Production a Novel Flavoured-Yoghurt Drink Using Tamarind Extract

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Abstract: The tamarind considered a favourite beverage for most Egyptians. Addition of tamarind extract at levels of 0, 1, 3, 5, 7, 9 and 11% with yoghurt drinks was the purpose of the present study to get a novel yoghurt drink. With regard to the chemical composition, the protein content was appeared a significant ($p < 0.05$) decrease. The total solids (TS), fat and ash contents were showed insignificant differences whether adding of tamarind extract or during the storage period up to 14 days. Titratable acidity of the treatments was recorded significant ($p < 0.05$) increases, whereas the pH values was acquired significant ($p < 0.05$) decreases with adding of tamarind extract and during the storage period. Both of total phenolic compounds (TPC) and radical scavenging activity (RSA) had been significantly ($p < 0.05$) increased with adding tamarind extract and decreased over the storage periods. Adding tamarind extract had been resulted significant ($p < 0.05$) decreases in each the viscosity and water binding capacity (WBC) of treatments, and the same parameters significantly ($p < 0.05$) decreased as the storage period advanced. The lightness (+L*), chroma and total colour intensity have significantly ($p < 0.05$) decreases, but the greenness (–a*) and yellowness (+b*) were significantly ($p < 0.05$) increased in parallel with tamarind extracts increased. On the other hand, the lightness, yellowness, chroma and total colour intensity were decreased significantly ($p < 0.05$) from 1 day up to 14 days. According to sensory evaluation scores, the two treatments of 5 and 7% tamarind extract were recorded higher scores than other treatments. In addition, the same treatments were recorded 16.15% and 14.62% profits values, respectively.

Keywords: Antioxidant activity, Tamarind extract, Yoghurt drink

INTRODUCTION

India is thought to be the first source for tamarind fruit production, and its derived from Persian word 'tamar-i-hind' which means date of India (Mishra, 1997). Also, Morton and Miami (1987) mentioned that the tamarind fruit has been originated from India, while others researches thought its grown out in the drier savannahs of tropical Africa, Ethiopia, Kenya, Tanzania, Sudan and westward through sub-Sahelian region of Africa up to Senegal (Vietmeyer, 1979). Tamarind tree becomes cultivated in semi-arid Africa and South Asia, and planted in Bangladesh, Malaysia, Myanmar, Sri Lanka, Thailand, Australia, Central American and South American countries (Sharma and Bhardwaj, 1997). All parts of tamarind tree used in chemical, food, pharmaceutical and textile industries, or used as fodder, fuel and timber (Rao and Mary, 2001; Pugalenthi *et al.* 2004). The fruit of tamarind tree act as the commonly part which used, moreover the fruit pulp was represented 30–50% from the ripe fruit (Purseglove, 1987; Shankaracharya, 1998), while the percentages of shell and fiber were 11–30%, and seed content was 25-40% (Page, 1984; Shankaracharya, 1998). Tartaric acid was acquired the ripened tamarind fruit an intensively acidic taste, in addition the content of tartaric acid was varied from country to another country (Feungchan *et al.,* 1996). The contents of tartaric acid and sugar were 8.4:12.4% and 21.4:30.9%, respectively as reported by Hasan and Ijaz (1972) in Pakistan sour tamarind. Other organic acids were discovered in tamarind fruit such as citric acid, oxalic acid, quinic acid and succinic acid (Singh, 1973; Anon, 1976). Ascorbic acid was 2–20 mg/100 g (Ishola *et al.,* 1990). Free amino acids, such as β-alanine, leucine, phenylalanine, proline and serine have been identified by Rao *et al.* (1954) in the tamarind fruit, moreover, the tamarind pulp rich in calcium, iron, phosphorus and potassium. High levels of magnesium and sodium contents in tamarind fruit were reported by Parvez *et al.* (2003), while copper and zinc contents were reported in fewer levels. In addition, tamarind fruit contain vitamins of riboflavin, niacin and thiamin which were ranked a good source, while vitamins of each A and C were recorded at low levels (De Caluwé *et al.,* 2010).

According to Bylund (1995), yoghurt drinks have three groups: 1) homogenized yoghurt which has shelf life from 2 up to 3 weeks. 2) pasteurized homogenized yoghurt which have shelf life 1 to 2 months. 3) UHT treated yoghurt which has shelf life up to several months. On the other hand, yoghurt drinks were classified into stirred yoghurt with low viscosity which consumed as a refresh products; moreover their chemical composition difference between countries (Tamime and Robinson, 2000). Addition of stabilizers such as gelatin or carboxylmethyl cellulose (CMC) for yoghurt drinks were important for avoiding of whey off and syneresis (Foley and Mulcahy, 1989; Chopra and Gandhi, 1990).

Food and Drug Administration was reported that yoghurt drink product should be contained > 8.25% milk solid not fat (MSNF), < 0.5% fat for free fat product, 2% fat for low fat product, > 3.25% fat for full fat product, in addition the pH values of yoghurt drinks ranged from 4.0 till 4.5 (Chandan *et al.,* 2006). The chemical composition of yoghurt drink was 3.8% protein, 3.5% fat, 8% sugar and 15% fruit (Tamime and Robinson, 2007). An increase of consumer needs was responded especially in supporting of yoghurt with different fruits (Küçüköner and Tarakçı, 2003) like apple concentrates, carrot, lemon, orange concentrates, pineapple, raspberry and strawberry (Tamime and Robinson, 2000). Therefore, the improvement of yoghurt drink characteristics were carried out using tamarind extracts to produce a novel tamarind-yoghurt drink.

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MATERIALS AND METHODS

Materials

Tamarind pulp (*Tamarindus indica*) and white sugar were obtained from the local market, Ismailia, Egypt. Whole milk powder (WMP) [28% fat, 27% protein, 36% lactose, 2.5% moisture, 7% minerals and 70% MSNF] and skim milk powder (SMP) [1.5% fat, 34% protein, 52% lactose, 8% minerals, 3% moisture and 94% MSNF] were imported from France and obtained from the local market, Ismailia, Egypt. YoFlex ® Express 1 (200 U) (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*) was purchased from Christian Hansen Laboratories, Denmark. CMC was purchased from Al Gomhoria Co., Cairo, Egypt. 1, 1-diphenyl-2-picrylhydrazyl (DPPH) was purchased from Sigma Chemical Co., (St. Louis, MO, USA). All chemicals used in the present work were of analytical grade.

Methods

Preparation of tamarind extract

Tamarind pulp were cut into small pieces by hand, soaked in distilled water and leaved 10 h at the room temperature. Tamarind pulp was extracted manually through the colander. Tamarind extract was filtered through sterilized white cloth, and the resultant tamarind extract was stored in the refrigerator at 4°C until the use.

Preparation of tamarind yoghurt drink

Table (1) represents the formulations of tamarind yoghurt drink. Control sample (3% fat) was prepared from WMP, SMP, sugar, CMC, starter and filtered water. SMP of control, T1, T2, T3, T4, T5 and T6 were replaced by solids of tamarind extract (refer to Table 2) at levels of 0%, 0.14%, 0.42%, 0.70%, 0.98%, 1.26% and 1.54%, respectively. The two-thirds of filtered water for all treatments separately were heated at 60°C, followed by adding of WMP and SMP with stirring, heated at 85°C for 15 min, cooled to 42°C and then inoculated by starter culture (2.8 g / 100 kg), followed by an incubation at 42°C for 3 h. Tamarind extract, sugar and CMC of each treatment were dissolved in a third of the remaining filtered water of each treatment, heated at 85°C for 15 min, cooled to 5°C and kept in the refrigerator until use. Both set yoghurt and the syrups were mixed well together using electric blender for 10 min to obtain the tamarind yoghurt drink, then packed in plastic cups (100 ml) and storage in the refrigerator at 5°C until analyzed.

Table (1): Formulations of tamarind yoghurt drink

Ingredients	**Kg / 100 Kg**						
	C*	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
WMP	10.71	10.71	10.71	10.71	10.71	10.71	10.71
SMP	2	1.86	1.58	1.3	1.02	0.74	0.46
Tamarind extract	−	1	3	5	7	9	11
White sugar	5	5	5	5	5	5	5
CMC	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Starter	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
Filtered water	81.987	81.127	79.407	77.687	75.967	74.247	72.527

*Control: (3 kg fat / 100 kg, 9.38 kg MSNF / 100 kg and 0 kg tamarind extract solid / 100 kg); T1: 3 kg fat / 100 kg, 9.24 kg MSNF / 100 kg and 0.14 kg tamarind extract solid /100 kg; T2: 3 kg fat / 100 kg, 8.96 kg MSNF / 100 kg and 0.42 kg tamarind extract solid /100 kg; T3: 3 kg fat / 100 kg, 8.68 kg MSNF / 100 kg and 0.70 kg tamarind extract solid /100 kg; T4: 3 kg fat / 100 kg, 8.40 kg MSNF / 100 kg and 0.98 kg tamarind extract solid / 100 kg; T5: 3 kg fat / 100 kg, 8.12 kg MSNF / 100 kg and 1.26 kg tamarind extract solid / 100 kg and T6: 3 kg fat / 100 kg, 7.84 kg MSNF / 100 kg and 1.54 kg tamarind extract solid / 100 kg.

Analysis of tamarind extract and yoghurt drink

Tamarind extract and yoghurt drink were analyzed for the TS, fat, protein and ash contents and titratable acidity according to methods of AOAC (2019). The pH values of samples were determined using a digital pH meter (Jenway electrode no. 3505, Dunmow, England). The radical scavenging activity (RSA) of samples was measured by DPPH as mentioned by Kadhum *et al.* (2011) and the inhibition percentage was determined by the following equation.

$$\text{Inhibition of DPPH \%} = \frac{A_{(control)} - A_{(sample)}}{A_{(control)}} \times 100$$

The total phenolic compounds (TPC) were determined by Folin-Ciocalteau reagent as described by Samovar *et al.* (2014). Carbohydrate content was evaluated by the following equation: Carbohydrate % = [100 − (protein % + fat % + moisture % + ash %)].

Viscosity

The viscosity of tamarind yoghurt drinks were measured at 20°C using a Höppler falling ball viscometer (BH2 NO. 17377, Germany).

Water binding capacity

The WBC of tamarind yoghurt drinks was determined using method of Parnell-Clunies *et al.*

(1986) with some modifications. Sample (30 g) of tamarind yoghurt drink was centrifuged (HERMLE Labor-tech GmbH, Germany) at 4000 rpm for 30 min at 5°C. The whey layer drained and the residual weight was determined.

$$\text{WBC \%} = \frac{\text{Sample weight} - \text{Whey weight}}{\text{Sample weight}} \times 100$$

Determination of colour

The instrumental colour of different treatments was determined in three replicates as the CieLab coordinates (L*, a* and b* values) using a hand-held Tristimulus reflectance colorimeter Minolta Chroma-meter CR-400 (Minolta Camera Co., Ltd., Osaka, Japan). The colour intensity or chroma (C) shows the purity or colour saturation which calculated from $C = (a^{*2} + b^{*2})^{0.5}$ and total colour intensity = $(a^{*2} + b^{*2} + L^{*2})^{0.5}$.

Sensory evaluation

The sensory evaluation of treatments was determined according to Pal and Gupta (1985). Twelve panelists evaluated of yoghurt drinks using parameters of flavour (45), body and texture (30), appearance (15), colour (10) and total acceptability (100).

Cost of production

Production costs of all treatments were calculated according to prices of materials which used in yoghurt drink in the Egyptian market. The calculations of production costs and profits were determined by US dollar.

Statistical analyses

All the obtained data were analyzed statistically by the two way analyses of variance using computer program software SAS (SAS, 1999). A Duncan analysis ($p < 0.05$) was used to determine the differences between mean values of treatments.

RESULTS AND DISCUSSION

Chemical composition of tamarind extract

The chemical composition of tamarind extract is represented in Table (2). Fat and protein contents of tamarind extract were 0.1 and 0.85%, respectively. The pH value was 2.71 which appeared that an intensively acidic taste of tamarind extract due to its high level of tartaric acid. Parvez *et al.* (2003) found that the dried tamarind pulp contains 8 – 18% tartaric acid. Feungchan *et al.* (1996) showed that the content of tartaric acid was varied from country to another country (2.5-11.3%). The tamarind extract have good levels of each the RSA and TPC values, which in turn will be supported of yoghurt drink. The darkness (L*) of tamarind extract was 4.84, while the redness (+ a) and yellowness (+ b) were 8.54 and 5.30 respectively, thus as expected the blending of tamarind extract with the plain yoghurt drink will be resulted significant changes in the three parameters of instrumental colour (refer to Table 4).

Table (2): Chemical composition of tamarind extract

Parameters		Values
Total solids %		14.02±0.11
Fat %		0.10±0.00
Protein %		0.85±0.06
Ash %		0.76±0.05
pH value		2.71±0.05
RSA %		45.50±0.90
TPC (mg Gallic acid /100 g)		42.35±0.76
Colour	**L* value**	4.86±0.04
	a* value	8.54±0.16
	b* value	5.30±0.12

Values are mean ± standard deviation (SD) of triplicates. L* value: denotes lightness-to-darkness from 100 to 0 units, respectively; a* value: represents redness (+ a) to greenness (–a); b* value: represents yellowness (+ b) to blueness (–b).

Effect of tamarind extract on chemical composition, titratable acidity, pH value, TPC and RSA of yoghurt drinks

The compositions of tamarind yoghurt drinks are shown in Table (3). No significant ($p > 0.05$) differences were observed between all treatments in parameters of TS, protein, fat and ash contents. In addition, the protein content of treatments significantly ($p < 0.05$) decreased during storage period from 1 day up to 14 days at 5°C, which can be attributed to protein degradation by *Lactobacillus delbrueckii* subsp. *bulgaricus* (Tamime and Robinson, 2007) or due to the interaction between lactose and basic amino groups (Humphreys and Plunkett, 1969). Furthermore, the reduction in fat contents of yoghurt drinks was related to the lipolytic activity of microorganisms (Gunawardhana and Dilrukshi, 2016). Throughout the storage period, no significant ($p > 0.05$) changes was observed for ash content.

Titratable acidity and pH values of tamarind yoghurt drinks were presented in Table (3). The gradual increase of tamarind extract led to significantly ($p < 0.05$) increases in titratable acidity of all treatments. In contrast the pH values were decreased significantly ($p < 0.05$) owing of the high acidity of tamarind extract (refer to Table 2).

Table (3): Chemical composition, titratable acidity, pH value, TPC and RSA of tamarind yoghurt drinks

Parameters	(days)	C*	T1	T2	T3	T4	T5	T6
TS %	**1**	18.10±0.21^{Aa}	18.06±0.20^{Aa}	18.14±0.12^{Aa}	18.10±0.17^{Aa}	18.05±0.21^{Aa}	18.14±0.18^{Aa}	18.04±0.15^{Aa}
	7	18.07±0.11^{Aa}	18.04±0.17^{Aa}	18.10±0.16^{Aa}	18.08±0.20^{Aa}	18.02±0.13^{Aa}	18.10±0.16^{Aa}	18.01±0.13^{Aa}
	14	17.98±0.12^{Aa}	17.97±0.21^{Aa}	18.00±0.13^{Aa}	17.98±0.14^{Aa}	17.96±0.11^{Aa}	18.02±0.12^{Aa}	17.96±0.15^{Aa}
Protein %	**1**	3.63±0.05^{Aa}	3.58±0.07^{Aab}	3.44±0.09^{Abc}	3.32±0.05^{Acd}	3.21±0.11^{Ade}	3.12±0.10^{Aef}	3.00±0.07^{Af}
	7	3.52±0.10^{ABa}	3.48±0.08^{ABa}	3.40±0.07^{Aa}	3.25±0.07^{Ab}	3.13±0.08^{Abc}	3.06±0.06^{Acd}	2.92±0.10^{Ad}
	14	3.33±0.07^{Ba}	3.30±0.06^{Ba}	3.23±0.08^{Ba}	3.08±0.07^{Bb}	2.95±0.06^{Bc}	2.83±0.08^{Bd}	2.74±0.04^{Bd}
Fat %	**1**	3.08±0.06^{Aa}	3.10±0.08^{Aa}	2.98±0.07^{Aa}	3.05±0.05^{Aa}	3.03±0.07^{Aa}	2.97±0.06^{Aa}	3.05±0.05^{Aa}
	7	3.05±0.05^{Aa}	3.00±0.08^{Aa}	2.97±0.06^{Aa}	3.00±0.05^{Aa}	3.05±0.08^{Aa}	2.96±0.10^{Aa}	2.98±0.06^{Aa}
	14	3.00±0.04^{Aa}	2.97±0.08^{Aa}	2.95±0.07^{Aa}	2.98±0.05^{Aa}	2.97±0.10^{Aa}	2.95±0.07^{Aa}	2.93±0.06^{Aa}
Ash %	**1**	0.88±0.04^{Aa}	0.86±0.03^{Aa}	0.84±0.03^{Aa}	0.87±0.05^{Aa}	0.85±0.04^{Aa}	0.88±0.05^{Aa}	0.86±0.02^{Aa}
	7	0.86±0.03^{Aa}	0.87±0.04^{Aa}	0.82±0.03^{Aa}	0.86±0.05^{Aa}	0.85±0.04^{Aa}	0.86±0.03^{Aa}	0.84±0.05^{Aa}
	14	0.87±0.05^{Aa}	0.86±0.03^{Aa}	0.84±0.04^{Aa}	0.88±0.03^{Aa}	0.87±0.06^{Aa}	0.84±0.02^{Aa}	0.87±0.04^{Aa}
Acidity %	**1**	0.60±0.04^{Cc}	0.61±0.05^{Cc}	0.64±0.06^{Cbc}	0.68±0.03^{Cabc}	0.71±0.05^{Cab}	0.73±0.02^{Cab}	0.75±0.03^{Ca}
	7	0.71±0.05^{Bc}	0.73±0.07^{Bc}	0.78±0.05^{Bbc}	0.80±0.06^{Bbc}	0.85±0.04^{Babc}	0.90±0.06^{Bab}	0.96±0.07^{Ba}
	14	0.84±0.06^{Ac}	0.87±0.05^{Ac}	0.91±0.04^{Ac}	0.95±0.07^{Abc}	0.98±0.06^{Aabc}	1.05±0.07^{Aab}	1.10±0.05^{Aa}
pH value	**1**	4.72±0.04^{Aa}	4.70±0.03^{Aa}	4.66±0.02^{Aab}	4.62±0.04^{Abc}	4.60±0.05^{Abc}	4.57±0.03^{Ac}	4.55±0.04^{Ac}
	7	4.64±0.03^{Ba}	4.62±0.05^{Bab}	4.60±0.04^{Babc}	4.57±0.03^{Babc}	4.54±0.05^{Bbcd}	4.52±0.03^{Bcd}	4.47±0.04^{Bd}
	14	4.52±0.04^{Ca}	4.50±0.05^{Cab}	4.46±0.02^{Cabc}	4.42±0.05^{Cabc}	4.40±0.06^{Cbcd}	4.36±0.04^{Ccd}	4.32±0.03^{Cd}
TPC (mg Gallic acid /100 g)	**1**	3.95±0.11^{Af}	4.10±0.14^{Af}	5.33±0.12^{Ae}	6.78±0.13^{Ad}	8.10±0.15^{Ac}	10.11±0.13^{Ab}	12.20±0.18^{Aa}
	7	3.90±0.10^{ABf}	4.03±0.12^{Af}	5.24±0.15^{ABe}	6.62±0.11^{Ad}	7.93±0.10^{Ac}	9.90±0.17^{Ab}	12.00±0.13^{Aa}
	14	3.71±0.08^{Bf}	3.74±0.10^{Bf}	5.00±0.12^{Be}	6.31±0.14^{Bd}	7.60±0.12^{Bc}	9.54±0.14^{Bb}	11.62±0.15^{Ba}
RSA %	**1**	5.51±0.13^{Ae}	5.53±0.11^{Ae}	6.87±0.12^{Ad}	6.98±0.06^{Ad}	7.56±0.15^{Ac}	8.78±0.17^{Ab}	9.90±0.16^{Aa}
	7	5.45±0.10^{ABe}	5.44±0.15^{ABe}	6.80±0.08^{ABd}	6.91±0.14^{ABcd}	7.10±0.11^{Bc}	8.61±0.15^{ABb}	9.66±0.18^{ABa}
	14	5.23±0.17^{Bd}	5.26±0.10^{Bd}	6.60±0.13^{Bc}	6.73±0.15^{Bc}	6.82±0.07^{Cc}	8.30±0.18^{Bb}	9.40±0.14^{Ba}

Capital letter: mean that values are significant ($p < 0.05$) differences with different letters for the column of parameter; Small letter: mean that values are significant ($p < 0.05$) differences with different letters for the row of treatments.

*Control: (3 kg fat / 100 kg, 9.38 kg MSNF / 100 kg and 0 kg tamarind extract solid / 100 kg); T1: 3 kg fat / 100 kg, 9.24 kg MSNF / 100 kg and 0.14 kg tamarind extract solid /100 kg; T2: 3 kg fat / 100 kg, 8.96 kg MSNF / 100 kg and 0.42 kg tamarind extract solid /100 kg; T3: 3 kg fat / 100 kg, 8.68 kg MSNF / 100 kg and 0.70 kg tamarind extract solid /100 kg; T4: 3 kg fat / 100 kg, 8.40 kg MSNF / 100 kg and 0.98 kg tamarind extract solid / 100 kg; T5: 3 kg fat / 100 kg, 8.12 kg MSNF / 100 kg and 1.26 kg tamarind extract solid / 100 kg and T6: 3 kg fat / 100 kg, 7.84 kg MSNF / 100 kg and 1.54 kg tamarind extract solid / 100 kg.

In addition, the early studies of Feungchan *et al.* (1996) and Parvez *et al.* (2003) reported that the dried tamarind pulp and ripened tamarind fruit contains high percentage of tartaric acid which in turn distinguished of the tamarind more acidic taste. Haron *et al.* (2019) found the pH values of bio-fermented milk decreased with the increasing of strawberry juice concentrations which have pH 3.3. During the storage periods, the fermentation process has progressed which promoted lactic acid production owing of the conversion of lactose into lactic acid by lactic acid bacteria (Nuzhat *et al.,* 2003), therefore the titratable acidity of all treatments increased, while the pH of same treatments decreased. Results of the present study are in agreement with that observed by Ding and Shah (2008).

As shown in Table (3), the TPC and RSA values of tamarind yoghurt drinks has been increased significantly ($p < 0.05$) with the gradual increase of added tamarind extract due to its high contents from TPC and RSA (refer to Table 2). As the storage period proceeding, both the TPC and RSA of all treatments were significantly ($p < 0.05$) decreased which can be explained by the decrease in stability of TPC (Sagdic *et al.,* 2012), besides occurrence of enzymatic and chemical reactions (Turfan *et al.,* 2012). Moreover the decline in the RSA of the present study during the storage period was consistent with that observed by Dimitrellou *et al.* (2020).

Effect of tamarind extract on viscosity, WBC and colour of yoghurt drinks

The viscosity values of treatments (T2 up to T6) were significantly ($p < 0.05$) decreased concurrently with the gradual increase of tamarind extract levels (Table 4), which can be attributed to the decrease of protein contents (refer to Table 3). The early studies of Ramaswamy and Basak (1992) and Akyüz and Coflkun (1995) showed that the viscosity of yoghurt treatments were decreased owing to its supported by high levels of concentrated fruit juices which decreased the WBC of protein or protein contents were diluted in the mixtures. During the storage period, the viscosity values of all treatments significantly ($p < 0.05$) increased which might be owing to gel structure solidification and thixotropy (Gomes *et al.,* 2013). Also, Guo *et al.* (2018) mentioned that the increase in the apparent viscosity of low-fat yoghurt was related to the evaporation of water during storage period.

Replacement of SMP by solids of tamarind extracts (refer to Table 2) has been resulted significantly ($p < 0.05$) decreases in the WBC from one hand and progress of whey off treatments from other hand (Table 4). In respect of storage proceeding, the WBC of all yoghurt drinks significantly ($p < 0.05$) decreased might be due to the increase of titratable acidity.

The colour is considered the substantial parameter for attracted the consumer towards dairy product. Table 4 represents the L* (lightness-to-darkness), a* (redness-to-greenness) and b* (yellowness-to-blueness) values of treatments. The lightness, chroma and total colour intensity values of control, T1, T2, T3, T4, T5 and T6 were significantly ($p < 0.05$) decreased. While, the greenness and yellowness of the previous samples were significantly ($p < 0.05$) increased with adding tamarind extract (refer to Table 2). As the advancing of storage period, the lightness, chroma, yellowness and total colour intensity values has been significantly ($p < 0.05$) decreased, in contrast the greenness were significantly ($p < 0.05$) increased.

Sensory evaluation of tamarind yoghurt drinks

In general, the flavour and body & texture of T1 till T6 were acquired high scores compared to control sample (Table 5). On other hand, scores of flavour, body and texture, appearance, colour and total acceptability of T1–T5 treatments were increased with the increase of tamarind extract added, and then decreased in case of T6 treatment. Furthermore, the sensory evaluation of T4 and T5 treatments recorded high panelists scores than other treatments. In addition, the flavour and body & texture of tamarind yoghurt drinks were related together. All parameters of sensory evaluation were significantly ($p < 0.05$) decreased during the storage period due to the development of acidity level or occasioned microbial metabolism (El-Nagar and Brennan, 2001; Ibrahim *et al.* 2003). The early study of Sobhay *et al.* (2019) reported that the shelf life of yoghurt drinks were not skip 14 days at 4°C due to the remarkable decreases in organoleptic properties scores.

Production cost and profits of tamarind yoghurt drinks

The cost production and profits of tamarind yoghurt drinks are shown in Tables (6a and 6b). The production costs of all tamarind yoghurt drinks were increased from control to T6 treatment, in spite of the variation in the production costs between all yoghurt drinks were slight. On the other hand, the percentages of cost reduction were decreased from control up to T6 due to the replacing of SMP by solids of tamarind extract. In addition, both T4 and T5 treatments were ranked as the better treatments according to the panelists scores. Therefore, through the economical point of view and sensory evaluation, we can show the tamarind yoghurt drink has been considered a novel dairy product. In spite of the cost of production was increased with the increase of tamarind extracts, but the resultant profits were good in case of the comparison between the selling price (US dollar) and cost of production (US dollar), moreover the sales opportunities will be become more.

Table (4): Viscosity, WBC and instrumental colour of tamarind yoghurt drinks

Parameters	(days)	C*	T1	T2	T3	T4	T5	T6
Viscosity (mPa.s)	1	28.36±0.15^{Ca}	27.85±0.26^{Cb}	27.57±0.17^{Cb}	27.12±0.32^{Cc}	26.88±0.28^{Bcd}	26.47±0.22^{Cde}	26.25±0.32^{Be}
	7	29.44±0.20^{Ba}	29.13±0.33^{Bab}	28.90±0.24^{Bb}	27.77±0.16^{Bc}	27.15±0.31^{Be}	26.90±0.18^{Bde}	26.65±0.35^{Be}
	14	30.92±0.27^{Aa}	30.65±0.32^{Aa}	29.37±0.13^{Ab}	28.57±0.38^{Ac}	28.26±0.34^{Acd}	27.87±0.20^{Ade}	27.53±0.18^{Ae}
WBC %	1	15.66±0.17^{Aa}	15.60±0.20^{Aa}	15.30±0.26^{Aab}	15.10±0.18^{Abc}	14.87±0.22^{Acd}	14.75±0.24^{Acd}	14.57±0.18^{Ad}
	7	15.36±0.13^{Ba}	15.24±0.16^{Ba}	15.10±0.21^{Aab}	14.85±0.23^{ABbc}	14.62±0.26^{ABcd}	14.50±0.20^{ABcd}	14.30±0.27^{ABd}
	14	14.80±0.13^{Ca}	14.73±0.16^{Ca}	14.63±0.21^{Bab}	14.50±0.23^{Babc}	14.28±0.26^{Bbc}	14.15±0.20^{Bcd}	13.88±0.27^{Bd}
L* value	1	79.30±0.78^{Aa}	77.60±0.63^{Ab}	74.65±0.71^{Ac}	71.71±0.67^{Ad}	65.65±0.51^{Ae}	62.46±0.62^{Af}	60.40±0.51^{Ag}
	14	75.80±0.61^{Ba}	72.40±0.45^{Bb}	70.10±0.57^{Bc}	65.66±0.60^{Bd}	60.70±0.44^{Be}	57.35±0.50^{Bf}	53.82±0.41^{Bg}
a* value	1	–3.24±0.07^{Bg}	–2.97±0.05^{Af}	–2.10±0.08^{Be}	–1.74±0.04^{Bd}	–1.57±0.09^{Bc}	–1.33±0.07^{Bb}	–1.05±0.03^{Ba}
	14	–2.95±0.06^{Ag}	–2.81±0.08^{Bf}	–1.91±0.04^{Ae}	–1.57±0.05^{Ad}	–1.30±0.03^{Ac}	–1.10±0.09^{Ab}	–0.86±0.07^{Aa}
b* value	1	12.35±0.17^{Af}	12.66±0.33^{Aef}	13.10±0.14^{Ae}	13.94±0.10^{Ad}	14.78±0.38^{Ac}	16.23±0.24^{Ab}	18.90±0.34^{Aa}
	14	11.65±0.31^{Be}	11.95±0.27^{Be}	12.60±0.11^{Bd}	13.34±0.20^{Bc}	14.00±0.13^{Bc}	15.45±0.38^{Bb}	17.52±0.30^{Ba}
Chroma	1	79.37±1.10^{Aa}	77.65±0.90^{Aa}	74.68±1.22^{Ab}	71.73±0.75^{Ac}	65.67±1.17^{Ad}	62.47±0.78^{Ae}	60.41±0.88^{Af}
	14	75.86±0.94^{Ba}	72.45±1.16^{Bb}	70.13±0.80^{Bc}	65.68±0.66^{Bd}	60.71±1.21^{Be}	57.36±0.57^{Bf}	53.83±0.67^{Bg}
Total colour intensity	1	80.32±0.55^{Aa}	78.68±0.95^{Ab}	75.82±0.90^{Ac}	73.07±1.32^{Ad}	67.31±0.63^{Ae}	64.55±0.87^{Af}	63.30±1.10^{Af}
	14	76.75±1.20^{Ba}	73.43±0.76^{Bb}	71.27±0.58^{Bc}	67.08±1.22^{Bd}	62.31±0.71^{Be}	59.40±0.77^{Bf}	56.61±0.92^{Bg}

Capital letter: mean that values are significant ($p < 0.05$) differences with different letters for the column of parameter; Small letter: mean that values are significant ($p < 0.05$) differences with different letters for the row of treatments.

*Control: (3 kg fat / 100 kg, 9.38 kg MSNF / 100 kg and 0 kg tamarind extract solid / 100 kg); T1: 3 kg fat / 100 kg, 9.24 kg MSNF / 100 kg and 0.14 kg tamarind extract solid /100 kg; T2: 3 kg fat / 100 kg, 8.96 kg MSNF / 100 kg and 0.42 kg tamarind extract solid /100 kg; T3: 3 kg fat / 100 kg, 8.68 kg MSNF / 100 kg and 0.70 kg tamarind extract solid /100 kg; T4: 3 kg fat / 100 kg, 8.40 kg MSNF / 100 kg and 0.98 kg tamarind extract solid / 100 kg; T5: 3 kg fat / 100 kg, 8.12 kg MSNF / 100 kg and 1.26 kg tamarind extract solid / 100 kg and T6: 3 kg fat / 100 kg, 7.84 kg MSNF / 100 kg and 1.54 kg tamarind extract solid / 100 kg.

Table (5): Sensory evaluation of tamarind yoghurt drinks

Parameters	(days)	C*	T1	T2	T3	T4	T5	T6
Flavour (45)	1	41.86±0.55^{Ad}	41.80±0.63^{Ad}	42.26±0.27^{Acd}	42.90±0.70^{Abc}	43.65±0.45^{Aab}	44.50±0.18^{Aa}	42.92±0.56^{Abc}
	7	41.65±0.42^{Ad}	41.68±0.30^{Ad}	42.13±0.62^{Acd}	42.77±0.22^{Abc}	43.40±0.50^{Ab}	44.25±0.65^{Aa}	42.70±0.44^{Abc}
	14	41.05±0.38^{Ade}	40.94±0.65^{Ae}	41.75±0.24^{Acd}	42.40±0.47^{Abc}	42.80±0.34^{Ab}	43.77±0.50^{Aa}	42.31±0.35^{Abc}
Body and texture (30)	1	28.05±0.34^{Ac}	28.00±0.17^{Ac}	29.32±0.20^{Ab}	29.45±0.35^{Aab}	29.65±0.26^{Aab}	29.86±0.30^{Aa}	28.32±0.26^{Ac}
	7	27.81±0.15^{Ac}	27.70±0.18^{Ac}	29.20±0.33^{ABb}	29.30±0.40^{ABab}	29.40±0.15^{ABab}	29.73±0.22^{Aa}	28.11±0.36^{Ac}
	14	27.00±0.12^{Bd}	26.91±0.16^{Bd}	28.75±0.18^{Bb}	28.80±0.10^{Bb}	28.94±0.12^{Bab}	29.15±0.14^{Ba}	27.46±0.10^{Bc}
Appearance (15)	1	13.35±0.20^{Acd}	13.30±0.17^{Acd}	13.17±0.15^{Ad}	13.60±0.18^{Abc}	13.80±0.22^{Aab}	14.10±0.25^{Aa}	13.55±0.15^{Abc}
	7	13.22±0.14^{Acde}	13.18±0.15^{Ade}	13.08±0.21^{Ae}	13.51±0.13^{Abc}	13.68±0.17^{Ab}	14.00±0.14^{Aa}	13.41±0.24^{ABbcd}
	14	12.70±0.17^{Bc}	12.62±0.21^{Bc}	12.54±0.12^{Bc}	13.05±0.15^{Bb}	13.25±0.12^{Bb}	13.63±0.10^{Ba}	13.18±0.13^{Bb}
Colour (10)	1	8.93±0.10^{Ae}	9.05±0.12^{Ade}	9.21±0.14^{Acd}	9.36±0.10^{Abc}	9.50±0.12^{Aab}	9.70±0.15^{Aa}	9.43±0.11^{Ab}
	7	8.84±0.15^{Ad}	8.88±0.10^{Acd}	9.13±0.17^{Abc}	9.24±0.12^{Ab}	9.36±0.18^{Aab}	9.57±0.10^{Aa}	9.33±0.18^{Aab}
	14	8.41±0.20^{Bc}	8.35±0.18^{Bc}	8.46±0.11^{Bbc}	8.58±0.21^{Bbc}	8.72±0.13^{Bb}	9.10±0.16^{Ba}	8.50±0.12^{Bbc}
Total acceptability (100)	1	92.19±1.21^{Ad}	92.15±0.93^{Ad}	93.96±1.10^{Acd}	95.31±1.44^{Abc}	96.6±1.51^{Aab}	98.16±1.62^{Aa}	94.22±1.30^{Acd}
	7	91.52±0.96^{Ad}	91.44±1.18^{Ad}	93.54±1.22^{Ac}	94.82±1.05^{Abc}	95.84±0.81^{Aab}	97.55±1.18^{Aa}	93.55±1.42^{Ac}
	14	88.26±1.35^{Be}	88.08±1.11^{Be}	90.92±0.87^{Bcd}	91.86±1.45^{Bbc}	92.96±1.12^{Bb}	95.04±0.92^{Ba}	90.61±1.26^{Bd}

Capital letter: mean that values are significant ($p < 0.05$) differences with different letters for the column of parameter; Small letter: mean that values are significant ($p < 0.05$) differences with different letters for the row of treatments.

*Control: (3 kg fat / 100 kg, 9.38 kg MSNF / 100 kg and 0 kg tamarind extract solid / 100 kg); T1: 3 kg fat / 100 kg, 9.24 kg MSNF / 100 kg and 0.14 kg tamarind extract solid /100 kg; T2: 3 kg fat / 100 kg, 8.96 kg MSNF / 100 kg and 0.42 kg tamarind extract solid /100 kg; T3: 3 kg fat / 100 kg, 8.68 kg MSNF / 100 kg and 0.70 kg tamarind extract solid /100 kg; T4: 3 kg fat / 100 kg, 8.40 kg MSNF / 100 kg and 0.98 kg tamarind extract solid / 100 kg; T5: 3 kg fat / 100 kg, 8.12 kg MSNF / 100 kg and 1.26 kg tamarind extract solid / 100 kg and T6: 3 kg fat / 100 kg, 7.84 kg MSNF / 100 kg and 1.54 kg tamarind extract solid / 100 kg.

Table (6a): Cost production of tamarind yoghurt drinks

Item	Kg and price / 100 Kg ingredients													
	C*		T1		T2		T3		T4		T5		T6	
	Quantity	USD	Quantity	USD	Quantity	USD	Quantity	USD	Quantity	USD	Quantity	USD	Quantity	USD
Whole milk powder (6.07 USD /1 Kg)	10.71	65.06	10.71	65.06	10.71	65.06	10.71	65.06	10.71	65.06	10.71	65.06	10.71	65.06
Skim milk powder (4.05 USD/1 Kg)	2	8.10	1.86	7.53	1.58	6.40	1.30	5.26	1.02	4.13	0.74	3.00	0.46	1.86
Tamarind extract (1.62 USD/1 kg)	0	0.00	1	1.62	3	4.86	5	8.10	7	11.34	9	14.58	11	17.82
Sugar (0.77 USD/1 Kg.)	5	3.85	5	3.85	5	3.85	5	3.85	5	3.85	5	3.85	5	3.85
CMC (4.05 USD/1 Kg.)	0.30	1.21	0.30	1.21	0.30	1.21	0.30	1.21	0.30	1.21	0.30	1.21	0.30	1.21
Starter culture (DVS)▪ (22.27 USD/200 U.)	20 U	2.23	20 U	2.23	20 U	2.23	20 U	2.23	20 U	2.23	20 U	2.23	20 U	2.23
Distilled water (0.016 USD/1 kg)	81.99	1.33	81.13	1.31	79.41	1.29	77.69	1.26	75.97	1.23	74.25	1.20	72.53	1.17
Tap water (0.13 USD/1 cubic meter)	1	0.13	1	0.13	1	0.13	1	0.13	1	0.13	1	0.13	1	0.13
Electricity (0.057 USD/1 kilowatt)	70	3.97	70	3.97	70	3.97	70	3.97	70	3.97	70	3.97	70	3.97
Plastic cup l00 g (0.02 USD/ each one)	100	2.02	100	2.02	100	2.02	100	2.02	100	2.02	100	2.02	100	2.02
Cost of using equipment (Rental cost) (USD.)	–	6.07	–	6.07	–	6.07	–	6.07	–	6.07	–	6.07	–	6.07
Labor charges (USD. 7.29 /8 h.)	–	7.29	–	7.29	–	7.29	–	7.29	–	7.29	–	7.29	–	7.29
Total cost of production (USD.)	101.27		102.31		104.38		106.46		108.54		110.62		112.70	
% Reduction of cost as compared to C*	–		– 0.042		– 0.125		– 0.208		– 0.291		– 0.374		– 0.457	
Cost of 100 g yoghurt drink (USD.)	0.101		0.102		0.104		0.107		0.109		0.111		0.113	

% Reduction of cost as compared to C* = [(total cost of control- total cost of each one treatment) × 100] / total cost of control.
*Control: (3 kg fat / 100 kg, 9.38 kg MSNF / 100 kg and 0 kg tamarind extract solid / 100 kg); T1: 3 kg fat / 100 kg, 9.24 kg MSNF / 100 kg and 0.14 kg tamarind extract solid /100 kg; T2: 3 kg fat / 100 kg, 8.96 kg MSNF / 100 kg and 0.42 kg tamarind extract solid /100 kg; T3: 3 kg fat / 100 kg, 8.68 kg MSNF / 100 kg and 0.70 kg tamarind extract solid /100 kg; T4: 3 kg fat / 100 kg, 8.40 kg MSNF / 100 kg and 0.98 kg tamarind extract solid / 100 kg; T5: 3 kg fat / 100 kg, 8.12 kg MSNF / 100 kg and 1.26 kg tamarind extract solid / 100 kg and T6: 3 kg fat / 100 kg, 7.84 kg MSNF / 100 kg and 1.54 kg tamarind extract solid / 100 kg.

Table (6b): Profits of tamarind yoghurt drinks

Items	C*	T1	T2	T3	T4	T5	T6
Price of selling in supermarket (USD / 100 g)	0.130	0.130	0.130	0.130	0.130	0.130	0.130
Cost of 100 g (USD.)	0.101	0.102	0.104	0.107	0.109	0.111	0.113
Profit / 100 g yoghurt drink (USD.)	0.029	0.028	0.026	0.023	0.021	0.019	0.017
Profit %	22.31	21.54	20.00	17.69	16.15	14.62	13.08

Profit % = [(Price of selling in supermarket – Cost of yoghurt drink) / Price of selling in supermarket]*100.
*Control: (3 kg fat / 100 kg, 9.38 kg MSNF / 100 kg and 0 kg tamarind extract solid / 100 kg); T1: 3 kg fat / 100 kg, 9.24 kg MSNF / 100 kg and 0.14 kg tamarind extract solid /100 kg; T2: 3 kg fat / 100 kg, 8.96 kg MSNF / 100 kg and 0.42 kg tamarind extract solid /100 kg; T3: 3 kg fat / 100 kg, 8.68 kg MSNF / 100 kg and 0.70 kg tamarind extract solid /100 kg; T4: 3 kg fat / 100 kg, 8.40 kg MSNF / 100 kg and 0.98 kg tamarind extract solid / 100 kg; T5: 3 kg fat / 100 kg, 8.12 kg MSNF / 100 kg and 1.26 kg tamarind extract solid / 100 kg and T6: 3 kg fat / 100 kg, 7.84 kg MSNF / 100 kg and 1.54 kg tamarind extract solid / 100 kg.

CONCLUSION

Replacement of SMP by solids of tamarind extract in yoghurt drink preparation had been resulted an obvious changes in the chemical, physiochemical and rheological properties of tamarind yoghurt drinks. Also, the sensory evaluation of tamarind yoghurt drinks was accepted by the panelists, due to role of tamarind extracts in the improvement of sensory evaluation especially flavour parameter. In spite of the production costs of tamarind yoghurt drinks slightly increased with the increase of tamarind extracts, however the profits obtained were good. Ultimately, the tamarind yoghurt drinks consider a novel dairy product in Egyptian market, and we recommended the dairy factories to produce tamarind yoghurt drink, where it will be accepted by the consumers, especially a wide sector of Egyptian likes tamarind beverage.

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إنتاج مشروب الزبادي بنكهة جديدة باستخدام مستخلص التمر الهندي

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يعتبر التمر الهندي مشروب مفضل لدي المصريين ولذلك فان إضافة مستخلص التمر الهندي (٠، ١، ٣، ٥، ٧، ٩ و ١١٪) مع مشروب الزبادي كان هو غرض الدراسة الحالية لأجل الحصول على مشروب زبادي بنكهة جديدة. فيما يتعلق بالتركيب الكيميائي للمعاملات، فقد لوحظ انخفاض معنوي في محتوى البروتين، بينما ظهرت اختلافات طفيفة غير معنوية في محتوي الجوامد الصلبة الكلية والدهن والرماد بإضافة مستخلص التمر هندي وخلال فترة التخزين والتي استمرت حتى ١٤ يوم. وقد حدثت زيادة معنوية في النسبة المئوية للحموضة وانخفاضا معنويا في قيم الأس الهيدروجيني بإضافة مستخلص التمر هندي وخلال التخزين. كما حدثت زيادة معنوية في محتوي المركبات الفينولية الكلية وفي النشاط المضاد للتأكسد بزيادة إضافة التمر هندي وقد انخفضت تلك الخصائص أثناء فترة التخزين. وقد حدث انخفاض معنوي في قيم اللزوجة وقدرة الارتباط بالماء بإضافة متخلص التمر هندي وخلال فترة التخزين. انخفضت قياسات الإضاءة وكثافة اللون وكثافة اللون الكلية معنويا بزيادة مستخلص التمر الهندي، إلا أن كل من نتائج اللون الأخضر والأصفر زادت معنوياً. من ناحية أخرى انخفضت قيم شدة الإضاءة واللون الأصفر وكثافة اللون الكلية بشكل معنوي خلال فترات التخزين. أظهرت نتائج التقييم الحسي أن المعاملات المحتوية علي ٥ و ٧٪ مستخلص التمر هندي هي أفضل المعاملات مقارنة بالمعاملات الأخرى. وأظهرت تلك المعاملات أرباح بنسبة 16.15٪ و 14.62٪ علي الترتيب.