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Effect of tomato seed supplementation on chemical and nutritional properties of tarhana

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Abstract Tomato paste waste materials are rich in bioactive food ingredients and have a low economic value. In this research, the potential use of tomato seeds, a part of tomato waste materials, in tarhana was studied. During the production of tarhana, wheat flour of tarhana was partially (15, 25 and 35%) substituted with tomato seed meal. Protein, oil, dietary fiber, ash, mineral contents (Mg, Ca, K, P, Mn, Zn, Fe, Cu), amino acid compositions, total phenolic contents, antioxidant activity values, color values and sensory properties of tarhanas were analyzed. It was found that the protein, oil, insoluble dietary fiber, total dietary fiber, ash, mineral and total phenolic contents, and antioxidant activity values of tarhanas increased by increasing the amount of tomato seed meal in the formulation ($P<0.05$). Substitution of tomato seed instead of wheat flour also increased lysine, phenylalanine, threonine, serine, alanine, glycine, histidine, aspartic acid, arginine and tyrosine contents of tarhanas significantly ($P<0.05$). The results of color analysis showed that higher substitution levels of tomato seed instead of wheat flour decreased L values significantly ($P<0.05$). Although all of the tarhana samples received sensory scores higher than the mid of hedonic scale, C (control) tarhana and tarhana having 15% of tomato seed received the best liking scores ($P<0.05$).

Keywords Tomato seed · Tarhana · Chemical composition · Amino acid composition · Mineral content · Total phenolics

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Introduction

Tomato (*Lycopersicon esculentum* L.) is one of the major vegetable crops throughout the world [1]. Around the world, nearly 37 million tons of tomatoes are used in the industry in a year [2]. Most of the world's tomato crop is processed into tomato paste, which is used as an ingredient in many products, such as sauces, ketchup and soups [3].

The problems of industrial waste are becoming harder to solve, and much effort will be needed to develop the nutritional and industrial potential of by-products, waste and under-utilized agricultural products [4]. The industrial processing of tomato leads to by-products, namely tomato seeds, peels, pulp and cores representing 10–30% of total processed tomatoes [5]. The wet tomato pomace contains 33% seeds, 27% peels and 40% pulp, while the dried pomace contains 44% seeds and 56% pulp and peels [6, 7]. Tomato seeds are the major constituent of the pomace and they are rich in nutritional value. They contain 20.2–33.9% protein, 6.4–36.9% lipids and 34.7–40.2% total dietary fiber in dry basis [8–13]. It is also underlined in some studies that they are rich in mineral matters [12, 13]. Tomato seed protein has been found to have a high lysine content; therefore, could substantially improve the protein quality of cereal products, which are low in lysine [9].

Fermented foods are an important part of diets in many parts of the world. As a fermented product tarhana is the dry form of yoghurt-cereal mixture and form an important part of the diets of many people in Turkey. Tarhana is prepared by mixing yoghurt, wheat flour and a variety of vegetables and spices (tomatoes, onions, paprika, salt and mint) followed by fermentation for several days, drying the mixture and grinding it to a partical size of <1 mm [14, 15]. Tarhana has an acidic and sour taste with a strong yeasty flavour, and it can be readily reconstituted for soup making.

It is a good source of proteins, vitamins, and minerals, and therefore it is used largely for feeding children and elderly people [15, 16]. There are some other food products similar to tarhana such as kishk in Egypt, Syria and Jordan, trahana in Greece, turkhana in Bulgaria, kushuk in Iraq and Iran, tahonya/talkuna in Hungary and Finland and tarana in Serbia [17, 18].

It is thought that tarhana could be an alternative food for the consumption of tomato seeds which are rich in biologically active compounds. Thus, in this study, wheat flour was substituted with tomato seed meal at different levels in tarhana production, and chemical, sensory and color properties of tarhanas were determined.

Materials and methods

Materials

Commercial wheat flour (Type 550), yoghurt, tomato, paprika, onion, compressed baker's yeast in wet form, dry mint, and salt used in this study were purchased from local markets in Denizli, Turkey. The yoghurt was full-fat set yoghurt made of cow's milk. Tomato waste materials were provided from Honaz Paste Plant (Honaz, Denizli, Turkey).

Preparation of seed meal

Preparation of seed meals were carried out as stated in Isik and Yapar [19]. At the beginning, wet pomace of tomato was put into water in a large saucepan. After waiting for a few minutes, the seeds settled down at the bottom of the saucepan, and other materials were allowed to come to the surface of the water. Then, the materials floating on the surface of the water were removed manually and the seeds were taken from the deep of water. Wet seeds were dried in a cabinet dryer and after drying, foreign materials were separated from them. Then, the seeds were ground to a particle size of <400 µm.

Preparation of tarhana

In this study, control (traditional) tarhana (C) was prepared without any tomato seed meal. In tomato seed meal enriched tarhana samples, wheat flour was replaced with 15, 25 and 35% (w/w) (TS15, TS25 and TS 35) tomato seed meal. Formulations of tarhana samples are given in Table 1.

Firstly, tomatoes, paprika and fresh onions were cut into small pieces and brought to boil separately in stainless steel saucepans. After simmering for 10 min, the purees were left to cool to room temperature. Then the ingredients were calculated as mentioned in Table 1 and the mixtures were kneaded (Inoksan, MPM-40) at 50 rpm for 5 min. During kneading, the water in tarhana doughs having tomato seed meal was absorbed too much and the doughs couldn't get the proper structure. To prevent this problem, additional water (Table 1) was used in the tarhana formulations having tomato seed meal. After kneading, the doughs were put into plastic containers and fermented at 30 °C until the acidity value exceeded 15 [20].

Table 1 Formulations of control tarhana and tarhana with tomato seed meals

Ingredient	C	TS15	TS25	TS35
Wheat flour (g)	1000	850	750	650
Waste material (g)	–	150	250	350
Yoghurt (g)	500	500	500	500
Tomato puree (g)	120	120	120	120
Paprika puree (g)	120	120	120	120
Onion puree (g)	120	120	120	120
Salt (g)	20	20	20	20
Yeast (g)	20	20	20	20
Water (mL)	–	10	15	20
Mint powder (g)	2	2	2	2

C control tarhana, *TS15* tarhana of whose 15% of wheat flour was substituted with tomato seed, *TS25* tarhana of whose 25% of wheat flour was substituted with tomato seed, *TS35* tarhana of whose 35% of wheat flour was substituted with tomato seed

After fermentation, the tarhana doughs were separated into small pieces of about 5–6 g and dried in a cabinet dryer at 50 ± 1 °C until a moisture content of about 10% was reached. Then, the samples were ground with a grinder to a particle size of <400 µm.

Preparation of tarhana soup for sensory analysis

Tarhana soups were cooked as mentioned in Isik and Yapar [19]. Soups having the recipe of tarhana powder (4.5%), water (88.3%), corn oil (4.5%), tomato paste (2.2%) and salt (0.5%) were used for sensory evaluation. Firstly, 25% of initial water was added to tarhana powder for dissolving the powder and the mixture was stirred continually. Corn oil was heated to about 150 °C in a saucepan, and tomato paste was fried for 2 min until the tomato paste blended in well. Then, the tarhana powder-water mixture, remaining water and salt were added and they were heated gently with stirring until boiling. After starting to boil, the mixture simmered for 15 min and then cooled to 70 °C for sensory evaluation.

Analytical measurements

Proximate composition

Total solids, ash, protein and fat contents of the tarhana samples were determined according to the methods of AOAC [21].

Dietary fiber content was determined with the fiber assay kit (Megazyme K-TDFR, Wicklow, Ireland) according to the Mes-Tris AOAC method 991.43 [23] and AACC 32-07 [24]. Briefly, samples suspended in the Mes-Tris buffer were sequentially digested by heat-stable α-amylase, protease, and amyloglucosidase to remove starch and protein. Insoluble dietary fiber was recovered from the enzyme digestate after filtration. Soluble dietary fiber in the filtrate was precipitated with ethanol and filtered. All dietary fiber fractions collected were dried at 103 ± 2 °C for a night. Total dietary fiber content was calculated as the sum of insoluble and soluble dietary fiber contents. All dietary fiber contents were corrected for residual protein, ash, and blank.

Amino acid composition

Amino acid compositions of the samples were determined by the method of Erkan et al. [25]. The samples were prepared in accordance with the hydrolysis technique described by Waters AccQ·Tag Chemistry Package Instruction Manual (Waters AccQ·Tag Chemistry Package Instruction Manual 1993). The samples were hydrolysed with 6 M hydrochloric acid having 1 g/L phenol.

The high performance liquid chromatograph (HPLC) system [Shimadzu LC-10 VP (Kyoto, Japan)] was used for the determination of amino acid compositions. The results were calculated with the computer program of Class-VP 6.14 (Shimadzu, Kyoto, Japan). Eluent A used in the analysis was 200 mL AccQ·Tag™ Eluent A (WAT052890, Waters Corporation, Milford, USA)/2 L water and eluent B was acetonitrile/deionizer water (6:4). Injection volume was 5 µL and flow rate was 1 mL/min. A fluorescence detector and silica base C18 column (AccQ·Tag™ amino acid analysis column, dimensions: 150×3.9 mm, particle size:4 µm, Waters Corporation, Milford, USA) were used. Oven temperature was 37 °C.

Mineral composition

Inductively coupled plasma optical emission spectrometer (ICP-OES, Perkin Elmer, Optima 2100 DV, Massachusetts, USA) was used to determine the mineral elements (Mg, Ca, K, P, Mn, Zn, Fe and Cu) of tomato seeds and the tarhana samples. In the pretreatment stage, samples were ashed in a muffle furnace according to AOAC 985.35 [26] and dissolved in 1 N HNO_3.

The optimal operation conditions for ICP-OES analysis of mineral matters were as follows: RF power, 1.5 W; plasma gas (Ar) flow rate, 15 L/min; auxiliary gas (Ar) flow rate, 0.2 L min; nebulizer flow rate, 0.6 L/min; sample flow rate, 1.5 mL/min; delay time, 10 s; ambient temperature, 24 °C. Sensitive wavelengths for mineral identification were obtained from the tables provided by the manufacturer [27].

Total phenolic content and antioxidant activity

For the extraction of phenolics, 1 g of tarhana samples were mixed with 10 mL of aqueous methanol (70: 30, v/v). The mixture was sonicated for 10 min in an ultrasonic bath (E 60 H Model, Elma Co., Germany), followed by mechanical shaking (WiseShake SHO-1D, Wertheim, Germany) for 15 min at room temperature. After the centrifugation of the mixture (Universal 30 RF, Hettich Co., Germany) at 26,000×*g* at 4 °C for 20 min, clear supernatants were collected into amber vials. Total phenolic content and antioxidant capacity of these extracts were performed in duplicates.

Total phenolic contents of tarhana extracts were determined with the Folin- Ciocalteu reagent according to the method of Singleton et al. [28] using gallic acid as a standard. 1 mL of extracts were pipetted into test tubes, and then 5 mL of diluted Folin–Ciocalteu's reagent and 4 mL of Na_2CO_3 (7.5%) were added. After incubating the mixtures at 30 °C for 2.0 h in dark, the absorbance values were measured at 760 nm using a spectrophotometer (PG-80 UV–Vis Spectrometer, PG Instruments, England). Results were expressed as milligrams of gallic acid equivalent (GAE) per 100 gram of dry weight.

2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay was used to determine the antioxidant activity of tarhana extracts according to the method of Thaipong et al. [29]. The stock solution was prepared by dissolving DPPH (24 mg) in methanol (100 mL) and then stored at −20 °C until use. The working solution was obtained by mixing stock solution (10 mL) with methanol (45 mL) to obtain an absorbance value of about 1.10 ± 0.02 units at a wavelength of 515 nm. Tarhana extracts (150 µL) were allowed to react with the working solution (2850 µL) for 24 h in dark. Later, the absorbances were taken at 515 nm. The standard calibration curve was linear between 25 and 800 µM Trolox. Results were expressed in µmol Trolox equivalent (TE)/100 g dry weight.

Color measurement

Color parameters *L* (lightness), +*a* (redness) and +*b* (yellowness) were determined by a Hunter LabMini Scan XE model colorimeter (Reston,VA, USA) [22].

Sensory analysis

A panel of 56 subjects in the Department of Food Engineering (Pamukkale University, Denizli, Turkey) evaluated the sensory properties of tarhana soups, and gave scores for color, smell, flavor, consistency and overall acceptance on a hedonic scale from 1 (dislike extremely) to 7 (like extremely). The panel consisted of students, staff and faculty members (30 females, 26 males), and 80% of the subjects were between 18 and 25, 11% between 26 and 40 years old, and 9% older than 40 years. Approximately 60 mL of tarhana soup at about 70 °C was presented to each panelist in the sensory analysis. The samples were labeled with randomly selected three-digit numerical codes. In performing the test, panellists were instructed to rinse their mouths with water, and to eat unsalted crackers between samples. The panel was performed in partitioned boots equipped with daylight.

Statistical analysis

Data were analysed using "Minitab 13 Statistical Software". To determine significant differences at $\alpha = 0.05$, ANOVA (one-way analysis of variance) with Tukey's multiple comparison test was performed.

Results and discussion

Crude protein, crude oil, crude ash, soluble, insoluble and total dietary fiber contents, mineral (Mg, Ca, K, P, Mn, Zn, Fe, Cu) and amino acid compositions of wheat flour and tomato seed meal are given in Table 2. As seen in the table, tomato seed meal has significantly higher values of components than wheat flour. The results also show that tomato seed has a lysine content nearly 5 times higher than wheat flour which is poor in lysine (Table 2).

In some other studies it was mentioned that tomato seed had a protein content of 20.23–25.00%, oil content of 19.9–36.9%, dietary fiber content of 36.61–40.71% and ash content of 3.240–5.180% [8, 10–12]. Our results were mostly similar to those reported in the literature. The small differences can be due to several factors including climate, geography, geochemistry, agricultural practices like fertilization and the genetic composition [30]. The results of other studies [10, 31, 32] also show that tomato seed has higher mineral matter and amino acid contents than wheat flour.

Table 2 Chemical compositions and color values of wheat flour and tomato seed meal

	Wheat flour	Tomato seed meal
Crude protein (%)*	11.93	30.66
Crude oil (%)*	1.25	26.61
Total dietary fiber (%)*	2.95	34.65
Soluble dietary fiber (%)*	1.41	4.11
Insoluble dietary fiber (%)*	1.54	30.54
Crude ash (%)*	0.470	3.887
Mg (ppm)*	430.6	5037.1
Ca (ppm)*	395.0	1347.6
K (ppm)*	1920.6	9765.3
P (ppm)*	1485.7	10737.6
Mn (ppm)*	9.5	77.7
Zn (ppm)*	13.2	96.8
Fe (ppm)*	21.1	240.9
Cu (ppm)*	2.9	18.8
Amino acid composition (mg/100 g)*		
Lysine	325.0	1670.2
Leucine	878.9	1691.3
Isoleucine	516.6	1186.7
Phenylalanine	630.8	1337.1
Methionine	210.0	684.5
Valine	708.8	1394.7
Threonine	400.7	1048.2
Alanine	360.1	2036.9
Glycine	495.8	1418.0
Aspartic acid	497.1	2894.1
Glutamic acid	4060.4	4838.9
Serine	569.4	1356.9
Hystidine	302.9	713.3
Arginine	434.6	2695.7
Proline	1458.8	1381.0
Cysteine	168.7	256.2
Tyrosine	347.2	1132.1
Hunter color values		
L	94.33	49.86
a	0.42	3.38
b	9.15	9.95

*Values are in dry basis

Table 3 shows the chemical composition of tarhana samples. It was found that the protein, oil, insoluble dietary fiber, total dietary fiber and ash contents of the tarhanas increased by increasing the amount of tomato seed meal in the formulation and tarhanas having 35% of tomato seed meal had significantly ($P < 0.05$) higher contents than others. The reason is most likely that the tomato seed has higher protein, oil, insoluble dietary fiber, total dietary fiber and ash contents than wheat flour (Table 2).

Table 3 Chemical compositions of tarhana powders

Tarhana sample	Crude protein (%)*	Crude oil (%)*	Dietary fiber*			Crude ash (%)*
			Soluble dietary fiber (%)*	Insoluble dietary fiber (%)*	Total dietary fiber (%)*	
C	14.86 ± 1.22b**	2.27 ± 0.24d	1.03 ± 0.03a	1.47 ± 0.07d	2.50 ± 0.10d	2.958 ± 0.338b
TS15	16.74 ± 1.45ab	6.17 ± 0.24c	1.17 ± 0.10a	6.19 ± 0.13c	7.36 ± 0.23c	3.998 ± 0.004 a
TS25	18.57 ± 1.74ab	9.03 ± 0.28b	1.21 ± 0.09a	9.32 ± 0.17b	10.53 ± 0.26b	4.140 ± 0.069 a
TS35	21.37 ± 1.29a	12.02 ± 0.42a	1.34 ± 0.14a	12.36 ± 0.37a	13.70 ± 0.51a	4.256 ± 0.165 a

*In dry basis

**Different letters within the column across the table show significant differences at α = 0.05

Protein and dietary fiber intake provides many health benefits. Proteins are an essential component of the diet needed for the survival of humans and animals. Their function in nutrition is to supply adequate amounts of needed amino acids for the metabolism [31]. A generous intake of dietary fiber reduces the risk of developing the following diseases: coronary heart disease, stroke, hypertension, diabetes, obesity and certain gastrointestinal disorders [34]. In this case, an increase in the protein content and dietary fiber content of foods could be useful for health.

Although the addition of tomato seed meal increased the soluble dietary fiber contents of the tarhanas, the differences in values were statistically insignificant ($P > 0.05$).

Amino acid compositions of tarhana powders are given in Table 4. The results show that the substitution of tomato seed instead of wheat flour increased the lysine, phenylalanine, threonine, serine, alanine, glycine, histidine, aspartic acid, arginine and tyrosine contents of the tarhanas. It was determined that tarhanas having 25 and 35% of tomato seed meal in formulation had significantly ($P < 0.05$) higher contents of essential amino acids of lysine, phenylalanine, threonine, histidine and arginine than C tarhana. Tarhana having 15% of tomato seed meal had also higher ($P < 0.05$) arginine content than C tarhana. The results also indicate that control tarhana had significantly lower alanine, aspartic acid and tyrosine contents than othen tarhanas. The reason for these results is most likely that the tomato seed meal had these kinds of amino acids at least 2–3 times higher than wheat flour (Table 2). The differences in leucine, isoleucine, methionine, valine, glutamic acid, proline and cysteine contents of tarhana samples were insignificant ($P > 0.05$).

Temiz and Pirkul [35] also studied the amino acid composition of tarhanas and their results were in relation with

Table 4 Amino acid compositions of tarhana powders (mg/100 g)

Amino acid	C	TS15	TS25	TS35
Lysine	663.7 ± 40.8b*	956.8 ± 66.4ab	1084.2 ± 155.8a	1220.6 ± 79.2a
Leucine	1305.0 ± 62.9a	1399.5 ± 47.3a	1524.6 ± 105.4a	1533.8 ± 63.1a
Isoleucine	853.6 ± 67.2a	955.1 ± 68.7a	1030.3 ± 73.1a	1059.1 ± 57.4a
Phenylalanine	883.7 ± 7.4b	969.0 ± 89.1ab	1097.0 ± 10.8a	1104.7 ± 21.1a
Methionine	374.7 ± 45.5a	378.2 ± 66.2a	382.5 ± 15.8a	379.5 ± 6.8a
Valine	963.2 ± 54.5a	1067.3 ± 39.4a	1150.7 ± 86.6a	1174.5 ± 49.8a
Threonine	570.3 ± 42.0b	655.0 ± 41.9ab	714.9 ± 0.8a	736.7 ± 29.11a
Alanine	669.0 ± 2.8c	812.1 ± 16.5b	818.1 ± 19.1b	934.0 ± 16.9a
Glycine	698.7 ± 50.1b	810.7 ± 20.8b	971.6 ± 16.8a	1006.3 ± 18.8a
Aspartic acid	879.4 ± 31.7d	1328.0 ± 62.4c	1659.9 ± 69.7b	1906.7 ± 46.2a
Glutamic acid	5411.8 ± 232.7a	5193.5 ± 430.9a	5320.4 ± 302.5a	5247.8 ± 336.0a
Serine	817.5 ± 73.8b	916.4 ± 58.0ab	1032.1 ± 20.8a	1054.4 ± 37.7a
Hystidine	443.6 ± 20.4b	484.3 ± 23.8b	578.3 ± 1.5a	579.2 ± 12.1a
Arginine	761.0 ± 13.2c	1014.8 ± 47.2b	1287.3 ± 14.8a	1429.0 ± 63.1a
Proline	2130.3 ± 212.6a	2206.2 ± 164.7a	2138.1 ± 141.6a	2092.3 ± 122.8a
Cysteine	171.2 ± 9.5a	190.4 ± 21.5a	191.4 ± 10.8a	198.3 ± 17.2a
Tyrosine	554.8 ± 32.0b	718.9 ± 37.6a	730.6 ± 6.3a	804.1 ± 7.1a

In dry basis

*Different letters within the row across the table show significant differences at α = 0.05

Table 5 Mineral compositions of tarhana powders (ppm)

Mineral	C	TS15	TS25	TS35
Mg	546.8 ± 1.1d*	1325.4 ± 76.0c	1734.5 ± 1.8b	2183.4 ± 2.1a
Ca	1411.9 ± 20.0c	1691.3 ± 19.9b	1729.5 ± 26.4b	1913.5 ± 63.3a
K	3393.5 ± 53.8b	4505.0 ± 153.7a	4542.1 ± 154.6a	4572.2 ± 38.9a
P	2427.7 ± 153.7c	3836.5 ± 199.1b	4688.4 ± 293.4b	5627.2 ± 187.6a
Mn	8.8 ± 0.3d	20.1 ± 0.4c	26.7 ± 0.4b	34.0 ± 1.1a
Zn	14.9 ± 0.4d	26.8 ± 0.3c	33.4 ± 0.9b	42.1 ± 0.1a
Fe	23.3 ± 1.1b	48.9 ± 3.5a	52.0 ± 5.5a	58.6 ± 4.0a
Cu	6.4 ± 0.6c	8.5 ± 0.2b	10.8 ± 0.4a	11.4 ± 0.1a

In dry basis

*Different letters within the row across the table show significant differences at $\alpha = 0.05$

our results found for the C tarhana. The results of this study also show that tarhanas having tomato seed meal in the formulation had higher lysine, isoleucine, phenylalanine, threonine, alanine, glycine, aspartic acid, serine, arginine and tyrosine contents than the tarhanas studied in Temiz and Pirkul [35]. As known amino acids are cell signaling molecules, regulators of gene expression, protein phosphorylation cascade, key precursors for syntheses of hormones and low-molecular weight nitrogenous substances with each having enormous biological importance [36]. In this case, these results indicate that tomato seed meal could be used in tarhana formulations for fortification of total and essential amino acid compositions of tarhanas.

Mineral compositions of tarhanas are given in Table 5. It was observed that tarhana samples substituted with tomato seed meal had significantly ($P < 0.05$) higher mineral contents than C tarhana and increasing the tomato seed meal content in formulation also increased the mineral contents of tarhana samples. The reason for this increase is most likely that tomato seed has higher mineral matter concentrations than wheat flour (Table 2).

Minerals represent a class of inorganic substances found naturally in a variety of foods. Minerals are essential for a wide variety of metabolic and physiologic processes in the human body. Minerals are involved in muscle contraction, normal heart rhythm, nerve impulse conduction, oxygen transport, oxidative phosphorylation, enzyme activation, immune functions, antioxidant activity, bone health, and acid base balance of the blood. An adequate daily amount of minerals is necessary for optimal functioning [37, 38].

An adult needs nearly 370 mg Mg, 1000 mg Ca, 2000 mg K, 800 mg P, 2 mg Mn, 10 mg Zn, 9 mg Fe and 900 µg Cu intake a day [39, 40]. The consumption of one portion (250 g) of C group tarhana soup is adequate for 1.66, 1.59, 2.38, 3.41, 4.95, 1.53, 2.91 and 9.00% of Mg, Ca, K, P, Mn, Zn, Fe and Cu daily requirements of an adult respectively. The addition of tomato seed meal to the formulation could increase the percentages of meeting the mineral needs. By the consumption of one portion of tarhana soup having 35% tomato seed meal, adults can meet 6.64% of Mg, 2.15% of Ca, 2.57% of K, 7.91% of P, 19.13% of Mn, 4.74% of Zn, 7.33% of Fe and 14.25% of Cu daily needs.

'Antioxidants' are substances that neutralize free radicals or their actions. A diet rich in natural antioxidants can significantly influence the increase of reactive antioxidant potential of the organism, and decrease the risk of some diseases of free radicals origin. Antioxidants include carotenoids, flavonoids and related polyphenols, α-lipoic acid,

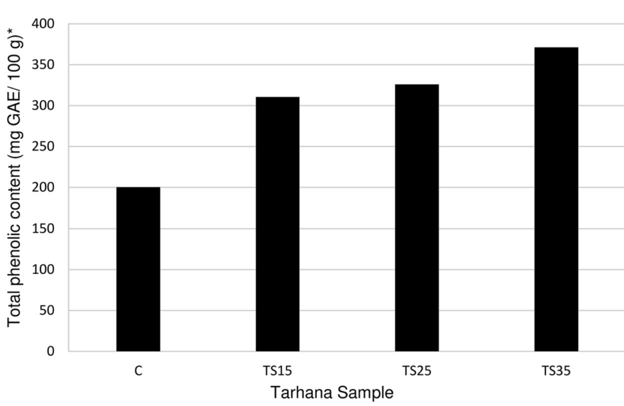

Fig. 1 Total phenoliuc contents of tarhana samples. *In dry basis

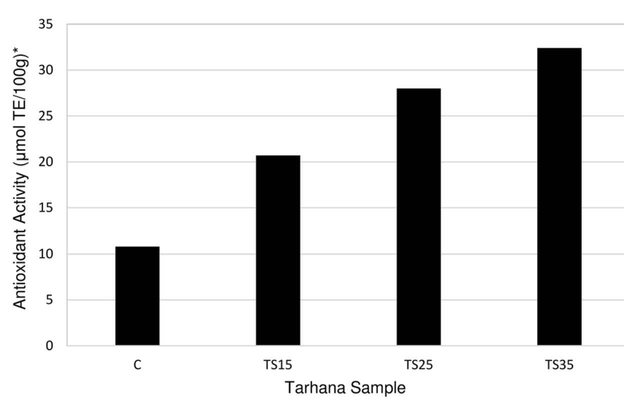

Fig. 2 Antioxidant activity values of tarhana samples. *In dry basis

Table 6 Sensory analysis results of tarhana soups

Tarhana sample	Sensory characteristic				
	Color	Smell	Flavor	Consistency	Overall acceptance
C	4.66 ± 0.09a*	4.46 ± 0.04a	4.52 ± 0.03a	4.89 ± 0.03b	4.55 ± 0.07a
TS15	4.50 ± 0.03a	4.43 ± 0.04a	4.59 ± 0.01a	5.14 ± 0.04a	4.68 ± 0.06a
TS25	4.13 ± 0.02b	3.93 ± 0.10b	4.02 ± 0.03b	4.41 ± 0.06d	4.00 ± 0.07b
TS35	4.17 ± 0.03b	4.07 ± 0.03b	4.09 ± 0.04b	4.66 ± 0.07c	4.05 ± 0.08b

*Different letters within the column across the table show significant differences at $\alpha = 0.05$

glutathione, α-tocopherol (vitamin E), ascorbic acid (vitamin C) etc. [41, 42].

In this study, tarhanas having tomato seed meal in the formulation had significantly ($P < 0.05$) higher total phenolic contents and antioxidant activities than control tarhana (Figs. 1, 2). Tomato seed by-products contain polyphenol compounds such as quercetin and kaempherol, carotenoids such as lycopen, β-caroten and lutein, and vitamin C as antioxidants [12, 42]. Therefore, it's thought that these components were responsible for the higher total phenolic contents and antioxidant activity values of tarhanas having tomato seed.

L values of C, TS15, TS25 and TS35 tarhana samples were 84.62, 78.37, 76.95 and 74.39 respectively. The results show that higher substitution levels of tomato seed instead of wheat flour decreased *L* values significantly ($P < 0.05$). This result can be explained by the difference in *L* values of wheat flour (94.33) and tomato seed meal (49.86) (Table 2).

C, TS15, TS25 and TS35 samples had *a* values of 9.42, 10.20, 10.04, 9.46 and *b* values of 22.24, 23.65, 22.75, 21.94 respectively. The differences in *a* and *b* values of samples were insignificant ($P > 0.05$). This result is related to the closeness of the *a* and *b* values of wheat flour and tomato seed (Table 2).

The results of sensory analysis are given in Table 6. C tarhana and TS15 received the best liking score for color, smell, flavor, consistency and overall acceptance ($P < 0.05$) from the panelists. Although TS25 and TS35 received lower sensory scores than others, all tarhana soups received sensory scores higher than 3.5, which was the midpoint of hedonic scale. The decrease in the sensory scores of TS25 and TS35 can be explained by the effect of higher substitution levels of tomato seed. The results of sensory analysis also showed that the decrease in lightness (*L*) values of tarhanas had a decreasing effect on the likeness scores of color.

Conclusion

Tomato seeds are good sources of proteins, oil, dietary fiber, minerals and essential amino acids. In this present study, it was found that the protein, oil, insoluble dietary fiber, total dietary fiber, ash, mineral and total phenolic contents and antioxidant activity values of tarhanas increased by increasing the ratio of tomato seed meal in tarhana formulation ($P < 0.05$). Lysine, phenylalanine, threonine, serine, alanine, glycine, histidine, aspartic acid, arginine and tyrosine contents of tarhanas were also increased significantly ($P < 0.05$) by the substitution of tomato seed instead of wheat flour. Sensory analysis results of tarhana soups indicated that C and TS15 tarhana soups were liked more. But TS25 and TS35 also received color, flavor, consistency and overall acceptance scores higher than 4.00. As a result, it can be seen that there would be some improvements in the nutritional properties of tarhana by the addition of tomato paste waste material tomato seeds. Moreover, sensory acceptability of products will allow the use of tomato seed, which is a good source of functional food ingredients, in human diet. The use of tomato seeds in human diet could also play a role in decreasing environmental pollution problems and increasing the added value of wastes.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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