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Quality Attributes of Carrot-Tamarind Leathers

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ABSTRACT

The objective of this study was investigated to study the quality attributes of carrot-tamarind leather samples which containing carrot and tamarind puree at ratios 75-25, 50-50, 25-75, and 0-100. These puree blends with 15 g sugar, 0.3 ginger, and 3ml lemon juice. The leather samples were analyzed for chemical composition, physical, organoleptic properties, and microbiological contamination. The findings revealed that as the increasing of levels of tamarind puree the moisture, ash, fiber, and total sugar contents were increased but protein, fat, and carbohydrate were decreased. Furthermore, β–carotene was decreased but vit c and titratable acidity were increased so, the PH value was decreased. Moreover, minerals content such as Ca, K, P, Mn, Mg, and Na were increased. Besides, the total phenolic content and DPPH radical scavenging activity were increased. TSS was decreased by increasing the level of tamarind puree. The leather sample containing 25% tamarind had the highest value of L* (lightness), *a** (redness), and b* (yellowness) color compared to other samples. Texture profile such as hardness was decreased but the cohesiveness, springiness, gumminess, and chewiness were increased. Similarly, sensory properties such as color, odor, flavor, taste, and overall acceptability were increased, so the leather sample containing 100% tamarind had the highest overall acceptability compared to other leather samples. By microbiological evaluation all leather samples can be storage more than 4 months at room temperature. Finally, the incorporation of carrot puree with tamarind puree can be improved the nutritional value and physical, microbiological, and sensory properties of carrot-tamarind leathers

Keywords: carrot, tamarind, leathers,puree

INTRODUCTION

Fresh fruits and vegetables are an essential part of our diet. They are high resources of fibers, carbohydrates, minerals vitamins, and other bioactive compounds. (Mounika and Mashewari *et al.*, 2019 and El-Said, 2020). Fruit leather is called a fruit bar or a fruit slab (Diamante et al., 2014). The leather is prepared by only fruit or by blending of several kinds of fruit (Bandaru and Bakshi, 2020). It is produced by using fruit puree and additional components such as sugar, honey for sweetness, citric acid to extend the period of storage, maltodextrin, wheat flour, pectin, and gums to prevent the leather from getting sticky, to enhance the calories, acceptability, and storage stability. Its product is one method to preserve fresh fruit for long-term consumption (Ho *et al*., 2018 and Bandaru and Bakshi, 2020). Fruit leathers are produced by spreading pureed fruit into a flat surface for drying. The dried fruit taking out from the surface and rolled up (El-Said, 2020). Most of fruit leathers are dried at 30 to 80 °C for up to 24 hours to reach the optimum final moisture content (12-20 %) (Diamante et al., 2014). The leather has intrinsic properties of flexibility, texture, color, viscosity, and taste (Sȧnchez Riaṅo *et al.* 2018 and Mounika and Mashewari *et al.*, 2019). Fruit leathers are an inexpensive and practical alternative to fresh fruits with significant nutritional value (Kurniadi *et al.* 2022). Leather was eaten as desserts or snacks and contains rich fruit flavor and nutritional benefits. Fruit leather frequently keeps well in this state and doesn't need to be refrigerated. (El-Said, 2020).

Tamarind (*Tamarindus indica, L.*) is a tropical fruit that is cultivated in Asia and Africa that has respected for its pulp. It has a sweet-sour taste resulting to it has high contents of reducing sugars and tartaric acid (Bhadoriya *et al.*, 2011). Tamarind fruit pulp contains about seed (34.0%), pulp (55.0%) and shell (11.0%), and the fiber in a pod. The pulp is brown or reddish brown color, thick and soft (Yahia & Salih, 2011)) .The pulp is used in formulated foods, to flavor sweetmeats, sauces, and curries, and as the main ingredient in juices and other beverages (Morsy *et al.*, 2011 and Minh *et al.*, 2019) concentrates, pickles, confections, fruit leather and powdered….etc (Ahmed *et al.*, 2013 and Alawad *et al.*, 2015). And it is used as chutney (Deokar *et al.*, 2019). In addition, tamarind contains high contents of vitamins (B1, B3, B5- B6, and B9), and E, but contains a small amount of vitamin A and C. It is agood source of minerals such as iron, calcium, phosphorous, potassium, manganese, and dietary fiber. (Manjula, *et al.*, 2017 and Deokar *et al*., 2019). Besides, it contains phytosterols, and other phytochemicals (Minh *et al*., 2019). These compounds make tamarind can be used as a functional food, and as powerful antioxidant and anti-inflammatory agents (Patel *et al.*, 2020). Moreover, tamarind enhances the gastrointestinal system and immune system. It Improves nervous function and weight loss when used as manages diabetes and it is also suitable for pregnant. It improves cardiovascular health by reducing cholesterol (Toungos, 2019 and Ebifa-Othieno *et al*., 2020).

Carrot *(Daucus carota L.)* root is one of the greatest important vegetables in the world. It can be consumed raw, cooked, or processed (Krivokapić *et al.*, 2020) like juice,

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preserve, candy, canned, pickle, concentrate, and gazrailla and dried powder. (Singh *et al.* 2021). The importance of raw carrots has to be increased through the addition of components or processes that make them more granular to the consumer. (Ekawati and Bazarado, 2016). Carrot has a high content of βcarotene and also contains carotenoids, vitamin C, phenolic compounds, and polyacetylenes (Krivokapić *et al.,* 2020). It also contained minerals such as calcium, phosphorus, magnesium, potassium, and selenium, and vitamins such as vitamins B1, B2, B3, B6, B9, E, and K, and dietary fibers (Mounika and Mashewari *et al.*, 2019).

Ginger (*Zingiber officinale Roscoe*) is a widespread cooking herb and it is widely used as a condiment and food seasoning due to its spicy style and sweetened aroma (Rehman *et al.*, 2003) it has numerous biological activities, like antioxidant, antifungal, antimicrobial, anticancer, respiratory protective, chronic heart disease protective, and lowering blood sugar (Mao *et al*., 2019) Besides, lemon (*Citrus aurantifolia*) is a citrus fruit that is high in nutrients and bioactive substances and used to increase total antioxidants (Vichaibun and Kanchanaphu 2019). Lemon juice can be used to increase the acidy, antioxidant, and flavor of fruit, vegetables, and their leather samples (El-Said, 2020). These compounds could be used as alternative agents for curing chronic liver diseases (Bekkouch *et al*., 2022)

For these reasons, this study was done to produce carrot-tamarind leather samples by incorporating tamarind puree with carrot puree. Then studying the quality attributes such as chemical composition, nutritional value, physical, and organoleptic properties at zero time and studying the effect of storage for 4 months at room temperature (26.6-30ºC) on moisture, water activity, and microbial evaluation.

MATERIALS AND METHODS

Materials

Tamarind fruit (*Tamarindus indica*, *L.*), carrots *(Daucus carota)* roots, lemon (*Citrus limon***),** and ginger (*Zingiber officinale*), sugar were bought from local markets of Aswan government, Egypt.

Nutrient agar, MacConkey broth, molds, and yeasts agar were bought from Elgomhuria, Mansoura, Egypt.

Methods

Preparation of tamarind and carrot puree:

Preparation of tamarind puree:

Tamarind fruit (*Tamarindus indica*, *L.*) was cleaned from a peculiar substance and was washed with tap water; it was soaked in boiled water of 1 kilogram to 2 liters for 2 hours at room temperature and kept in a refrigerator for 24 hours. Seeds were removed manually from the soaked by clearance and filtration

Preparation of carrot puree

Carrots *(Daucus carota)* roots were cleaned and washed with tap water after removing the top, bottom, and surface layers with a sharp knife and cut into sticks (1×4×1 cm) and steamed for 15 minutes, and were mashed with a hand blender as methods of Blassy *et al.*(2019).

Preparation of carrot-tamarind leather samples:

Carrot-tamarind leather samples were prepared by mixing puree of tamarind and carrot as found in Table (1) the puree blend was prepared by blending 1 liter of tamarind puree sugar, lemon juice, ginger powder and stirred constantly till all ingredients distributed uniformly. All mixed purees were made of 1000 g each and then spread on tray size trays 50 X 40 cm which was covered with an aluminum sheet about 8mm thick. Drying was done by using an electric oven with an air fan (Indeset 6-EM-IN-02, Italy) for two hours at 70 ˚C and continued at 55˚C for 10 hours. The leather samples wrapped by polyethylene bags keep for storage for 4 months at room temperature (26.6- 30oC).

Table 1. Formula of carrot-tamarind leather samples

Products Ingredients	**CT1 (25% Tamarind puree)**	**CT2 (50% Tamarind puree)**	**CT3 (75% Tamarind puree)**	**CT4 (100% Tamarind puree)**
Tamarind puree gm	25	50	75	100
Carrot puree gm	75	50	25	--
Sugar gm	15	15	15	15
Ground ginger gm	0.3	0.3	0.3	0.3
Lemon juice ml	3	3	3	3

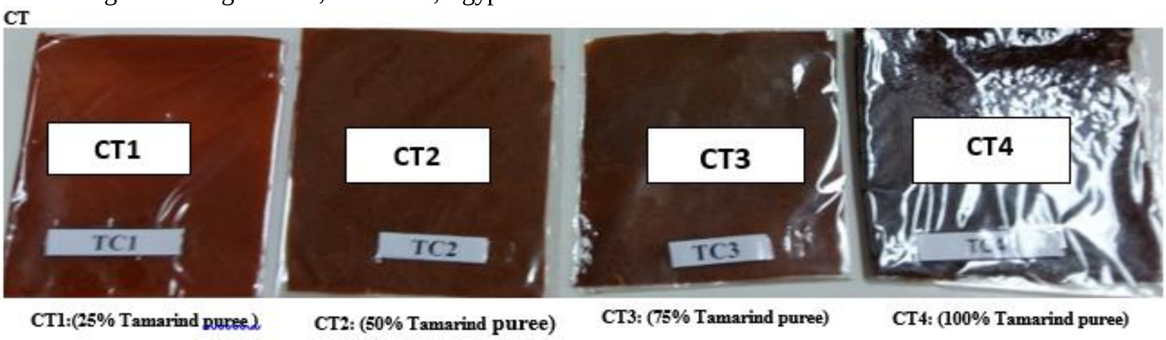

Fig. 1. formula of carrot-tamarind leather samples

All the processes used in this study were approved by the Research Ethics committee, at Aswan University, Egypt

Chemical analysis

Moisture, protein, fat, ash, fiber and total sugar of tamarind fruit, carrot and its puree and leather samples were determined according to methods described by AOAC (2005). Total carbohydrates were calculated by difference as following: Carbohydrates% = 100 - (moisture % + protein % + ash %+ fat %). Energy values were determined using the following formula: (4x 1g protein 4x 1g carbohydrate + 9x 1g fat) according to Paul and Southgate (1979). The pH was determined using the method described by Mamade *et al.* (2013). Tartaric acid content was estimated by using AOAC (1975). Mineral contents such as (phosphor, magnesium, potassium, iron, and calcium) and vitamins as ascorbic acid and β-carotene were determined according to AACC (1983).

Physical properties of carrot-tamarind leather samples

The total soluble solid (TSS) of the tamarind, carrot puree and its leather samples were determined using the method described by Shakoor *et al. (*2015).

Measurement of water activity (^aW):

The water activity of the carrot-tamarind leather samples was assessed by using a water activity meter (AquaLab Dew Point Water Activity Meter 4TE, USA) according to Schmidt (2004)

Texture profile analysis (TPA):

The texture profile of the fruit leather samples items as hardness (kg), springiness (mm), cohesiveness, gumminess, and chewiness was determined by using a Texture Analyzer (single arm texture analyzer TA-XT Plus, Stable Micro Systems, Surrey, UK) with a capacity cell of 2 kg weight. A force versus time curve for a two-cycle compression was measured, with a disk probe (of 35mm diameter) and at a displacement speed of 10 mm/min. In-built software of the texture analyzer was used for analyzing the data collected using the method given by Patil *et al.* (2017)

Determination of color:

The color of the carrot-tamarind leather samples was determined by using Konica Minolta CR-400 Chromameter (Japan) as the method described by HO *et al*. (2018)

Organoleptic evaluation of carrot-tamarind leather samples:

Carrot-tamarind leather samples were estimated for sensory properties. 20 semi-rained panel members from the Department of Home Economics, Specific Education, Aswan University, Judgment was made through the rating of were asked to evaluate color, taste, flavor, odor, and overall acceptability according to the method of Pushpa *et al. (*2006).

Microbiological examination:

Microbiological examination of carrot-tamarind leather samples as total viable counts were counted as the method described by Anon (1984). And Spore-forming bacteria were counted as a method described by Gould and Hurst (1983). The *coliform group* was detected on MacConkey agar (Oxoid) at 35-37 °C for 48 hours, as the method described by Anon (1988). Mold and yeast counts were counted as the method described by Oxoid Manual (1982).

Statistical analysis

Data were subjected to statistical analysis by the SAS (2004) computer program. Groups will be compared by one way analysis of variance (ANOVA) and the significance of the mean difference between the groups will be done by Tukey's multiple comparison tests

RESULTS AND DECISION

The chemical composition of carrot, tamarind puree, and its leather

As given in Table (2) the tamarind puree had low contents of protein, fat, ash, fiber, and total sugar, but had the high content of carbohydrates as compared to tamarind. So, the energy value (kcal/100g) of tamarind pulp was more than those of tamarind puree, raw carrot, and carrot puree. The result of tamarind puree was might be due to the method of preparation by soaking in water and filtration. The chemical composition of raw carrots is in contract with this Hussein (2022). Moreover, steaming carrot puree had a negligible effect on the moisture content compared to fresh carrot this result is consistent with those of Buratti *et al.* (2020). Also, the chemical composition of tamarind pulp was in acceptable to those of El-Gindy and Youssif (2015) and Mani *et al.* (2020). The result of the total sugar content of tamarind pulp is in agreement with that of Girma (2014) who reported that tamarind pulp is rich in total sugars (41.20-58.7%). As well, the result of the total sugar of orange carrot is lined up with those of Marta *et al. (*2013)

From the same table the moisture, ash, fiber, and total sugar contents of carrot-tamarind leathers were increased but protein, fat and carbohydrates, and total sugar contents were decreased by increasing the level of tamarind puree. So, the energy value of the carrot-tamarind leather sample was reduced by increasing the level of tamarind puree. These results might be due to that tamarind puree had high contents of moisture, fiber, and ash, but it had low contents of fat, protein, and carbohydrates compared to carrot puree. Also, these results were in agreement with those of Sukasih and Widayanti (2022) they found that the final product moisture can be affected by the moisture content of the raw fruit or mash that used. Also, the result showed that all carrot-tamarind leathers had high contents of carbohydrates and total sugar and low contents of protein, ash, and fat as compared to tamarind or carrot puree this result was due to adding table sugar to carrot-tamarind leathers.

Table 2. The chemical composition of carrot, tamarind puree and its leather samples in dry weight basis

Constituents	Moisture %	Dry matter %	Protein %	Fat %	Ash %	Fiber %	Carbohydrate %	Total sugar %	Energy value (kcal/100g)
Tamarind plup	30.00 C	70.00D	5.14B	1.00B	7.29B	12.71B	86.57E	42.43G	462.58C
Tamarind puree	75.00B	25.00E	4.80C	0.93 CB	6.80C	11.86C	80.80G	39.60H	431.74D
Fresh carrot	88.20A	11.8F	12.71A	2.46A	9.65A	23.05A	75.18F	45.08F	435.53D
Carrot puree	88.08A	11.92F	12.76A	2.49A	9.71A	23.04A	75.04F	45.94E	435.02D
CT1 (25% Tamarind puree)	13.40E	86.60 A	5.00C	0.90CD	2.76F	9.26E	91.34A	52.23A	486.33 A
CT2 (50% Tamarind puree)	13.85D	86.15B	4.91C	0.93CB	3.87E	9.82D	90.29B	51.47B	480.61A
CT3 (75% Tamarind puree)	14.10D	85.90B	4.49D	0.85D	4.79D	9.94D	89.87C	50.70C	476.75B
CT4 (100% Tamarind puree)	14.60C	85.40C	4.59D	0.88CD	6.47C	11.27C	88.06D	49.94D	467.93B
SEM	0.078	0.078	0.024	0.037	0.026	0.037	0.030	0.092	0.099
p<.	****	****	****	****	****	****	****	****	****

Each record is a mean value of three replicates. SEM: Standard Error of means. (a, b, c, d, e, f, g and h): means in the same column with different superscript differ significantly at $p< 0.05$. *$P< 0.05$. **$P< 0.01$. *** $P< 0.001$. $P< 0.0001$

Furthermore, all leather samples will have good quality because the leather had low moisture content so, these products will had good quality. These results are in agreement with those of Nurlaely *et al.* (2002) cited in

Safaei *et al.*(2019) they reported that a good fruit leather that has low moisture contains (10% to 20%), middle water activity (less than 0.7), and chewy texture, so, it can be consumed directly. Also, Sukasih and Widayanti (2022) found that the moisture content of food marks on numerous food qualities attributes as color, texture and flavor and the shelf life of the food.

Vitamin contents of carrot, tamarind puree and its leather samples

Data from Table (3) indicated that tamarind puree had a low content of β -carotene compared to fresh or carrot puree. So, the β -carotene of carrot-tamarind leathers content was decreased by increasing levels of tamarind puree. This result is harmony with that of Arscott *et al.* (2010) they reported that orange carrots usually contain high amounts of carotenoids, especially α- and β-carotene. Also, the results are in line with that of EL-Siddig *et al.* (2006) they reported that tamarind pulp and puree contained a small amount of vitamin A and C. as well, Bembem and Sadana (2014) reported that steaming carrot contained total carotenoid was 13.50 (mg/100g). It also showed that tamarind puree had a high content of vit.c compared to carrot puree. The result of tamarind is contracted with those of Sulieman *et al.* (2015) found that the vit c of tamarind varies between 3.5 and.5.7 mg/100g. Likewise, Girma (2014) found that tamarind contained very small ascorbic acid that ranged from 2-20 mg/100g.

From Table (3) the results showed that the titratable acidity of tamarind pulp is more than that of fresh carrot and tamarind or carrot puree. This result might be due to tamarind pulp containing organic acids like citric acid, malic acid, and high content of tartaric acid 12-18% as reported by Roopa and Kasiviswanatham, (2013). Similarly, Prasanth and Mishra (2017) reported that the acidity in fruit bars was reduced by the addition of carrot puree in different proportions. Besides, the titratable acidity of carrot-tamarind leathers was more than that of carrot or tamarind puree. This result might be due to adding lemon juice and ginger powder. Moreover, the titratable acidity content of carrot-tamarind leathers was increased by increasing the level of tamarind puree. This result was due to tamarind puree having more titratable acidity compared to carrot puree. All these results caused decreasing in pH level by increasing on tamarind puree level. All these results are in agreement with those of Castelló *et al.* (2011) they reported that the incorporation of citric acid with persimmon fruit to reach a final pH of the product nearby 3.5. Moreover, Safaei *et al.* (2019) reported that the pH of leather fruit must be between 2.5 and 4.5.

From the same table, the TSS of tamarind pulp was more than that of tamarind or carrot puree, this result might be due to carrot puree having a high content of moisture compared to tamarind puree as found in Table (2). TSS of carrot-tamarind leathers was more than that of tamarind or carrot puree, this result might be due to adding sugar, ginger, and drying oven. This result is in agreement with Kang (2017) who reported that a high value of TSS indicated an incidence of high levels of sugars, with other dissolved minerals and acids. On the other hand, the TSS of carrot-tamarind leathers was reduced by increasing the level of tamarind puree. This result was due to that the TSS of tamarind puree was more than that of carrot puree. This result might be due to carrot puree having low moisture content compared to tamarind puree content as shown in Table (2). So, the TSS level of leather containing 100% tamarind puree was the highest compared to other carrot-tamarind leather samples; this result was due to the leather containing 100% tamarind having the highest water content compared to others. These results are in line with those of Rashidi and Khabbaz (2010) they reported that the water content of carrots affects their firmness and total soluble solids.

Table 3. Vitamin contents of carrot, tamarind puree and its leather samples:

Constituents	β-carotene and α-carotene mg	Vit c mg/100g	Titratable acidity% and % citric acid	pH	T.S.S birx %
Tamarind plup	0.18F	4.40E	8.90E	2.40F	50.03E
Tamarind puree	0.16F	4.10E	6.96F	3.10C	29.03F
Fresh carrot	30.00A	3.20F	2.04G	5.70A	24.80G
Carrot puree	29.60A	3.00F	2.00G	5.60A	25.00G
CT1 (25% Tamarind puree)	10.90B	5.30D	12.96D	3.20B	86.88A
CT2 (50% Tamarind puree)	8.40C	6.40C	16.54C	2.90D	86.44B
CT3 (75% Tamarind puree)	6.75D	7.50B	18.74B	2.70E	85.30C
CT4 (100% Tamarind puree)	5.90E	8.80A	20.00A	2.40F	85.01D
SEM	0.013	0.011	0.038	0.010	0.029
p<.	****	****	****	****	****

Each record is a mean value of three replicates . SEM: Standard Error of means . (a, b, c, d, e, f and g): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

Minerals content of carrot, tamarind puree and its leather samples (mg/100g dry sample)

Data found in Table (4) displayed that there were differences between the minerals content of tamarind pulp or puree. The tamarind puree had high contents of calcium, potassium, phosphorous, magnesium, and sodium compared to carrot puree. So, the minerals content of carrot-tamarind leather samples was increased by increasing tamarind puree levels. This result might be due to tamarind having high contents of minerals compared to carrot. The content of tamarind minerals is accepted with those of Muzaffar *et al.* (2018). Likewise, Almeida *et al.* (2009) they reported that tamarind is a rich source of minerals, especially copper, magnesium, and potassium, moreover, tamarind is a good source of phosphorous, calcium, and selenium. But this result was a disagreement with those of Sulieman *et al.* (2015) and Adam (2021). These findings could be explained by the possibility that the chemical content of fruits and vegetables varies depending on the cultivar, season, management of production, environmental factors, and postharvest handling and storage processes according to Yahia (2017).

Total phenolic content and DPPH radical scavenging activity of carrot, tamarind puree, and its leather samples:

Data from Table (5) indicated that the total phenolic content and DPPH radical scavenging activity of tamarind puree were more than that of carrot puree. The results are harmonious with those of Mahmood *et al.* (2012) they described that *Tamarindusindica*, L. had high polyphenolic content with potential for antioxidant activity. However, the antioxidant contents may be different with geographical location. Comparing another study of fresh carrot and steaming carrot as carrot puree, their no clear increase in total phenolic as related to the boiling or steaming. This result is in line with those of Buratti *et al.* (2020).

The result of total phenolic contents and DPPH radical scavenging activity of tamarind-carrot leather samples were increased as tamarind levels were increased. This result is due to tamarind having more total phenolic content than that of carrot puree also, the result might be due to the addition of lemon juice and ginger powder. These results are in harmony with those of Hajimahmoodi *et al.* (2012) they found that fruit daily servings must contain natural lemon juice, as it provides nutritional antioxidants with specific flavor that could act as an antioxidant protective system.

Table 4. Minerals content of carrot, tamarind puree and its leather samples(mg/100g dry sample)

Constituents	Potassium (mg/100g)	Calcium (mg/100g)	Phosphorous (mg/100g)	Magnesium (mg/100g)	Sodium (mg/100g)
Tamarind plup	725.20B	429.36A	150.40D	87.16B	62.00 E
Tamarind puree	720.20B	424.36A	150.00 D	84.16B	61.25E
Fresh carrot	89.80F	100.83F	37.967F	22.02F	19.815F
Carrot puree	80.00F	101.03F	38.07F	22.05F	20.15F
CT1 (25% Tamarind puree)	355.69E	321.60E	131.84E	28.12E	65.00D
CT2 (50% Tamarind puree)	487.60D	353.50D	152.64C	53.05D	69.96C
CT3 (75% Tamarind puree)	634.28C	390.10C	175.4733B	81.00C	75.59B
CT4 (100% Tamarind puree)	805.18A	402.00 B	202.45A	113.29A	82.46A
SEM	0.369	0.279	0.197	0.051	0.045
p<.	****	****	****	****	****

Each record is a mean value of three replicates . SEM: Standard Error of means . (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

Table 5. Total phenolic content and DPPH radical scavenging activity of carrot, tamarind puree and its leather samples:

Constituents	Tamarind puree	Carrot puree	CT1 (25% Tamarind puree)	CT2 (50% Tamarind puree)	CT3 (75% Tamarind puree)	CT4 (100% Tamarind puree)	SEM	p<.
Total phenolic content (mg GAE/100g)	61.20 D	35.70F	56.64E	62.69C	68.75B	78.00A	0.066	****
DPPH radical scavenging activity (%)	92.30C	64.20F	83.55E	90.89D	98.24B	110.00A	0.133	****

Each record is a mean value of three replicates . SEM: Standard Error of means . (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

The color values of carrot-tamarind leather samples

Color is an essential factor to determine the quality and it indicates the fitness of the fruit leather for the consumption (Barrett, *et al.* 2010 and Sukasih and Widayanti (2022)

The chromaticity (*L**, *a**, and *b**) values of carrot-tamarind leather samples were presented in Table (6). The results disclosed that the L* value of leather samples decreased as increasing tamarind puree. The L* value showed that the degree of color lightness or color light intensity. So, the leather sample containing 25% tamarind puree had the highest level of L* value compared to other leather samples. This result might be due to this leather sample had the highest value of carrot compared to other leather samples also; this leather had the lowest content of moisture. This result is in covenant with those of HO *et al.* (2018) and Hartel and Hartel (2008) they found that at extremely low moisture content, the fruit leather may reach a glassy state like hard candy. Consequently, the L* value is increased as the sample becomes more glassy and transparent. On the other hand, all leather samples had dark color because of the (L value < 50). This result might be due to, the color tamarind and might be due to the Maillard reaction being a factor in the reduction in color brightness. This result is in agreement with those of Sukasih and Widayanti (2022)

Table 6. The color values of carrot-tamarind leather samples

Constituents	CT1 (25% Tamarind puree)	CT2 (50% Tamarind puree)	CT3 (75% Tamarind puree)	CT4 (100% Tamarind puree)	SEM	P <.
L*	44.38A	30.82B	27.33C	26.31C	0.366	****
a*	13.62A	12.70A	6.57B	6.69B	0.233	****
b*	23.42A	14.12B	6.82C	6.18C	0.279	****

Each record is a mean value of three replicates . SEM: Standard Error of means. (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

The leather contained 25% tamarind puree had the highest value of *a** (redness) compared to other leather samples, This result might be due to it had a high content of carrot that has red pigment (carotenoid) these results conform with those of Ahmad *et al.* (2019) they reported that the high contents of carotene are present in orange carrots. Besides, Zaire *et al. (*2017) reported that carotenoids are lipid-soluble pigments that range in color from orange to red and have significant effects on the acceptance of products. Furthermore, the leather contained 25% tamarind puree and had *a** value (redness). This result might be due to the carrot fruit containing a variety of pigments. As well, leather containing 25% tamarind puree had the highest b* values (yellowness) compared to other leather samples. The result from L*a*b* analysis indicated that the carrot ratio to tamarind gave a major effect on the color of the final product.

This result is in concord with those of HO *et al.* (2018). Moreover, Sukasih and Widayanti (2022) they reported that the fruit leather color significantly is influenced by the fruit kind that is used.

Texture profile analysis of carrot-tamarind leather samples

Food has particular attributes that are very important in evaluating how it will be accepted by consumers. The most important attributes of fruit leather are its texture, which may be evaluated based on its hardness, cohesiveness, springiness, gumminess, and chewiness. These properties help in determining how much force should be used to chew or bite the piece of fruit leather during mastication. (Patil, *et al.,* 2017). Adhesiveness is an essential attribute of dried fruit goods as it could indicate the stickiness of the products (Nishinari and Fang, 2018).

From Table (7), the results showed that texture profile analysis of carrot-tamarind leather samples as hardness was decreased but the cohesiveness, springiness, and gumminess of carrot-tamarind leather samples were increased as the level of tamarind puree was increased. The result of hardness might be due to an increase in moisture; this result is in line with those of Patil *et al*. (2017). Also, the lowering in pH conditions is essential for the production of structure gels during the fruit leather industrial method, as structure gels can only be formed at a low pH as reported by Kurniadi *et al.* (2022). Similarly, this result might be due to a decrease in total sugar. During the drying process, the crystallization of sugar occurs. Fruit leather may have a higher hardness value as a result of sugar crystallization; this result is in agreement with that of Perera (2005). On the other hand, all carrot-tamarind leather samples had good hardness so this product is suitable for consumers; this result is in harmony with that of Srilakshmi (2020) who reported that if the product is so hard the consumer can't bite the food; it should be in the correct order for the mouth's biting action to take place. The result of cohesiveness, springiness, and gumminess might be due to tamarind pure having a high content of pectin compared to carrot pure. This result is in accord with that of Orrego *et al*. (2014) they reported that pectin was the main factor causing (raising) the springiness of fruit leather. Also, the pectin of tamarind is 2-4 average of the pectin of carrot is 0.72- 1.01 Baker (1997).

From the same table the cohesiveness of leather samples was increased as a result of decreasing in total sugar this result might be due to tamarind pure having low content of total sugar and a high level of acidity and high content of pectin compared to carrot puree caused gelly system, this result is match up with those of Al Hinai *et al.* (2013) they found that contribute to relatively high molecular weight polymer compounds, that can compete with sugars for the water-hydrogen bonding that, inhibiting the product's stickiness. Also, Rao (1948) cited in El-Siddig *et al.,* (2006) reported that tamarind polysaccharides can produce gel at a variety of levels of pH, including neutral and basic ones. Contrary to fruit pectin, tamarind polysaccharides are unaffected by long periods of boiling in neutral aqueous solutions. As a result, it can serve as a gel-forming agent and be used in place of fruit pectin. Since tamarind polysaccharides lack methyluronate and galacturonic acid, they are referred to as "jellose" and are not considered to be real pectin. In addition, the result showed that all carrot-tamarind leathers had a good texture profile. This result is in line with those of Raab and Oehler (2000) they reported that fruit leather products with good quality must have an elastic texture so, that they can be rolled up and not easily broken. The elastic texture is affected by gel formation; it is controlled by a mixture of pectin, water, sugar, and acid

Table 7. Texture profile analysis of carrot -tamarind leathers

Constituents	Hardness (kg)	Cohesiveness	Springiness (mm)	Gumminess	Chewiness
CT1 (25% Tamarind puree)	63.15A	0.87D	0.690C	54.90D	37.91D
CT2 (50% Tamarind puree)	60.00B	1.20C	0.705C	72.00C	50.76C
CT3 (75% Tamarind puree)	58.98C	1.39B	0.899B	82.00B	73.7B
CT4 (100% Tamarind puree)	55.00D	1.70A	1.01A	93.50A	94.44A
SEM	0.049	0.009	0.034	0.011	0.042
p<.	****	****	****	****	****

Each record is a mean value of three replicates. SEM: Standard Error of means . (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

Sensory properties of carrot-tamarind leather samples

Data concerning in Table (8) showed that the sensory properties of carrot-tamarind leather samples. The odor, taste, flavor, and overall acceptability were increased but the color was decreased by increasing tamarind puree levels. So, the leather sample that contained 100% tamarind puree had the highest overall acceptability compared to other carrot-tamarind leather samples. Also, these results might be due to leather containing 100% tamarind having a high content of ash, fiber total sugar, carbohydrate vitamins, and phytochemicals, and low content of fat. These results were in agreement with those of Girma (2014) found that high acidity in fruit leather helps maintain the flavor of the fruit; thus, using tamarind with high acidity is essential in terms of processing or manufacturing. Moreover, Singh and Tiwari, (2019) they found that fruit bars made from natural fruit pulp have more flavor and nutrition because they contain a significant amount of dietary fiber, minerals, vitamins, and other phytochemicals. Fruit leathers enhance the value of fruit which might be unacceptable for the fresh goods market. Likewise, Diamante *et al*., (2014) they reported that fruit leather is naturally chewy, flavorful and high in carbohydrates and fiber, and low in fat.

As shown in the same table all leather samples were acceptable. This result might be due to ingredients such as sugar, ginger, and lemon juice. This result was in agreement with those of Sukasih and Widayanti (2022) they found that citric acid is a flavoring agent in food particularly for treated fruit products, citric acid acts as an acid source to avoid sugar crystallization, and browning, as a catalyst for the hydrolysis of sucrose to invert sugar through storage, and as a gel. Also, Vasanthakaalam *et al*. (2018) found that fruit leathers are prepared from fruit mash and other components such as citric acid and sugar to improve the calories, nutritional quality, acceptability, and storage stability.

Table 8. Sensory properties of carrot-tamarind leather samples

Constituents	Color	Oder	Taste	flavor	Overall acceptability	Average
CT1 (25% Tamarind puree)	8.40A	6.90B	7.00B	7.40B	7.00C	7.23C
CT2 (50% Tamarind puree)	7.40B	7.40BA	7.20B	7.60B	8.20B	7.45B
CT3 (75% Tamarind puree)	6.90B	8.00A	7.90BA	7.80BA	8.50B	7.75B
CT4 (100% Tamarind puree)	6.70B	8.30A	8.50A	8.70A	9.40A	8.33A
SEM	0.196	0.255	0.284	0.239	0.201	0.127
p<.	****	****	****	****	****	****

Each record is a mean value of three replicates . SEM: Standard Error of means . (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001** P< 0.0001**

Moisture and water activity of carrot-tamarind leathers as storage for 4 months at room temperature (26.6-30 c)

Data in Table (9) showed that the effect of storage for 4 months at room temperature (26.6-30 c) on moisture contents and water activity of carrot-tamarind leathers. The moisture contents were decreased as the period of storage was increased. This result might be due to the vaporization of some moisture and the separation of some liquids inside the polyethylene bags. Also, the water activity of all leather samples at zero time is less than 0.7. Moreover, the water activity of all leather samples decreased as the storage period increased. This result is in accordance with those of Jay *et al.* (2005) they found that dried fruit products contained 13-25% moisture content, and have less than 0.8 water activity, which is below that most of the microbial are impeded to growth, especially bacteria.

All these results are in contract with those of Welti-Chanes et al. (2000) they found that water activity, which was significantly unchanged during storage, was 0.7. This value offers a margin of safety for the storage of acid foods. As well, Roos (1995) who found that it would not only inhibit the growth of pathogenic microorganisms, on the other hand, it would strongly inhibit the growth of non-pathogenic yeasts and fungi. However, for this level of water activity, rates of non-enzymatic browning and enzymatic activity are not negligible and may even be considerable.

Table 9. Moisture and water activity of carrot-tamarind leathers during storage for 4 months at room temperature (26.6-30 c)

Constituents	Moisture			Water activity ^{a}W		
	zero	2months	4 months	zero	2months	4 months
CT1 (25% Tamarind puree)	13.40C	12.97D	12.67C	0.501C	0.50CD	0.49CD
CT2 (50% Tamarind puree)	13.85B	13.63C	13.45B	0.511C	0.52BC	0.51BC
CT3 (75% Tamarind puree)	14.10B	13.82B	13.58B	0.55B	0.54AB	0.52AB
CT4 (100% Tamarind puree)	14.60A	14.3A	14.09A	0.58A	0.56A	0.54A
SEM	0.0190	0.333	0.245	0.1009	0.2304	0.3670
p<.	***	***	***	***	***	***

Each record is a mean value of three replicates . SEM: Standard Error of means . (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

Microbiological assay of carrot-tamarind leather samples

Data in Table (10) disclosed that the total count, spore-forming bacteria, yeast, and mold count, and the coliform group were not detected in all carrot-tamarind leather samples at zero time and during the storage period (4 months) at room temperature. This result might be attributable to the absence of raw materials used it might be due to superior hygienic practices during handling, and processing methods.

Table 10. Microbiological evaluation of carrot-tamarind leather samples as storage for 4 months at room temperature (26.6-30 c)

Constituents	Contaminated bacteria	parameters	Storage period/months		
			zero	2	4
CT1 (25% Tamarind puree)	Total count	(CFU/g x 10-1)	5	22	40
	spore-forming bacteria	(CFU/g x 10-1)	Nil	Nil	Nil
	Yeast and Mould Count	(CFU/g x 10-1)	Nil	Nil	Nil
	Coliform Test	(CFU/g x 10-1)	Nil	Nil	Nil
CT2 (50% Tamarind puree)	Total count	(CFU/g x 10-1)	5	19	36
	spore-forming bacteria	(CFU/g x 10-1)	Nil	Nil	Nil
	Yeast and Mould Count	(CFU/g x 10-1)	Nil	Nil	Nil
	Coliform Test	(CFU/g x 10-1)	Nil	Nil	Nil
CT3 (75% Tamarind puree)	Total count	(CFU/g x 10-1)	5	18	31
	spore-forming bacteria	(CFU/g x 10-1)	Nil	Nil	Nil
	Yeast and Mould Count	(CFU/g x 10-1)	Nil	Nil	Nil
	Coliform Test	(CFU/g x 10-1)	Nil	Nil	Nil
CT4 (100% Tamarind puree)	Total count	(CFU/g x 10-1)	5	16	29
	spore-forming bacteria	(CFU/g x 10-1)	Nil	Nil	Nil
	Yeast and Mould Count	(CFU/g x 10-1)	Nil	Nil	Nil
	Coliform Test	(CFU/g x 10-1)	Nil	Nil	Nil

Nil: Not detected. Each record is a mean value of four replicates . SEM: Standard Error of means . (a, b, c, d, e, and f): means in the same column with different superscript differ significantly at p< 0.05. *P< 0.05. **P< 0.01. *** P< 0.001. P< 0.0001

This result is in harmony with those of Gibbons *et al.* (2006). Also, this result might be due to the leather samples had low content of moisture and had high acidy and antioxidant properties as a result of their content of tamarind, lemon juice, and ginger as shown in Table (5, 9) these contents had high antioxidant and antibacterial properties. These results were in agreement with those of Safaei *et al*. (2019) and Suna *et al.(*2014) they reported that fruit leather must contain moisture of less than 15% and a pH that can limit microbial growth for several months without the use of chemical preservatives. Also, Mani *et al*. (2020) reported that Ascorbic acid deterioration in storage is a normal process. Moreover, Girma (2014) who reported that fruit leather's high acidity inhibits the growth of pathogens. And Bhadoriya *et al.* (2011) and Toungos, (2019) they reported that tamarind has antimicrobial activity. Also, Suna et al. (2014) they reported that according to the standard, the pH of the leather must fall within the acceptable range of 2.5 and 4.5. Even though, the lower threshold limit for bacterial growth (4.0), some fungi and yeasts may be able to grow. Similarly, World Health Organization guidelines (WHO) according WHO (1994) the total viable count for bacteria, yeast, and mold should be fewer than 1 x 104 cfu/g,

Also, all leather samples can be storage more than 4 months at room temperature (26.6-30 c). Therefore, to be adjudged safe for consumption this result aligned with those of Kadam *et al*. (2012).

CONCLUSION

The quality attributed of leather samples containing carrot and tamarind at different levels was improved by increasing the level of tamarin puree. So, leather with high content of tamarind had nutritional value as minerals, phytochemical, and good physical properties such as texture and high organoleptic properties. Also, all leather samples can be storage more than 4 months at room temperature with high quality attributed.

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خواص الجودة للفائف الجزر و التمر هندى

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الملخص

الهدف من هذا البحث هو دراسة خصائص جودة لفائف الجزر والتمر الهندي المحتوية على بيورية الجزر والتمر الهندي بنسب 75-25 ، 50-50 ، 25-75 ، 0-100. يمزج هذا الخليط مع 15 جرام سكر و 0.3 زنجبيل و 3 مل عصير ليمون. تم تحليل عينات لفائف الجزر والتمر الهندي من حيث التركيب الكيميائي والخصائص الفيزيائية و الحسية والتلوث الميكروبيولوجي. أظهرت النتائج أنه نتيجة لزيادة مستويات الاستبدال للتمر هندى زادت الرطوبة والرماد والألياف والسكر الكلي ولكن انخفض محتوى البروتين والدهون والكربوهيدرات. علاوة على ذلك حدث انخفاض فى البيتا- كاروتين بينما حدث ارتفاع فى فيتامين ج والحموضة وبالتالي انخفض الرقم الهيدروجيني للمنتجات. كما حدث ارتفاع فى محتوى المعادن مثل Caو K و P و Mn Mg و .Na إلى جانب زيادة المحتوى من الفينولات الكلية والنشاط المضاد للشقوق الحرة لـ .DPPH وجد بزيادة نسبة بيورية التمر الهندي قلت نسبه المواد الصلبة الذائبة الكلية. و كانت عينة اللفائف المحتوية على 25٪ بيورية التمر الهندي كان لها أعلى مستويات لونية ، (الشفافية واحمرار اصفرار) بالمقارنة بلفائف التمر الأخرى. كما قلت خواص القوام (النسيج) مثل الصلابة وزاد معد التماسك و المطاطية و اللزوجة والمضغية. وبالمثل ، حدث ارتفاع فى الخواص الحسية مثل اللون ، والرائحة ، والمذاق ، والنكهة ، و القبول الكلى ، لذا فإن عينة اللفائف المحتوية على 100٪ بيورية التمر الهندي كانت لها اعلى قبولا حسيا بالمقارنة بعينات لفائف الجزرو التمر الهندي الأخرى. و بالتقييم الحمل الميكروبى لجميع اللفائف المصنعة وجد إمكانية حفظها لمدة أطول من 4 اشهر على درجة حرارة الغرفة. أخيرًا ، يمكن خلط بيورية الجزر و التمر الهندى لتحسين القيمة الغذائية و الخواص الفيزيائية والميكروبية والحسية للفائف الجزر و التمر الهندي

الكلمات الدالة: تمر هندي - جزر - لفائف – بيورية