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Standardization of process development for fortified tamarind fruit leather with pulp of red tamarind variety Anantha Rudhira

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Abstract
The fortified tamarind fruit leather was prepared by blending tamarind pulp with oats flour, soya flour and peanut flour with different ratios of 75:25, 50:50 each flour, respectively and 100:0 (Control). Influence of fortification on the physico-chemical parameters were analyzed and sensory attributes of fortified tamarind fruit leathers were recorded. The highest TSS, titratable acidity, ascorbic acid, anthocyanins, total sugars, total phenols found in control (T_7) of 59.29 °Brix, 2.47%, 38.10 mg/100 g, 0.73%, 16.23%, and 0.61% respectively. The highest crude fibre content (0.42) was recorded in 50% T:50% O (T_2) and maximum yield (recovery %) (69.67%) and protein content (3.19%) was recorded in 50% T:50% P (T_6). Sensory evaluation of fortified tamarind fruit leather revealed that the highest score (8.30) for colour and appearance was recorded in 50% T:25% O (T_1), maximum score for texture (8.45), taste (8.66), flavour (8.71) and overall acceptability (8.59) was recorded in 50% T:50% P (T_6). In general, there was decrease in TSS, acidity, ascorbic acid, total sugars, anthocyanins and total phenols decrease by addition of flour to the tamarind leather and increase of yield, crude fibre and total proteins by the addition of flour to the tamarind leather.

Keywords: Tamarind, oat flour, soya flour, peanut flour, fortified, fruit leather

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) [26]. The fruit of the tamarind tree or 'Assam tree' is known as 'imli' or 'Indian date'. In India, tamarind is grown on 47,000 hectares, with a production of 189 thousand tonnes (NHB, 2018-2019). Karnataka, Tamilnadu, Kerela, Andhra Pradesh, Telangana, Maharashtra, Madhya Pradesh, Nagaland, and Mizoram are the major states that grow tamarind.

Tamarind is used as a conventional medicine, food, confection, pharmaceutical, and textile industries, as well as grain, timber, and fuel industries, all portions of the tree are used in some way (Vuyyala *et al*., 2020) [26]. Tender leaves and flowers are also edible. Tamarind seeds yield a cheap substitute for cereal starch which is in textile industry. In India, practically all parts of the tamarind tree are used for various purposes. The tamarind fruit can be processed to create a variety of value-added products, including tamarind concentrate, powders, juice, rasam paste, sauce, pickles, and chocolates (Shiny Israel *et al*., 2019) [24]. Dehydrated fruit items called fruit leathers are used as snacks or desserts. These fruit leathers are flexible sheets with a concentrated fruit flavour and health benefits (Lemuel *et al*., 2014) [14].

Well recognized tamarind varieties of tamarind *viz*., PKM 1, Urigam, Hasanur, Prathisthan, DTS 1, Yogeshwari, Goma prateek, Anantha Rudhira, Thettu Amalika. The scientists of AICRP on Arid Zone Fruits, HRS, Ananthapuram released Anantha Rudhira cultivar in February 2018, with the pulp vacuoles containing a red non-toxic pigment anthocyanin that is water soluble. The Anantha Rudhira variety of tamarind is used for the present study. The Anantha Rudhira, the red tamarind was rich in protein (3.8 %), fat (0.30 %), reducing sugars (6.85 %), ascorbic acid (0.54 %) and tartaric acid (3.87 %) (Bhavani *et al*., 2021) [7].

Food fortification has come into picture since several decades back and refers to the addition of essential nutrients which are originally deficient or lost during processing. Usually, fruits which normally lack protein and fibre, they can be fortified with protein enriched products *viz*., soya bean, oat flour and peanut flour. Flour can be prepared from soyabeans, oats, peanuts which is used as fortificant in preparation of tamarind leather.

Soybeans (*Glycine max* L.) are a cheap and plentiful source of protein (Anderson *et al*., 1995) [3]. Legumes are low-cost, nutrient-dense protein sources that can be used in place of animal protein in the diet (Anderson *et al*., 1999) [2]. Oats (*Avena sativa* L.) have received a lot of attention due to their high content of dietary fibres, phytochemicals, and nutritional value (Prasad *et al*., 2013) [18]. Peanuts are a legume that contains more protein than any other nut, with levels comparable to or higher than a serving of beans. After extracting the peanut oil, the protein content of the cake can reach 50% (Zhao *et al*., 2011) [27]. Hence, in present investigation, the effort has been made to prepare of tamarind leather from red pulp variety Anantha Rudhira fortified with three different types of flours with different proportions and good storability along with retention of nutritive value.

Material and methods

An experiment entitled "Standardization of process development for fortified tamarind fruit leather with pulp of red tamarind variety Anantha Rudhira" was carried out in the Department of Post Harvest Technology, Dr. Y.S.R.H.U, College of Horticulture, Anantharajupeta, Andhra Pradesh during the year 2021-2022.

Ingredients

Ingredients used in preparation of leather *viz*., soya, oats, peanuts, sugar, ginger, cardamom and ghee were procured from local sources.

Selection of tamarind pulp

Full ripe and deseeded tamarind pulp was obtained from AICRP on arid zone fruits, HRS, Rekulagunta, Anantapur district of Andhra Pradesh.

Cleaning of pulp

The tamarind pulp was cleaned thoroughly to remove the adhered soil, dirt and other impurities.

Pretreatment

Pre-treatment of tamarind pulp was done with ascorbic acid (3000 mg/litre) in order to prevent browning.

Preparation of fruit leather

The puree was made by soaking the fruit pulp in distilled water through continues stirring in a beaker. Then fruit pulp was subjected to preliminary treatment (washing and pre-treatment) in order to avoid excessive browning. It was pureed in a beaker that operates manually by a method called cold extraction. The optimum conditions for the water extraction of tamarind fruit pulp were 1:5 ratio of pulp to water (w/v), for two hours. The tamarind pulp extract was subsequently filtered through a 1mm filter sieve. The puree mix was prepared by mixing 250 grams of tamarind puree with 130 grams of sugar and 3 grams of ground ginger and stirred continuously till all ingredients distributed uniformly. The proportion of the ingredients were estimated from literature and decided after the observation of the result from preliminary tests. Its flavour was improved by adding ground ginger (0.3% the weight of the pulp i.e., 3gm/kg). The pulp was passed through sieve and 0.2 % of sodium benzoate was added to this.

Preparation of flour

Roasting of oats, soya seeds and groundnuts was done on gas stove. After cooling for some time, the roasted oats, soya seeds and groundnuts were grinded into flour by using table top grinder.

Treatment combinations

T_1: 75% tamarind pulp + 25% Oat flour
T_2: 50% tamarind pulp + 50% Oat flour
T_3: 75% tamarind pulp + 25% Soya flour
T_4: 50% tamarind pulp + 50% Soya flour
T_5: 75% tamarind pulp + 25% Peanut flour
T_6: 50% tamarind pulp + 50% Peanut flour
T_7: 100% tamarind pulp (Control)

Stewing the puree mix

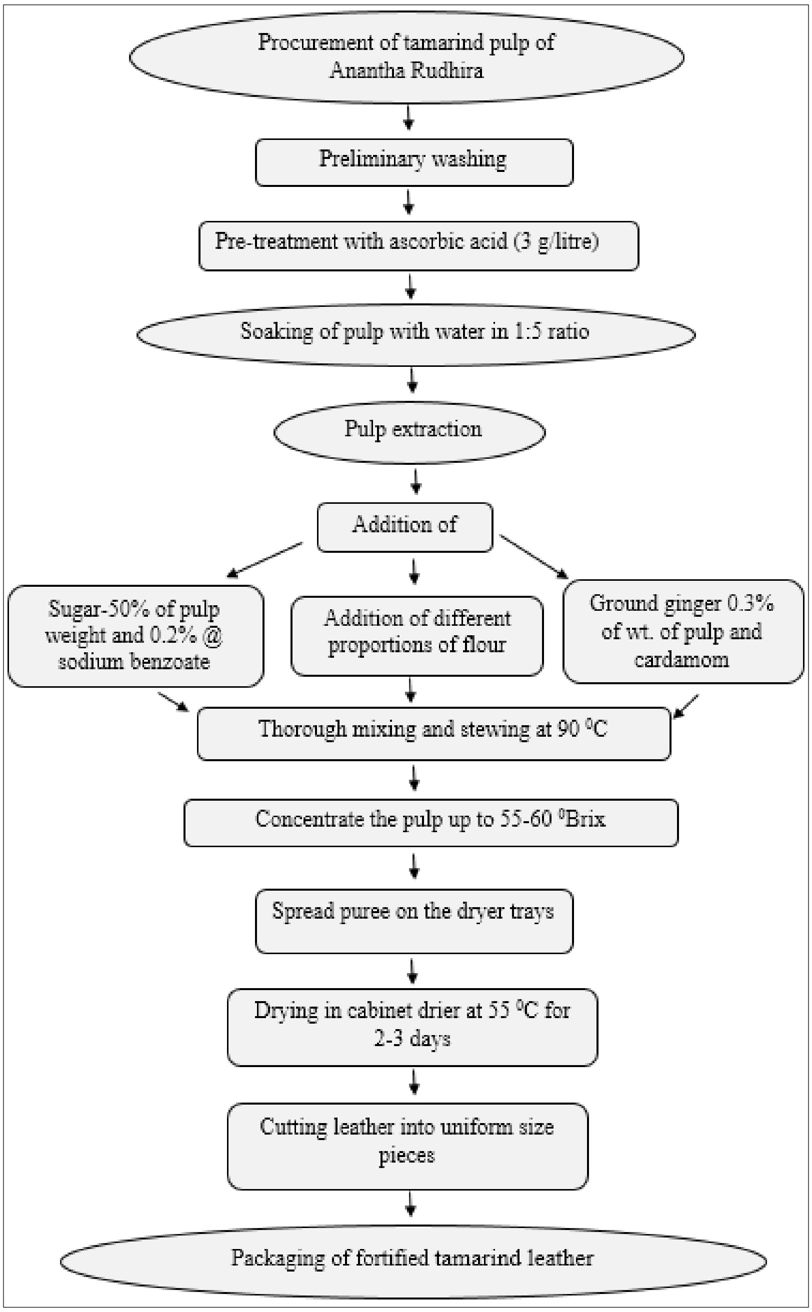
The tamarind puree was mixed with 50% and 75% each of soya flour, oat flour, peanut flour, respectively and cooked to get concentrate puree mix so as to shorten the drying time and to save energy during the process of drying. This was done by heating the puree at 90 ºC and it stirred it continuously until the mixture become thick. The concentrate was allowed to cool to room temperature by natural convection prior to processing.

Drying

Aluminum trays were smeared with ghee and concentrated puree mix was poured on the trays in 0.5-1mm thickness for uniform drying and the trays were kept in tray drier at 50 °C for 6-8 hours.

Cutting, filling and packing

Dried sheets of each blend were cooled and cut into rectangular pieces of 5cm x 2cm size. The cut pieces were packed individually with butter paper and labelled with details of treatments and replications.



Flowchart for preparation of fortified tamarind fruit leather

Result and discussion

The fortified tamarind leather prepared by standard method was chemically analyzed for total soluble solids (TSS), titratable acidity, ascorbic acid, yield, crude fibre, anthocyanins, total sugars, total protein, total phenols, microbial count and sensory evaluation.

The parameters such as TSS were analysed by Atago make RX 1000 digital refractometer, titratable acidity, ascorbic acid and total sugars was analyzed by the methods suggested by Ranganna (2007) [19]. Yield was estimated by Byarugaba, (2008) and crude fibre was estimated by (AOAC, 2000). Protein content in fortified tamarind sample was estimated by using Lowry (1951) [15] method and phenols are estimated by Singleton *et al.* (1965) [25]. Microbial count in the fortified tamarind leather was measured based on the procedure described by Agarwal and Hasija (1986) [1] and sensory characteristics evaluated based on the procedure described by Ihekoronye and Ngoddy (1985) [12].

Physico-chemical parameters of tamarind fruit leather influenced by fortification

TSS (^{o} Brix)

The highest TSS content of 59.29°B was recorded in 100 % tamarind pulp (T_7) which was at par with 75% tamarind pulp + 25% peanut flour (T_5) (58.93°B), 50% tamarind pulp + 50% oat flour (T_2) (58.23°B) and 75% tamarind pulp + 25% oat flour (T_1) (57.57°B) and the lowest of 56.90°B in 50% tamarind pulp + 50% soya flour (T_4). The significant decreasing trend in TSS content might be due to the fortification of different proportions of flour with tamarind puree. Anju *et al*. (2014) [4] also reported decreasing trend in TSS content might be due to soy-slurry blended with peach fruit leather. Kaushal and Bhat (1999) [13] also reported similar results in fruit leather blended with sprouted soy-slurry. The data represented in table 1.

Titratable acidity (%)
The percent of acidity was found highest (2.47) in 100% tamarind pulp (T_7) and the lowest (1.25) in 50% tamarind pulp + 50% peanut flour (T_6). The study shows that as the content of flour in tamarind puree increased, the titratable acidity decreased significantly. This is due to dilution of acidic factor of the fruit with the addition of the flour. Anju *et al*. (2014) [4] also reported that with increase in content of soy-slurry in peach pulp, there was decrease in titratable acidity. The similar observation has been reported by Chauhan *et al*. (1993) [8] in apricot soy fruit bar and Kaushal and Bhat (1999) [13] in fruit leather blended with sprouted soy-slurry. The data represented in table 1.

Ascorbic acid (mg/100g)
All the fortified leathers recorded significantly lesser ascorbic acid content compared with 100% tamarind pulp (T_7). The highest ascorbic acid was recorded in 100% tamarind pulp (T_7) with 38.10 mg/100g and the lowest ascorbic acid was recorded in 50% tamarind pulp + 50% oat flour (T_2) with 22.50 mg/100g. Similar findings were reported by Shanthi (2000) in mango bar enriched with soy flour.

Yield (%)
The percent of leather yield significantly increased with different flours blended for preparation of fortified tamarind leather. The highest yield was recorded in 50% tamarind pulp + 50% peanut flour (T_6) (69.67%) which was at par with 50% tamarind pulp + 50% oat flour (T_2) (66.33%) and lowest yield was recorded in 100% tamarind pulp (T_7) (46.93%). The yield (%) of fortified tamarind leather increased by increasing the amount of flour in tamarind pulp. Increasing the amount of soy slurry in papaya pulp, the moisture content decreased due to the coarser texture of the soy slurry (Endres, 2001) [10]. The data represented in table 2.

Crude fibre (%)
The crude fibre content of the fortified fruit leather varied significantly from each other. The data presented in table 1. The 50% tamarind pulp + 50% oat flour (T_2) recorded highest with 0.42 per cent of crude fibre and the lowest crude fibre content was recorded in 100% tamarind pulp (T_7) with 0.11 per cent. The crude fibre content increased by increasing formulation of oat flour reported by (Ayalew and Emire, 2019). The crude fibre content of tamarind leather increased with addition of flour. The loss of fibre was likely due to thermal degradation resulting in disruption of the polysaccharide network of the cell wall (Miranda *et al*., 2010 and Scala *et al*., 2011) [17, 20]. The data represented in table 2.

Anthocyanins (mg/100ml)
The anthocyanin content was found highest in 100% tamarind pulp (T_7) with 0.73 mg/100ml whereas, it was lowest in 50% tamarind pulp + 50% soya flour (T_4) with 0.31 mg/100ml. The anthocyanin content also decreased significantly with increasing the proportion of flour to the tamarind puree. The anthocyanins are water soluble and also thermal degradation of anthocyanins occur during processing. The data represented in table 2.

Total sugars (%)
The highest percent of total sugar (16.23) was recorded in 100% tamarind pulp (T_7) which was at par with 75% tamarind pulp + 25% peanut flour (T_5) (15.87 %), 50% tamarind pulp + 50% peanut flour T_6 (15.86 %) and the lowest total sugar was recorded as 15.27 percent in 50% tamarind pulp+ 50% soya flour (T_4). The data revealed that there is a decrease in sugar percentage with increase in concentration of flour in the fruit leather. Anju *et al*. (2014) [4] also reported that there is decrease in sugar percentage with increase in soy-slurry in blends. Kaushal and Bhat (1999) [13] also reported decrease in sugars in fruit leathers blended with sprouted soy slurry. The decrease in total sugars probably due to inversion of sugars to monosaccharides by acid hydrolysis (Aruna Muralkrishhna *et al*., 1969). The data presented in table 3.

Total proteins (%)
With regard to percent of proteins, the highest protein content of 3.19 was obtained in 50% tamarind pulp + 50% peanut flour (T_6) which was at par with 75% tamarind pulp + 25% peanut flour ($T_{5)}$ (3.09%) and the lowest (2.36%) in 100% tamarind pulp (T_7). All blended fortified leathers showed high in protein content compared to control. The fortified leathers obtained from tamarind puree and different proportions of flours showed an increase in protein content. It is due to highest protein content in legumes. Increase in protein content of mango bars fortified with soy protein concentrate were also reported by Mir (1990) [16]. Increase in protein content of peach soy leather was also reported by Anju *et al*. (2014) [4]. similar findings also reported by Sharma (1997) [23] in plum-soy leather. The data represented in table 3.

Total phenols (%)
The total phenols were observed highest (0.61%) in 100% tamarind pulp (T_7) and lowest phenols (0.18%) was observed in 50% tamarind pulp + 50% peanut flour (T_6). Phenols in fruit leather decreased by addition of flour. It has been observed that the values of phytochemicals in fruit leathers samples were also affected by the formulation of oats (Ayalew and Emire, 2019). Moreover, cell structure disrupted during processing and the materials became prone to non-enzymatic oxidation, which could also be one of the major causes for loss in total phenols of the products. Similar findings were also observed by Deepika *et al*. (2016) [6] in aonla based fruit bars. The data represented in table 3.

Sensory evaluation of fortified tamarind fruit leather influenced by fortification
In the sensory evaluation, the highest score of 8.30 for colour and appearance was recorded in 75% tamarind pulp + 25% oat flour (T_1) which was at par with 75% tamarind pulp + 25% peanut flour (T_5) (8.28), 75% tamarind pulp + 25% soya flour (T_3) (8.25) and 50% tamarind pulp + 50% peanut flour (T_6) (8.10) and lowest score of 7.03 was recorded in 100% tamarind pulp (T_7). The data related to sensory attributes are presented in table 4.
The highest score of texture (8.45) was recorded in 50% tamarind pulp + 50% peanut flour (T_6) and the lowest scores of 7.76 was recorded in 100% tamarind pulp (T_7). The highest score in 50% tamarind pulp + 50% oat flour (T_2) might be attributed to a better consistency of the blend.
For taste, the highest score of 8.66 was recorded in 50% tamarind pulp + 50% peanut flour (T_6) which was at par with 100% tamarind pulp (T_7) (8.55) and 75% tamarind pulp + 25% peanut flour (T_5) (8.24) and the lowest score of 7.30 was recorded in 75% tamarind pulp + 25% oat flour (T_1).

Maximum score of flavour (8.71) was recorded in 50% tamarind pulp + 50% peanut flour (T_6) and the lowest of 8.17 was recorded in 100% tamarind pulp. The highest score for 50% tamarind pulp + 50% peanut flour (T_6) might be assigned to a balanced proportion of tamarind puree and peanut flour in the blend, thereby enhancing the flavour and also roasted peanut having flavour character such as methyl pyrazine.

The highest score (8.59) for overall acceptability was recorded in 50% tamarind pulp + 50% peanut flour (T_6) and the lowest score of 7.70 was recorded in 100% tamarind pulp (T_7) which was statistically at par with 50% tamarind pulp + 50% oat flour (T_2) (7.78). The reason could be assigned to the fact that leather prepared from 50% tamarind puree and 50 % peanut flour had a better taste and flavour due to best blending ratio. The mean values represented in table 4. The leather prepared from (90:10) of papaya pulp and soy-slurry had a better consistency and flavour due to an ideal ratio of the blend reported by Ghimire and Pravin (2016) [11]. Kaushal and Bhat (1999) [13] reported similar results in fruit leather blended with sprouted soy-slurry. Anju *et al*. (2014) [4] also reported similar results in peach soy leather.

Table 1: Physico-chemical parameters of tamarind fruit leather influenced by fortification

Treatments		TSS (ºBrix)	Titratable acidity (%)	Ascorbic acid (mg/100g)
T_1	75% Tamarind pulp + 25% Oat flour	57.57	1.92	22.80
T_2	50% Tamarind pulp + 50% Oat flour	58.23	1.90	22.50
T_3	75% Tamarind pulp + 25% Soya flour	57.03	2.12	31.20
T_4	50% Tamarind pulp + 50% Soya flour	56.90	1.98	29.70
T_5	75% Tamarind pulp + 25% Peanut flour	58.93	1.51	28.80
T_6	50% Tamarind pulp + 50% Peanut flour	56.93	1.25	28.50
T_7	100% Tamarind pulp (Control)	59.29	2.47	38.10
S.Em ±		0.63	0.09	0.80
C.D at 5%		1.92	0.26	2.43

Table 2: Physico-chemical parameters of tamarind fruit leather influenced by fortification

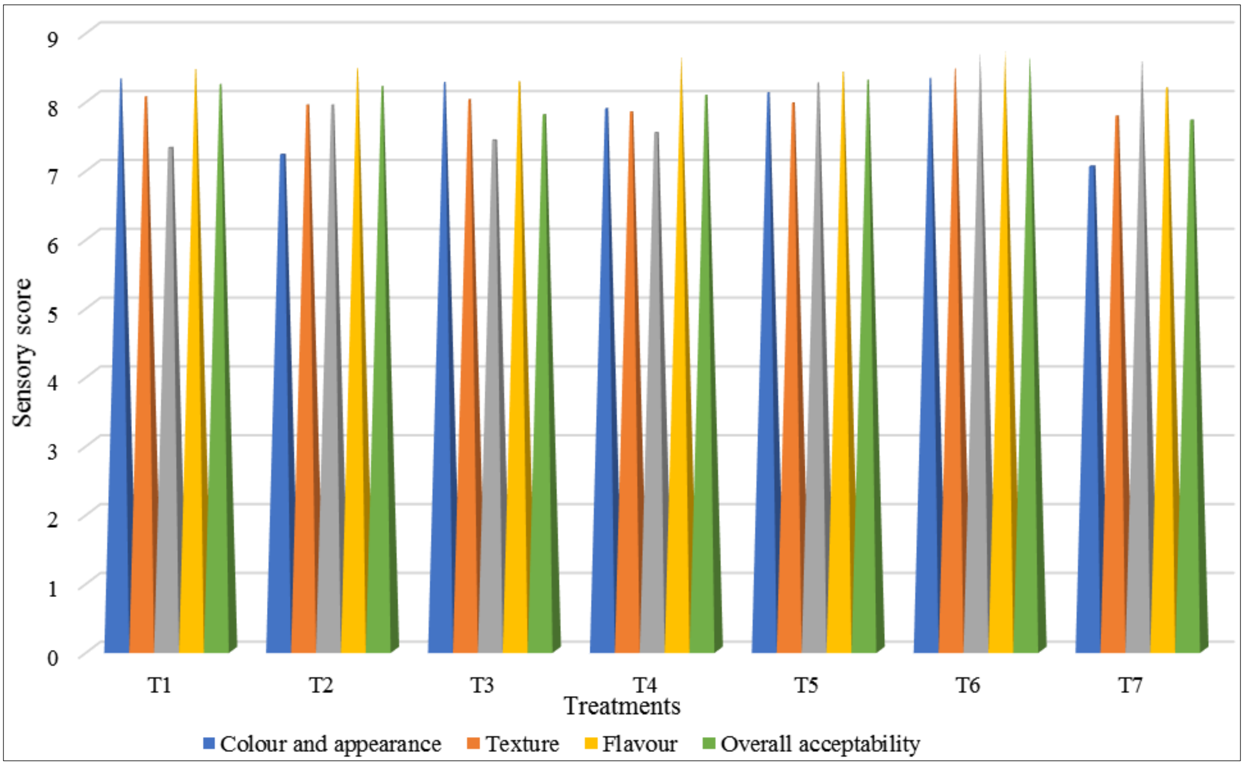
Treatments		Yield (%)	Crude fibre (%)	Anthocyanins (mg/100ml)
T_1	75% Tamarind pulp + 25% Oat flour	57.83	0.29	0.58
T_2	50% Tamarind pulp + 50% Oat flour	66.33	0.42	0.37
T_3	75% Tamarind pulp + 25% Soya flour	56.92	0.13	0.52
T_4	50% Tamarind pulp + 50% Soya flour	60.83	0.27	0.31
T_5	75% Tamarind pulp + 25% Peanut flour	59.67	0.12	0.51
T_6	50% Tamarind pulp + 50% Peanut flour	69.67	0.15	0.39
T_7	100% Tamarind pulp (Control)	46.93	0.11	0.73
S.Em ±		1.23	0.01	0.01
C.D at 5%		3.74	0.03	0.02

Table 3: Physico-chemical parameters of tamarind fruit leather influenced by fortification

Treatments		Total Sugars (%)	Total Proteins (%)	Total Phenols (%)
T_1	75% Tamarind pulp + 25% Oat flour	15.52	2.37	0.38
T_2	50% Tamarind pulp + 50% Oat flour	15.47	2.38	0.31
T_3	75% Tamarind pulp + 25% Soya flour	15.49	2.60	0.25
T_4	50% Tamarind pulp + 50% Soya flour	15.27	2.62	0.22
T_5	75% Tamarind pulp + 25% Peanut flour	15.87	3.09	0.25
T_6	50% Tamarind pulp + 50% Peanut flour	15.86	3.19	0.18
T_7	100% Tamarind pulp (Control)	16.23	2.36	0.61
S.Em ±		0.16	0.04	0.02
C.D at 5%		0.50	0.11	0.05

Table 4: Sensory evaluation of fortified tamarind fruit leather influenced by fortification

Treatments		Colour and appearance	Texture	Taste	Flavour	Overall acceptability
T_1	75% Tamarind pulp + 25% Oat flour	8.30	8.04	7.30	8.44	8.22
T_2	50% Tamarind pulp + 50% Oat flour	7.20	7.92	7.92	8.45	8.19
T_3	75% Tamarind pulp + 25% Soya flour	8.25	8.00	7.41	8.26	7.78
T_4	50% Tamarind pulp + 50% Soya flour	7.87	7.82	7.52	8.61	8.06
T_5	75% Tamarind pulp + 25% Peanut flour	8.28	7.95	8.24	8.40	8.28
T_6	50% Tamarind pulp + 50% Peanut flour	8.10	8.45	8.66	8.71	8.59
T_7	100% Tamarind pulp (Control)	7.03	7.76	8.55	8.17	7.70
S.Em ±		0.10	0.11	0.15	0.05	0.09
CD at 5%		0.32	0.33	0.45	0.16	0.28



T_1-75% T+ 25% O, T_2-50% T+ 50% O, T_3-75% T+ 25% S, T_4-50% T+ 50% S, T_5-75% T+ 25% P, T_6-50% T+ 50% P, T_7-100% T

Fig 1: Sensory evaluation of fortified tamarind fruit leather influenced by fortification

Conclusion

The fortified tamarind leather with 50% tamarind pulp and 50% peanut flour (T_6) was found to be the best on the basis of sensory attributes with maximum score for texture (8.45), flavour (8.71), taste (8.66) and overall acceptability (8.59) whereas it is highest in protein content (3.19 %) and yield (69.67%) and lowest in titratable acidity (1.25%) and total phenols (0.18%). It also recorded 56.93ºBrix of TSS, 28.50 mg/100g of ascorbic acid, 0.15 % of crude fibre, 0.39 mg/100ml of anthocyanins and 15.86 % of total sugars and retained sufficient amount of nutrients.

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