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Research Article
Influence of Tomato Pomace Inclusion on the Chemical, Physical and Microbiological Properties of Stirred Yoghurt

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Abstract
Background and Objective: Yogurt is a poor source of fiber and antioxidant compounds. Therefore, the enrichment of yogurts with natural antioxidants and fiber is needed. Different by-products could be used to fill this gap. Therefore, the aim of this study was to evaluate the feasibility of using Tomato Pomace Powder (TPP), a by-product as a source of fiber and antioxidant in yogurt. **Materials and Methods:** sterilized dried tomato pomace powder have been added with levels of 0, 0.5, 1.0, 1.5 and 2.0% for UHT milk incubated with yoghurt starter for production of fortified yogurt and stored for 14 days. Different analysis has been occurred and the results were compared to plain yogurt as a control. Univariate Analysis of Variance (ANOVA) used when multiple comparisons were performed. **Results:** Enrichment with TPP resulted in higher acidity, total phenolic content and radical scavenging activity but lower pH and syneresis *versus* control. More TPP that was added, the darker the color that was obtained (lower L* and higher a* and b*) and positively affect on viscosity and the texture profile. One TPP (%) enriched yogurt received the highest acceptance sensory scores. Cold storage for 14 days, increased acidity, viscosity, hardness and springiness but decreased viable bacteria and sensory acceptance score. **Conclusion:** The incorporation of TPP successfully produced acceptable yogurt which can be considered a good source of dietary fiber in the human diet.

Key words: Yogurt, tomato pomace, texture profile analysis, viable starter, sensory evaluation, acceptability

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Regarding the huge increase in food products and development of food manufacturing, factory wastes have been increased, which may cause environmental and economic problems. The interests in those byproducts and the finding different ways to utilize it, especially for their high nutritional value have been recently increased. Among those waste tomato pomaces, a main byproduct of tomato paste production is rich source of fiber and antioxidant[1]. Dried tomato pomace has promising nutritional value (176.2 g kg^{-1} protein, 21.9 g kg^{-1} fat, 524.4 g kg^{-1} crude fiber and 42.1 g kg^{-1} ash) led to be new alternative for the recycling of this by product[2]. Therefore, lycopene is a promising bioactive compound used to enhance food ingredients and products. Consumption the tomato pomace with its natural gel led to maintain a healthy blood circulation by preventing blood from clotting[3].

The enrichment of yoghurt with varies fibers types have been found to enhance health outcomes. for example, it has been found to reduce cholesterol for cardiovascular health and hypercholesterolemia in addition to the inflammatory gastrointestinal diseases. Moreover, it improves glycemic control in type 2 diabetes and enhances the gut microbiotas which increase the immunity system[4].

Yoghurt with added antioxidants from natural sources becomes food reformatting to satisfy consumer needs, beneficial effects of starter cultures and health benefits of added antioxidants. Several researches focused yoghurts fortified with natural antioxidant-rich extracts including Hibiscus sabdariffa extract, apple polyphenols, grape, grape pomace, cinnamon and propolis[5-9].

Thus, the main objective of the present study was to incorporate tomato pomace powder as sources of lycopene and dietary fibers into yoghurt and to evaluate its effect on the yoghurt characteristics during storage. This new product could be a novel strategy of the present investigation to better utilize its benefits for human health.

MATERIALS AND METHODS

Study area: This study has been carried out between January and December, 2019 in the College of Agricultural and Food Sciences, King Faisal University, Kingdom of Saudi Arabia and Food, Dairy Sciences and Technology, Damanhour University, Egypt and Centro Universitario UAEM Amecameca, México.

Tomato pomace powder preparation: Tomato pomace were mechanically separated, stored at 20°C until drying, dried in an oven at 55°C for 48 h and then grinded to obtain TPP with a particle size of less than 275 µm. TPP was autoclaved at 121°C/15 min before use in yoghurt production.

Yoghurt preparation: Long life milk (UHT) was heated to 43°C, then inoculated with starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* (FD-DVS YC-X11-Yo-Flex-200U/1000L- obtained from CHR HANSEN- Denmark). After incubation at 42°C and pH 4.7 for 3.25 h, the sterile TPP was blended with yoghurt with various levels (0, 0.5, 1.0, 1.5 and 2.0%) and filled into cups. Treatments were stored at 4°C for different analysis after 1,7 and 14 days of storage.

Approximate analysis of tomato pomace powder: Determination of TPP moisture, protein, fat, ash, dietary fiber contents were estimated according to AOAC[10].

Total Phenolic Content (TPC) and radical scavenging activity (RSA): Total phenolic content (TPC) was determined according to Apostolidis *et al.*[11]. Radical scavenging activity was determined using the DPPH (1,1-diphenyl-2-picrylhydrazyl) as described by Gadow *et al.*[12].

Physicochemical characteristics of yoghurt: The pH value was measured using a pH meter (model pH 211; Hanna Instruments, Woonsocket, RI). Syneresis was determined according to Gengatharan *et al.*[13]. Colour measurement parameters was performed using scales of L, a*and b* by colorimeter (ColorFlex, HunterLab, Reston, VA).

Texture profile analysis: Texture Profile Analysis (TPA) were evaluated instrumentally using a texture analyzer (Texture Pro CT V1.2 Build 9, Brookfield Engineering Labs, Inc. USA) as described by Vital *et al.*[14].

Viscosity analysis: Yoghurt samples viscosity was measured using a rotational viscometer (DV-II+Pro Brookfield Engineering Laboratories, Inc. (USA). The analysis was carried out at 20°C by using spindle (L2) at speed of 100 rpm for all samples. The viscosity reading was recorded as (cP).

Microbiological analysis: To evaluate the growth of starter culture during the storage of the different treatments, under microaerophilic conditions at 37°C for 48 h the M-17 agar (Oxoid,) and Man Rogosa Sharpe agar (Oxoid) were used to count *Streptococci* and *Lactobacilli*, respectively. The results are given as colony-forming unit (CFU mL^{-1}).

Sensory evaluation: Tomato pomace powder enriched yoghurt and control yoghurt have been evaluated in terms of their appearance, texture, color, flavor and overall acceptability of each sample after 1, 7 and 14 days of storage using the nine-point hedonic scale according to Peryam and Pilgrim[15]. About 20 panelists with different ages and having sufficient background of scaling procedures were asked to evaluate the different treatments which have been signed with only numbers. The panelists recorded the sample number and their scale where (1 = dislike extremely and 9 = like extremely), furthermore, possible additional comments were available.

Statistical analysis: All data are presented as mean±SD for three replicates for each sample. Univariate Analysis of Variance (ANOVA) was applied using Stat graphics 16.1.11 (Stat Point Technologies, Inc. Virginia, USA) when multiple comparisons were performed. The differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Proximate chemical composition of tomato pomace and milk: Proximate chemical composition of pomace of tomato pomace powder and milk are presented in (Table 1). The tomato pomace showed higher total antioxidant comparing to milk (about 100 time) due to the high content of polyphenols compounds in tomato pomace, while milk antioxidant activity was lower as its activity is mainly due to the caseins[16].

Furthermore, results indicated that tomato pomace has high dietary fiber content (59.17±1.04 %), whereas no dietary fiber was detected in milk. Regarding the differences in chemical composition between milk and tomato pomace, the colour properties were differed as well. The obtained results for the chemical properties of the yoghurt samples enriched with tomato pomace powder in different ratios are included in Table 2. Regarding the low ratio of added TPP, the total solids, carbohydrate and fat of yoghurt samples were almost similar.

The addition of tomato pomace powder to yoghurt determined a significant ($p<0.05$) increase of total polyphenol content. The enriched yoghurt with 2% tomato pomace powder showed the highest content of phenolic compounds which was 12.56±0.33 mg GAE/100 g of yoghurt. In the control yoghurt, radical scavenging activity was 15.82±0.35 µmol TE/100 g yoghurt, respectively (Table 2). Tomato pomace powder enriched yoghurt showed higher radical scavenging activity than control yoghurt as a result of the presence of tomato pomace powder in the prepared milk and the values were ranged from16.48±0.38 and 17.56±0.31 µmol TE/100 g yoghurt.

Stirred yoghurt physiochemical properties during storage: As shown in Table 3, Control samples showed the highest pH value in the first day of storage (4.65±0.02), Instant significant decrease ($p<0.05$) have been noticed due to the addition of the tomato pomace powder which reduced the pH value to reach 4.61±0.02 and 4.47±0.02 for the 0.5 and 2% pomace addition. The reducing effect on pH value regarding the use of different dietary fibers has been previously reported by Tseng and Zhao[17], when they used grape pomace. The lowest acidity value at the first day of storage was resulted in the control sample (0.74±0.02%) while the highest one was in the 2% pomace powder treatment (0.85±0.02%). The pH values of all samples decreased during storage and this is mainly due to the increase in acidity by further metabolic activities of starter cultures during storage[17].

Table 1: Chemical composition and Color measurements of tomato pomace powder and milk used in yogurt manufacture

Parameters	Tomato pomace powder	Milk
Protein (%)	17.38±0.13	3.03±0.06
Fat (%)	7.33±0.06	3.11±0.02
Carbohydrates (%)	3.50±0.10	4.56±0.01
Total dietary fiber (%)	59.17±1.04	ND
Soluble dietary fiber (%)	5.07±0.15	ND
Insoluble dietary fiber (%)	54.10±0.52	ND
Moisture	8.92±0.07	86.28±0.63
Ash (%)	3.56±0.01	0.63±0.01
T P C (mg GAE/100 g)	403.70±5.50	5.80±0.36
Total antioxidant activity TAA (µmol TE/100 g)	71.67±2.52	6.70±0.62
Hunter color values		
L lightness	54.33±0.58	95.17±0.76
a* red (+) and green (-)	16.17±0.12	-0.77±0.06
b* Yellow (+) and blue (-)	19.33±0.15	6.03±0.15

Results are the Mean±Standard deviation of three determinations, ND: Not determined

Table 2: Chemical properties of stirred yogurt samples enriched with tomato pomace powder

Yogurt sample with TPP	Chemical parameters Total solid (%)	Protein (%)	Fat (%)	Carbohydrates (%)	Ash (%)	Total polyphenol (mg GAE/100 g)	Radical scavenging activity (μmol TE/100 g)
0% (Control)	15.09±0.37 [a]	3.11±0.07[a]	3.17±0.05[a]	4.57±0.03[a]	0.62±0.02[a]	6.47±0.38[a]	15.82±0.35[a]
0.5%	15.13±0.23[a]	3.13±0.04[a]	3.15±0.02[a]	4.61±0.02[a]	0.63±0.01[a]	6.68±0.25[a]	16.48±0.38[b]
1%	15.46±0.31[a]	3.18±0.07[ab]	3.20±0.05[a]	4.59±0.02[a]	0.64±0.02[a]	08.54±0.10[b]	16.51±0.09[b]
1.5%	15.57±0.24[a]	3.24±0.04[b]	3.18±0.06[a]	4.61±0.03[a]	0.67±0.02[b]	10.70±0.27[c]	16.78±0.29[b]
2%	15.59±0.26[a]	3.27±0.05[b]	3.22±0.03[a]	4.59±0.04[a]	0.68±0.02[b]	12.56±0.33[d]	17.56±0.31[c]

Data are Means±SD (n = 3), [a-d]Significant differences within the same column are shown by different letters at p<0.05

Table 3: pH, acidity and syneresis of different types of yogurt during storage

Parameters	Days	Treatments (% of TPP) 0% (Control)	0.5%	1%	1.5%	2%
pH	1	4.65±0.02[i]	4.61±0.02[h]	4.60±0.03[h]	4.53±0.01[g]	4.47±0.02[ef]
	7	4.53±0.03[g]	4.47±0.02[fg]	4.45±0.04[def]	4.35±0.06[cd]	4.30±0.02[bc]
	14	4.41±0.05[de]	4.38±0.04[cd]	4.26±0.03[b]	4.16±0.03[a]	4.15±0.03[a]
Acidity (lactic acid) %	1	0.74±0.02[a]	0.76±0.01[a]	0.81±0.02[b]	0.84±0.02[bc]	0.85±0.02[c]
	7	0.86±0.02[cd]	0.89±0.01[de]	0.90±0.03[e]	0.96±0.01[gh]	0.97±0.02[h]
	14	0.91±0.03[ef]	0.94±0.01[fg]	0.97±0.01[h]	0.99±0.02[i]	0.98±0.03[i]
Syneresis (%)	1	42.50±1.32[h]	40.33±1.53[fgh]	38.57±1.63[ef]	35.15±1.24[bcd]	34.50±1.95[abc]
	7	41.87±1.50[gh]	42.40±2.26[h]	39.40±2.12[efg]	35.19±2.30[cd]	32.15±0.87[a]
	14	42.60±0.56[h]	40.50±1.04[fgh]	37.57±1.82[de]	34.82±0.46[bc]	32.51±1.89[ab]

[a-j]Significant differences within the same columns and rows in the same parameter are shown by different letters at p<0.05, data are Means±SD (n = 3)

Table 4: Hunter color values of different types of yogurt during storage

Hunter color values	Days	Treatments (% of TPP) 0% (Control)	0.5%	1%	1.5%	2%
L lightness	1	95.60±0.95[g]	92.17±1.16[ef]	84.67±1.80[d]	81.01±0.95[c]	75.63±1.18[b]
	7	94.80±1.06[g]	91.28±0.85[e]	83.63±1.48[d]	79.27±1.55[c]	73.67±0.58[ab]
	14	94.13±1.21[fg]	92.20±2.01[ef]	84.23±1.31[d]	78.87±1.21[c]	73.04±1.96[a]
a*Red (+) and green (−)	1	-0.80±0.02[a]	2.10±0.20[b]	4.37±0.38[c]	6.53±0.46[d]	7.07±0.31[e]
	7	-0.72±0.03[a]	2.23±0.32[b]	4.87±0.31[c]	6.20±0.26[d]	7.27±0.46[ef]
	14	-0.53±0.03[a]	2.43±0.35[b]	4.73±0.25[c]	6.43±0.40[d]	7.60±0.36[f]
b*Yellow (+) and blue (−)	1	6.23±0.25[a]	8.63±0.32[c]	10.28±0.26[e]	11.83±0.29[g]	13.10±0.36[h]
	7	6.93±0.12[b]	9.03±0.45[cd]	10.33±0.58[e]	12.13±0.32[g]	13.00±0.20[h]
	14	7.30±0.26[b]	9.47±0.46[d]	11.03±0.25[f]	12.07±0.46[g]	13.33±0.45h

Data are Means±SD (n = 3), [a-j]Significant differences within the same columns and rows are of the same parameter shown by different letters at p<0.05

As shown in Table 3, the addition of tomato pomace powder led to reduce the syneresis value. This decreasing in syneresis effect of tomato pomace powder is probably due to increasing in water holding capacity by the fiber contents in yoghurt as well known that fiber may act as a stabilizer due to its capacity for binding water which positively affect the syneresis properties. Yoghurt colour was evaluated for the different treatments during cold storage for 14 days by colorimetry and the values of L*, a* and b* obtained according to the CIE colour scale was summarized in (Table 4). All supplemented samples with TPP were darker than control. On the other hand, this substitution had significantly higher effect on a* and b* values than the control sample. These higher values of red and yellow colours (a* and b*) are almost due to the high lycopene content in tomato pomace.

Furthermore, the Increasing the TPP level significantly (p<0.05) increased a* and b* values and decreased L* values. Among the TPP enriched yogurt, the highest TPP concentration 2% led to has the highest a* value 7.07±0.31 and b* values 13.10±0.36 and the lowest L value 75.63±1.18, in contrary to the lowest TPP concentration 0.5% where the a* and b* values were the lowest and the L* value was the highest.

During cold storage period, no significant changes in colour parameters were noticed among the different treatments.

However, other studies declared that comparing to plan yogurt, the fortification of yogurt with different fibers such as inulin, pea, oat, wheat or bamboo did not affect yogurt color as reported by Dabija *et al.*[18]. But in this study the most

Table 5: Texture profile and viscosity of different types of yogurt during storage

Parameters	Days	Treatments (% of TPP) 0% (Control)	0.5%	1%	1.5%	2%
Hardness (g)	1	104.80 ± 3.8^{a}	119.30 ± 4.2^{b}	137.90 ± 2.8^{c}	153.30 ± 5.5^{d}	165.30 ± 5.9^{e}
	7	138.30 ± 7.3^{c}	150.70 ± 6.0^{d}	173.80 ± 5.5^{ef}	184.00 ± 4.6^{g}	207.10 ± 6.6^{h}
	14	167.00 ± 6.2^{e}	180.70 ± 8.0^{fg}	211.30 ± 7.1^{h}	231.70 ± 6.7^{i}	246.80 ± 7.3^{j}
Gumminess (g)	1	41.80 ± 1.3^{a}	43.80 ± 0.8^{ab}	45.30 ± 0.6^{bc}	48.20 ± 0.9^{cd}	52.40 ± 2.7^{ef}
	7	44.90 ± 1.4^{b}	51.70 ± 2.1^{ef}	54.60 ± 2.3^{fgh}	56.30 ± 1.1^{gh}	61.80 ± 3.0^{i}
	14	50.60 ± 1.3^{de}	53.30 ± 2.1^{3fg}	57.30 ± 2.1^{h}	66.60 ± 2.5^{j}	71.70 ± 2.1^{k}
Adhesiveness (g sec^{-1})	1	-59.90 ± 1.2^{k}	-69.60 ± 1.4^{j}	-75.10 ± 1.9^{i}	-82.40 ± 1.5^{h}	-88.10 ± 2.0^{g}
	7	-82.40 ± 2.2^{h}	-94.20 ± 2.7^{f}	-103.60 ± 3.3^{e}	-104.10 ± 3.6^{e}	-112.80 ± 3.9^{d}
	14	-102.70 ± 3.5^{e}	-111.70 ± 3.8^{d}	-122.40 ± 1.7^{c}	-131.70 ± 3.4^{b}	-138.40 ± 4.2^{a}
Cohesiveness	1	0.43 ± 0.01^{cde}	0.44 ± 0.01^{def}	0.44 ± 0.01^{efg}	0.45 ± 0.01^{fg}	0.45 ± 0.01^{fg}
	7	$0.41\pm0.01a^{b}$	0.43 ± 0.10^{bcd}	0.43 ± 0.02^{cde}	0.43 ± 0.01^{bcd}	0.46 ± 0.02^{g}
	14	0.40 ± 0.02^{a}	0.42 ± 0.01^{bc}	0.43 ± 0.01^{bcd}	0.44 ± 0.01^{efg}	0.45 ± 0.01^{fg}
Springiness (mm)	1	41.73 ± 1.30^{bc}	45.03 ± 0.95^{fgh}	44.23 ± 0.71^{efg}	46.47 ± 1.01^{h}	49.57 ± 1.40^{i}
	7	40.60 ± 1.25^{b}	43.67 ± 1.17^{def}	43.43 ± 1.52^{def}	44.40 ± 0.53^{efg}	46.13 ± 1.00^{gh}
	14	38.43 ± 1.56^{a}	41.83 ± 1.61^{bc}	42.57 ± 0.64^{cd}	42.97 ± 1.00^{de}	45.13 ± 0.96^{fgh}
Viscosity (cP)	1	1972.00 ± 45^{a}	2410.00 ± 53^{b}	2690.00 ± 53^{c}	2784.00 ± 97^{c}	2969.00 ± 69^{de}
	7	2770.00 ± 113^{c}	2815.00 ± 110^{cd}	2812.00 ± 115^{c}	3043.00 ± 74^{ef}	3123.00 ± 92^{efg}
	14	3225.00 ± 89^{gh}	3197.00 ± 91^{fgh}	3312.00 ± 97^{hi}	3254.00 ± 57^{ghi}	3382.00 ± 95^{i}

Data are Means±SD (n = 3), $^{a-k}$Significant differences within the same columns and rows for the same parameter are shown by different letters at $p<0.05$

affected value was the (a*) regarding the red color of TPP, whereas in different studies using different fibers such as commercial apple fiber, orange fiber, asparagus fiber, date fiber and different grape seeds have affected the yogurt color and final color was brownish color, yellowish color or yellow-greenish depending on the fiber color properties[19,20]. This outcome revealed that the color parameters values are mainly affected by the type of added fiber and that yogurt final color is dependent on the color of the fiber source.

Textural properties: Rheological properties of yoghurt are affected by the chemical composition of yoghurt, mainly on the total solids, particularly the content and type of protein, in addition to proteolysis and degradation and yoghurt acidity[21]. Furthermore, other factors could affect the rheological properties due to some physical properties of milk and the type and concentration of starter, fermentation time and storage temperature[22].

As shown in Table 5, the addition of TPP had significantly higher hardness, gumminess and springiness values compared with the control while a lower adhesiveness values were observed, furthermore, the cohesiveness was the lowest affected parameter. Addition of 2% showed the most affected percentage resulted in the significant highest hardness 165.3±5.9 g whiles the control sample showed the lowest value 104.8±3.8 g. The increasing of the hardness comparing to the control sample may be related to moisture absorbing effect of TPP, whereas the fiber is well known with its higher water-holding capacity.

Yoghurt adhesiveness found to be a positive effect on the thickness of the yoghurt and is used as one of the judgments parameters on the products stability during storage. The lowest adhesiveness values were found in case of using 2% TPP. On the other hand, the control sample showed the highest adhesiveness value. Similar results were obtained[16,20,23] as they found a decrease in adhesiveness with increasing cellulose fiber, date fiber and inulin respectively. The rheological parameters showed different behavior during the cold storage whereas a general change has been noticed. These changes are mainly depending on the change in acidity, the interaction of protein-protein and its rearrangements in the acid casein gels which continue during cold storage[24].

The hardness and gumminess were significantly increased with the progress of storage. After 14 days of refrigerated storage, hardness and gumminess of control yoghurt increased systematically to reach 167.0±6.2 g and 50.6±1.3 g, respectively, however the effect of TPP addition kept its increasing effect during the storage. With the progress of cold storage, the adhesiveness and springiness values were significant decrease and reached the lowest values at the end of storage period. The reduction rate in the adhesiveness were differently between control and TPP treatments, more over was depending on the TPP concentration. The adhesiveness and springiness reduction at the end of cold storage was in accordance with the earlier findings of Ayar and Gurlin[25]; Güler-Akın *et al.*[23] and Helal and Tagliazucchi[8]. Enrichment of yoghurt with TPP could increase the viscosity depending on its effectiveness on water binding and subsequently are forming

Table 6: *Streptococcus thermophilus* and *Lactobacillus bulgaricus* accounts of different types of yogurt during storage

		Treatments (% of TPP)				
Log (CFU mL^{-1})	Days	0% (Control)	0.5%	1%	1.5%	2%
Streptococcus thermophilus	1	8.60	8.53	8.78	9.01	9.10
	14	8.48	8.63	8.58	8.93	9.13
Lactobacillus bulgaricus	1	7.24	7.33	7.37	7.57	7.83
	14	6.07	6.36	6.35	6.69	6.63

a gel-like network within the yoghurt matrix affecting the microstructure and the viscosity. The addition of 0.5, 1.0, 1,5 and 2.0% TPP has increased the viscosity respect to control (Table 5). In similar study on using orange fiber to enrich yogurt, viscosity increased with increasing fiber dose and fiber particle size[22]. Results of viscosity are in line with the findings of previous studies[8,26].

Among all the treatments, the viscosity value was, generally, increased by increasing of storage time. the control yoghurt sample, significant increased and the increasing rate during storage was the highest, on the other hand, TPP enriched yoghurt treatments showed slower increase, thus at the end of cold storage there was not much vary in viscosity values between the control sample and the TPP enriched treatments. In case of control samples, the only factors which could affect the viscosity during storage is the modification of total solids and acidity which led in increasing of viscosity during storage another hypothesis was reported by Sahan *et al.*[27] as they found that rearrangement of protein matrix interaction during the storage could increase yoghurt viscosity.

Bacterial counts: The addition of tomato pomace powder influenced the survival and viable count of starter strains during storage conditions, whereas both *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* had survived in tomato pomace powder enriched yoghurt. *Streptococcus thermophilus* viable counts in the tomato pomace powder enriched yoghurt were significant higher comparing to the control treatment in the 1st day of storage. The higher tomato pomace powder concentration the higher *Streptococcus thermophilus* viable count was achieved 8.60, 8.53, 8.78, 9.01 and 9.10 log CFU mL^{-1} in control yogurt , 0.5% TPP enriched yogurt, 1% TPP enriched yogurt, 1.5% TPP enriched yogurt and 2% TPP enriched yogurt, respectively (Table 6). This improvement effect could be due to the stimulated growth of *Streptococcus* species by tomato pomace powder[23]. Different previous outcome showed different behavior effect of fibers on viable count of starter strains. for examples, studies by Güler-Akın *et al.*[23] and Sendra *et al.*[22] reported that *Streptococcus thermophilus* counts increased by the fortification of yogurt with apple fiber, cellulose fiber and orange fiber, respectively. On the other hand, Marchiani *et al.*[28] reported that the addition of grape pomace to yogurt did not affect the survival of starter strains. The final viable concentration of *Streptococcus thermophilus* after 14 days of cold storage in control yoghurt was 8.48 log CFU mL^{-1}, whereas for the enriched yoghurt was 8.63, 8.58, 8.93 and 9.13 log CFU mL^{-1} for 0.5, 1.0, 1.5 and 2.0% TPP, respectively. Fortification of Tomato pomace powder with different concentrations cause significant change in the viable count of lactic acid bacteria compared to the control. At the first day of storage the average recorded viable counts of *Lactobacillus bulgaricus* for the control treatment were 7.24 log CFU mL^{-1} where it slowly increased with increasing the TPP levels 7.33, 7.37, 7.57 and 7.83 log CFU mL^{-1} for 0.5, 1.0, 1,5 and 2.0% TPP, respectively. The effect of TPP addition on *Lactobacillus* growth were more noticeable during the cold storage, although there was significant decrease of the viable counts of *Lactobacilli* during cold storage among all the treatments and control but the addition of TPP lowest reducing rate resulted in remaining the count of *Lactobacillus* more than control. After 14 days of cold storage, the 1.5% TPP enriched yoghurt showed the lowest reducing rate 12% while the control sample showed the highest rate 17%.

However, there were significant decrease in all the treatments during storage but it was remained in normal range. The final viable concentration of *Lactobacillus bulgaricus* after 14 days of cold storage which was 6.07, 6.36, 6.35, 6.69 and 6.63 log CFU mL^{-1}, for control yogurt , 0.5% TPP enriched yogurt, 1 % TPP enriched yogurt, 1.5% TPP enriched yogurt and 2% TPP enriched yogurt, respectively) . In different studies on using different fibers sources in yogurt or other fermented products, it was found that some fibers could increase probiotic and starter bacteria viability during fermentation process and storage and that results were also concentration dependable[23].

Sensory evaluations: Fortifying yoghurt with TPP had a significant effect on all sensory properties (Fig. 1a-e). The control sample was acceptable and exhibited the highest scores in the majority of sensorial parameters especially in

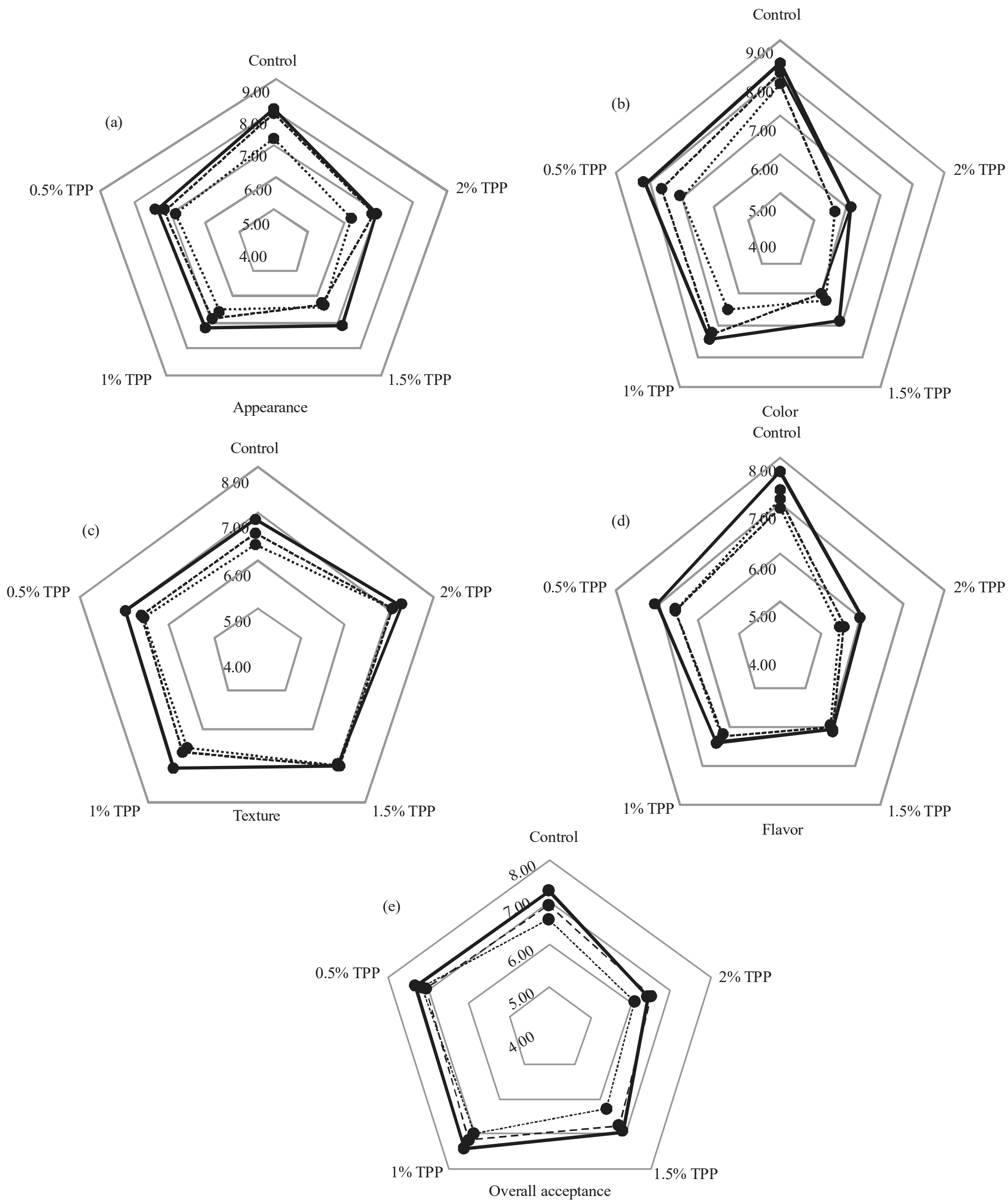

Fig. 1(a-e): Graphical representation of the sensory evaluation parameters, (a) Appearance, (b) Color, (c) Texture, (d) Flavor and (e) Overall acceptance of control and TPP enriched yogurt samples during cold storage
Solid line: Day 1, Round dot line: Day 7, Dash line: Day 14

colour and appearance (Fig. 1 a-b). The addition of TPP had significantly lower ratings for appearance, colour and flavor comparing to control treatment (Fig. 1a, b and d). Furthermore, this lowering effect was TPP concentration dependable. The using of 0.5% TPP showed comparable results to the control treatment appearance, colour and overall acceptability (Fig. 1a, b and e), while the using of 2% TPP resulted in significant lowering in appearance and colour of yoghurt, however it was still in the accepted range.

The addition of tomato pomace powder had influenced the yogurt texture properties. It was clear that increasing of TPP percentage led to significant improvement of yogurt texture and that was clear in the score of the different samples (Fig. 1c). The 2% TPP enriched yogurt showed the highest score 7.30±0.44 while the control sample showed the lowest value 6.87±0.32. Many researchers reported that the texture properties of yogurt are affected differently depending on the type of fiber source 4, 2s.

Furthermore, Dello Staffolo *et al.*[4] found that the addition of fiber improved the yogurt texture regarding their properties to increase the holding capacity which act as a stabilizer of high fat yogurt which led to improve the viscosity properties and gel forming. The high concentration of TPP had a negative effect on yoghurt flavour as well, the fortification of 2% TPP resulted in the lowest score among the different treatments as it received 5.97±0.37, In contrast this negative effect was deceased in case of the present of low TPP concentration such as the using of 0.5% as it gained 7.02±0.69 which was comparable to the control treatment 7.66±0.34 (Fig. 1d). Storage had negative effect on the majority of sensory scores of the samples which was decreased during storage, however it was still in the accepted range from the panelists.

Previous studies found that the addition of fibers to yogurt affect the sensory evaluation depending on the type of fibers used and its concentrations as well, these effects could be positive or negative[18,20,23,28,29].

Tomato pomace is a by-product of tomato paste production, is known as source of dietary fiber and antioxidant compounds. Regarding the poor of milk of dietary fibers, this addition of TPP as dietary fiber to yoghurt would improve its healthy characteristics. It was successfully produced enriched yoghurt with different concentration of TPP (0.5, 1, 1.5 and 2%). The addition of TPP to yoghurt resulted in a significant increase in the total polyphenols content and radical scavenging activity with respect to control yoghurt. Regarding the difference concentrations of TPP, the 2% addition showed the highest TPC and RSA values. The obtained results in this study suggested the ability to maximize the utilization of the TPP which is by product as an alternative source of dietary fibers and antioxidants in yoghurt.

CONCLUSION

Tomato pomace, a by-product of tomato paste production, is known as source of dietary fiber and antioxidant compounds. Regarding the poor of milk of dietary fibers, this addition of TPP as dietary fiber to yoghurt would improve its healthy characteristics. It was successfully produced enriched yoghurt with different concentration of TPP (0.5, 1, 1.5 and 2%). The addition of TPP to yoghurt resulted in a significant increase in the total polyphenols content and radical scavenging activity with respect to control yoghurt. The obtained results in this study suggested the ability to maximize the utilization of the TPP as an alternative source of dietary fibers and antioxidants in yoghurt.

SIGNIFICANCE STATEMENT

This study discovers the possible use of tomato pomace in enrichment yoghurt that can be beneficial for enhancing the nutritional value of yoghurt. Thus, a new theory on the utilization of tomato pomace byproduct and possibly other byproduct, may be arrived at.

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