pulp: Sugar: Liquid jaggery: Citric acid: Guar gum: Pectin: Maltodextrin (100:0:30:0.4:1:1:1)

T_3: Tamarind pulp: Sugar: Liquid jaggery: Citric acid: Guar gum: Pectin: Maltodextrin (100:0:45:0.4:1:1:1)

T_4: Tamarind pulp: Sugar: Liquid jaggery: Citric acid: Guar gum: Pectin: Maltodextrin (100:0:60:0.4:1:1:1)

It could be revealed from Table 5 that the maximum score for colour and appearance was recorded for control sample T_0 (8.2) followed by sample T_2 (7.9) which was comparatively higher than the sample T_1, T_3 and T_4. The treatment T_1 scored lowest score due to low percentage of addition of liquid jaggery which alters appearance of tamarind leather. Score of all the samples for colour and appearance parameter were above the acceptable level by comparing score given by panel members it was clear that colour and appearance of tamarind leather. Control sample T_0 had highest score for colour and appearance due to addition of sugar. The sample T_2 containing 30 percent liquid jaggery got highest score on headoic scale in all the sensory quality attributes and found to be highly acceptable whereas significant difference in sensory score was observed in sample T_1, T_3 and T_4.

Textural qualities were influenced by addition of the guar gum and maltodextrin in product hence sample T_2 (8.1) got highest hedonic score. Hedonic score for texture of T_0 (8.3), T_1 (7.5), T_3 (8.0) and T_4 (8.0). T_1 sample was scored highest as this contains sugar.

The data from Table 5 showed that there was no much difference in the score obtained on hedonic scale. Sample T_2 got highest score (8.0) as compared to sample T_1 and T_4.

Moreover, it could be seen that all the samples were found to be acceptable. The T_2 containing 30 percent liquid jaggery was found to be statistically significant over sample T_1, T_2 and T_4 in which 15 percent, 45 percent and 60 percent liquid jaggery was used. However, T_2 was found to be significantly superior over other samples (T_2) in terms of colour and appearance, texture, taste. Considering all the above sensory attributes sample (T_2) was highly acceptable and hence selected by panel members. Selected sample T_2 was used for further studies.

Chemical composition of prepared tamarind leather

Control sample (T_0) and selected sample (T_2) was analysed for chemical composition regarding with parameters moisture, crude fat, protein, carbohydrate, ash, acidity and pH.

Table 5: Chemical composition of Control sample (T_0) and selected sample (T_2)

Parameters	Samples	
	Control sample (T_0)	Selected sample (T_2)
Moisture	15.06±0.1	16.96±0.12
Protein	2.32±0.1	4.36±0.01
Crude fat	1.48±0.02	1.05±0.03
Carbohydrates	77.88±0.1	73.05±0.1
Ash	2.81±0.01	4.14±0.01
Acidity	1.46±0.03	1.92±0.02
pH	3.96±0.2	3.91±0.03

The chemical composition analysis of tamarind leather samples, labelled as Control (T_0) and selected (T_2) has provided valuable insights into their nutritional and chemical attributes. In the Control sample, the moisture content was measured at 15.06 percent with protein content at 2.32 percent, crude fat content at 1.48 percent, carbohydrate content at 77.88 percent, and ash content at 2.81 percent. Additionally, acidity was recorded at 1.46 with a pH value of 3.96

In the case of the T_2 sample, the moisture content was found to be 16.96%, protein content at 4.36 percent. crude fat content at 1.05 percent, carbohydrate content at 73.05 percent, and ash content at 4.14 percent. The acidity registered at 1.92 of tartaric acid with a pH value of 3.91.

Microbial analysis of selected T_2 tamarind leather stored at room temperature

Microbial analysis of food product is giving and indication about the shelf life and spoilage of food as well as regarding hygienic condition followed during preparation of food products. It gives and assumption about the definite storage period of particular product up to which it remains safe for consumption. Microbial populations like bacteria, yeast and mould were estimated by serial dilution followed by solidification in petri plate using nutrient agar and potato dextrose agar, respectively. Microbial load estimation for the tamarind leather was carried out for fresh as well as prepared leather at 30 days interval till 90 days. Microbial analysis of liquid jaggery based tamarind leather was estimated on the basis of laboratory trials and depicted in Table 6

Table 6: Microbial analysis of selected T_2 tamarind leather stored at room temperature

Storage period (Days)	Total plate count (CFU/gram)	Yeast mould count (CFU/gram)	Coliform
0	ND	ND	ND
30	ND	ND	ND
60	0.6×10^3	ND	ND
90	1.4×10^3	1.0×10^3	ND

ND- Not Detected

Tamarind leather was selected on the basis of sensory quality and analysed for microbial load at interval of 30 days stored at room temperature. The microbial study of sample was done for total plate count (TPC), yeast and mould count and total coliform (E. coli). The results obtained on microbial examination from present investigation is in Table 6

It is evident from given Table 6 that TPC and yeast and mould count observed in tamarind leather were found to be zero on the day as well as after 30 days of production. And could be increased as the storage period increased. TPC found after 60

days of production was 0.6×10^3 CFU/gram and increased 1.4×10^3 CFU/gram after 90 days.

Data presented in the Table 6 that plate count increased from 0.6×10^3 CFU/gram to 1.4×10^3 CFU/gram and yeast and mould count was found after 90 days of production and found to be 1.0×10^3 CFU/gram.

Coliform (E. coli) was not detected in product after each interval of time period. Similar findings were observed by Kumar *et al*., (2017) [4].

Conclusion

Fruits are good source of minerals, vitamins, phytochemical compound and many other such essential components which are major part of our daily diet. Leather is such a product which is liked by all ages group. Tamarind leather were evaluated for sensory evaluation and found that 30 g liquid jaggery was found to be best for each 100 g of tamarind pulp used to prepare leather. Selected sample (T_2) revealed chemical composition as moisture content 16.96 percent, protein 4.36 percent. crude fat 1.05 percent, carbohydrate 73.05 percent, and ash content at 4.14 percent. The acidity registered 1.92 of tartaric acid with a pH value of 3.91.

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