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Determining Some Quality Characteristics of Vegan Tarhana Added with Red Beet (*Beta Vulgaris Var. Cruenta*) Powder

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HIGHLIGHTS

- The 'vegan tarhana' produced without yogurt can be consumed as a functional food.
- Addition of red beet powder to vegan tarhana increased antioxidant capacity.
- Vegan tarhana can be consumed as an alternative to traditional tarhana.

Abstract: The present study aims to increase the number of tarhana versions, which have traditionally had a place in our culture, in order to increase the range of vegan products. In the present study, it was aimed to diversify the versions of tarhana, which has had a place in our traditional culture. For this purpose sauced and sauce-free vegan tarhana (yogurt-free) samples added with red beet (*Beta vulgaris var. Cruenta*) powder at different concentrations (control, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%) samples were produced. Several physicochemical, microbiological, and sensorial properties of tarhanas produced were examined. Vegan tarhana with tomato sauce with 1.0% red beet powder had the highest score for consistency, taste, aroma and general acceptability. The highest score of color and odor properties was determined in vegan tarhana with tomato sauce added with 2.0% red beet powder. Ash, total acidity, protein, water-holding capacity, total dietary fiber, total phenolic content, and antioxidant capacity increased in parallel with red beet powder concentration. It was found that microbiological characteristics met the standards for tarhana, that the total number of mesophilic aerobic bacteria was higher than that of total yeast-mold. *Staphylococcus aureus* and coliform-group bacteria could not be detected in vegan tarhanas with red beet powder. In conclusion, it can be stated that all the vegan tarhanas with red beet powder samples had equivalent physicochemical and bioactive characteristics in comparison to the tarhana samples examined in the literature.

Keywords: functional product; red beet powder; tarhana; vegan diet.

INTRODUCTION

Traditional tarhana is a traditional product, which is prepared by pulping onion, tomato, pepper, yogurt, and various spices with wheat products and fermented for 1-7 days. Having a sour and acidic aroma, tarhana is generally consumed as soup. Since it is rich in protein and vitamin content, it plays an important role in the diets of elderly people and children [1]. Although traditional tarhana production is common in Turkey, industrial production increased [2]. Low moisture (6-9%) and pH (3.8-4.2) protect tarhana from pathogens and other microorganisms. Moreover, thanks to its low moisture content, tarhana can be stored for 2-3 years [3]. The combination of vegetable and animal protein contents within tarhana and its fermented structure significantly improve its bioavailability and digestibility [4]. Red beet (*Beta vulgaris var. Cruenta*) growing in the Mediterranean region and it is grown in Asia, America, and Europe because of the demand from consumers. Moreover, red beet is used as a natural coloring agent for foods such as processed meat, ice cream, wine, jam, bakery products, candies, and yogurt [5]. Red beet's unique red color arises from betalain pigments including betanin and beta-cyanine. Thanks to its phenolic compound and betalain contents, Red beet is a very good antiradical and antioxidant source [6]. In the vegan diet, the important point is to ignore all animal-origin products [7]. The main reason for individuals to choose the vegan lifestyle is their concerns about the health, environmental, and economic problems that a diet having high animal-origin food would cause [8]. In comparison to the non-vegan population, it was reported that vegan individuals had a lower incidence of cardiovascular diseases, obesity, diabetes mellitus, arteriosclerosis, and hypertension, as well as a lower level of blood cholesterol [9].

In the present study, producing vegan tarhanas (without yogurt) with red beet powder (RP) additive at 0% (control), 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, and 3.0% concentrations, several characteristics of vegan tarhanas were examined. Given the literature review, although there are versions of tarhana containing different contents, no study on vegan tarhana could be found and it was aimed to carry out a new study on the vegan tarhana.

MATERIAL AND METHOD

Material

The raw materials used in tarhana production; wheat flour (Söke Flour), yeast (*Saccharomyces cerevisiae,* Pakmaya) and tomato sauce (Tat tomato sauce) were obtained from local markets while onion, red pepper, green pepper, red beet, and salt were procured from local open air markets.

Method

Production of Red Beet Powder

Red beets were washed, their leaves and stems were cut, and root parts were peeled. Using the slicing apparatus of a food processor, they were thinly sliced and then dried in a tray oven at 60° C for 11 hours. The dried red beets were ground and processed into red beet powder (RP) [10].

Production of Vegan Tarhana with Red Beet Powder and Sauce

Different formulations for vegan tarhana with red beet powder and sauce (RPSVT) were revised and the contents were wheat flour (56-59%), tomato sauce (9%), onion (16%), red pepper (7%), green pepper (7%), yeast (1%), salt (1%), and RP (0-3%) [11,12,13]. The mixture was homogeneously kneaded for 5 minutes. The doughs obtained were left for fermentation at 30-35°C for 1-5 days. pH values of doughs left for fermentation were measured using a pH-meter and the fermentation was then ceased when pH reached 3.8-4.2 [14]. After the fermentation, the RPSVT samples were dried using a domestic drier at 40 °C for 48 hours under control and then powdered by grinding [15].

Production of Sauce-free Vegan Tarhana with Red Beet Powder

In the production of sauce-free vegan tarhana with red beet powder (RPVT), different formulations were revised and the contents were wheat flour (65-68%), onion (16%), red pepper (7%), green pepper (7%), yeast (1%), salt (1%), and RP (0-3%) [11,12,13]. The mixture was homogeneously kneaded for 5 minutes. The doughs obtained were left for fermentation at 30-35°C for 1-5 days. pH values of doughs left for fermentation were measured using a pH-meter and the fermentation was then ceased when pH reached 3.8-4.2 [14]. After the fermentation, the RPVT samples were dried using a domestic drier at 40 °C for 48 hours under control and then powdered by grinding [15].

Physicochemical Analyses

Physicochemical analyses conducted for all vegan tarhana samples include dry matter and moisture [16], ash [17], salt [18], fat [19], total acidity [18], water-holding capacity, and foaming capacity [20]. Water activity (a_w) was analyzed using a water activity tester (Aqualab 4TE Meter Group, Inc., USA) [21]. Protein detection was performed using the Kjeldahl method (AACC 46-12) [22]. pH analyses of tarhana samples were conducted using a pH meter (Mettler-Toledo International Inc., Switzerland). Color determination of all vegan tarhana samples was performed using a color tester (Hunterlab MiniScan EZ 4000L, USA) and the results were presented as L* (dark-bright (0-100)), a* (green-red (-60-60)), and b* (blue-yellow (-60-60)) values [23]. Total dietary fiber content was determined using the gravimetric analysis method [24].

Determination of Total Phenolic Content

Total phenolic content of vegan tarhanas were conducted using the Folin-Ciocaltaeu method. Obtained using 70% ethanol, 0.5 mL red beet powder (RP) and all vegan tarhana samples were mixed with 2.5 mL Folin-Ciocalteu reactive (10% (v/v) (Sigma) and 2 mL sodium carbonate solution (7.5% (w/v)) (Sigma)and then kept in a dark place at the room temperature for 1 hour. The sample's blind absorbance was determined using UV-Visible Spectrophotometer (Hach DR6000, Lange GmbH, 189 Germany) at 725 nm. Using the calibration curve prepared with gallic acid, the total phenolic contents of the samples were expressed as mg gallic acid equivalent (GAE) per gram of dry weight (dw) [25].

Determination of Antioxidant Activity

Antioxidant activities of all tarhana samples were determined using ABTS radical. To be used in analyses, ABTS [2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)] (Sigma-Aldrich) solution was diluted by 1:10 using 96% ethanol (Sigma-Aldrich). Put into test tubes, x ml sample extract, (4-x) ml ethanol, and 1 mL ABTS solution were mixed. The mixture was kept at room temperature for 6 minutes and then the absorbance values were measured using a spectrophotometer (Hach DR6000, Lange GmbH. 189 Germany) at 734 nm. Similarly, 4 ml ethanol and 1 ml ABTS were mixed and, at the end of the 6 minutes, the absorbance value was measured as a witness test. Making use of the calibration curve prepared using the Trolox standard, the total antioxidant capacities of all vegan tarhana samples were calculated as µmol TE/100 g dry matter [26].

Microbiological Analyses

Plate Count Agar (Merck 105463, PCA) medium [27] was used for total mesophilic aerobic bacteria (TMAB) count (24 hours at 37ºC), Potato Dextrose Agar (Merck 110130, PDA) medium [28] for total yeast-mold (TYM) count (5 days at 25 ºC), Fluorocult Violet Red Bile Agar (Merck 101406, VRB) medium [29] for total coliform group bacteria (24 hours at 37ºC), and Baird Parker Agar (Merck 105406, BPA) medium added with egg yolk (Egg yolk tellurite emulsion, Merck 103785, Germany) for *Staphylococcus aureus* count (24 hours at 37ºC) [30].

Scanning Electron Microscope

Surface morphologies of RP and all vegan tarhanas were imaged using a scanning electron microscope (SEM). To have them show conductive characteristics, the samples were sprinkled on a carbon plate and coated with gold-palladium (80:20/w:w) (SPI-MODULE Sputter Coater) at room temperature. Images of samples were taken using SEM (ZEISS, EVO/LS 10, Germany). Micrographs were obtained at X250 magnification [31].

Sensorial Analysis

Sensorial analyses of the all vegan tarhana soups were performed by a 10-person panelist group(Giresun University consists of faculty members) who were informed prior. Using a 5-point hedonic scale (1: very poor, 2: poor, 3: moderate, 4: good, and 5: very good), the consumer test was conducted on the panelists considering the color, odor, taste, consistency, and general appreciation criteria for all vegan tarhana [32].

Statistical Analysis

The data obtained were analyzed using IBM SPSS Statistics 20 package software (SPSS, CHICAGO, IL, USA). The significance of differences between mean values of groups was tested using One-Way ANOVA, whereas where there were remarkable significant differences between the groups was determined using Duncan's multiple comparison test. Statistical significance was set at the confidence level of p≤0.05.

RESULTS

Raw Material Analysis Results

The analysis results of RP used in the experiments are presented in Table 1. Given the results presented, it was determined that RP used in vegan tarhana production contained high amounts of protein, ash, and dietary fiber. Besides that, it was also found to be rich in antioxidant capacity and total phenolic content.

Table 1. Physicochemical analysis findings of RP

	Values
pH	6.62
Total acidity (%)	5.3
Ash (%)	6.8
Protein (%)	8.75
Fat (%)	0.99
Salt (%)	0.31
Total Dietary Fiber	16.58
Antioxidant Activity (mMol Trolox equiv/g dry sample)	1.98
Total Phenolic Compounds (mM gallic acid/g dry sample)	199.07
Color Value	
*L**	32.08
*a**	18.9
*b**	16.6

Analysis Results of Vegan Tarhana Added with Red Beet *(Beta Vulgaris Var. Cruenta)* Powder Additive

Obtained from the color measurements of sauced and sauce-free vegan tarhana samples with and without RP (0%) additive, L* (brightness), a* (redness), and b* (yellowness) values are presented in Table 2. The color values of all vegan tarhana samples were found to be statistically significant in relationship with the RP additive concentration (p≤0.05).

Table 2. Color values of vegan tarhana samples

RP Addition Rate (%)	RPSVT				RPVT			
	*L**	*a**	*b**	Δ*E**	*L**	*a**	*b**	Δ*E**
Control	80.66±0.10^{f}	10.07±0.02^{b}	23.30±0.09^{d}	31.84±0.08^{c}	83.23±0.11^{g}	4.32±0.07^{a}	16.97±0.11^{a}	23.17±0.19^{a}
0.5	80.10±0.12^{e}	9.41±0.07^{a}	21.88±0.08^{a}	30.82±0.17^{a}	82.70±0.04^{f}	5.85±0.08^{b}	20.08±0.19^{b}	26.32±0.23^{b}
1.0	79.67±0.38^{d}	9.59±0.10^{a}	22.70±0.23^{c}	31.66±0.46^{bc}	81.14±0.16^{e}	6.81±0.00^{d}	21.20±0.01^{c}	28.38±0.09^{c}
1.5	79.59±0.16^{d}	9.54±0.16^{a}	22.03±0.31^{a}	31.25±0.41^{ab}	80.36±0.03^{d}	6.21±0.01^{c}	21.18±0.04^{c}	28.46±0.06^{c}
2.0	78.09±0.06^{c}	9.89±0.06^{b}	22.62±0.01^{bc}	32.62±0.08^{d}	77.57±0.11^{c}	6.49±0.05^{e}	24.14±0.22^{d}	32.13±0.29^{d}
2.5	77.71±0.20^{b}	10.32±0.12^{c}	22.55±0.22^{bc}	33.03±0.37^{d}	76.84±0.06^{b}	6.89±0.02^{e}	24.23±0.02^{d}	32.80±0.06^{e}
3.0	75.82±0.10^{a}	10.36±0.05^{c}	22.21±0.07^{ab}	33.93±0.16^{e}	73.73±0.05^{a}	6.83±0.03^{e}	24.73±0.09^{e}	34.98±0.05^{f}

Values are given as mean ± standard deviation. Different letters indicate significant differences between groups in the same column (p≤0.05).

The results for water holding and foaming of all vegan tarhana samples produced in the present study are presented in Table 3. Water holding and foaming capacities of all vegan tarhana samples were found to be statistically significant in relation to additive concentration ($p \leq 0.05$).

Table 3. Water holding and foaming capacity values of vegan tarhanas

	Water Holding Capacity (mL/g)		Foaming Capacity (mL/mL)	
RP Addition Rate (%)	RPSVT	RPVT	RPSVT	RPVT
Control	1.07±0.01^{a}	1.08±0.01^{a}	0.13±0.02^{d}	0.15±0.02^{a}
0.5	1.10±0.02^{ab}	1.16±0.01^{b}	0.12±0.01^{d}	0.13±0.02^{ab}
1.0	1.10±0.02^{ab}	1.21±0.01^{bc}	0.09±0.01^{cd}	0.12±0.02^{ab}
1.5	1.14±0.05^{abc}	1.21±0.01^{bc}	0.08±0.01^{bc}	0.12±0.01^{ab}
2.0	1.16±0.03^{bc}	1.27±0.01^{c}	0.06±0.01^{abc}	0.12±0.01^{ab}
2.5	1.17±0.01^{bc}	1.32±0.02^{d}	0.04±0.00^{ab}	0.10±0.02^{ab}
3.0	1.19±0.00^{c}	1.33±0.02^{d}	0.03±0.02^{a}	0.09±0.01^{b}

Values are given as mean ± standard deviation. Different letters indicate significant difference between groups in the same column ($p \leq 0.05$).

RP -added sauced and sauce-free vegan tarhana samples' dry matter, moisture, and ash results are presented in Table 4. The differences in dry matter and moisture values of RPSVT by additive concentration were found to be statistically significant ($p \leq 0.05$). This difference can be explained by the fact that the heat applied during the drying process was not homogeneously distributed and that they might vary depending on the characteristics of raw materials used. Moreover, the moisture content of the seeds of tomato, which is the main content in the sauce, was found to be high in previous studies [13]. Thus, it was found that the difference between dry matter ratios of RPSVT was statistically significant. No statistically significant difference was found in dry matter and moisture contents of RPVT by the additive concentration ($p \geq 0.05$). The difference in ash contents of sauced and sauce-free vegan tarhanas by the additive concentration was found to be statistically significant ($p \leq 0.05$) (Table 4).

Table 4. Dry matter, moisture and ash values of vegan tarhanas

RP Addition Rate (%)	Dry Matter (%)		Moisture (%)		Ash (%)	
	RPSVT	RPVT	RPSVT	RPVT	RPSVT	RPVT
Control	91.17±0.71^{a}	94.34±0.14^{a}	8.82±0.71^{a}	5.66±0.14^{a}	2.55±0.03^{a}	2.58±0.06^{a}
0.5	92.31±0.56^{ab}	94.76±0.25^{a}	7.69±0.38^{ah}	5.24±0.25^{a}	2.94±0.02^{b}	2.64±0.03^{b}
1.0	92.60±0.25^{ab}	94.64±0.10^{a}	7.40±0.25^{ab}	5.36±0.10^{a}	2.96±0.02^{b}	2.78±0.02^{b}
1.5	92.07±1.17^{a}	94.47±0.08^{a}	7.93±1.17^{ab}	5.53±0.09^{a}	3.20±0.15^{c}	2.92±0.03^{c}
2.0	91.70±0.72^{a}	94.51±0.38^{a}	8.30±0.72^{ab}	5.49±0.39^{a}	3.26±0.01^{c}	2.93±0.02^{c}
2.5	92.79±0.48^{ab}	94.71±0.60^{a}	7.21±0.48^{ab}	5.29±0.60^{a}	3.27±0.02^{c}	2.95±0.03^{c}
3.0	93.79±0.47^{b}	94.12±0.70^{a}	6.21±0.47^{b}	5.88±0.70^{a}	4.25±0.04^{d}	3.61±0.02^{d}

Values are given as mean ± standard deviation. Different letters indicate significant difference between groups in the same column ($p \leq 0.05$).

The statistical results for a_w, pH, and total acidity values of all vegan tarhana samples produced are presented in Table 5. The differences in a_w, pH, and total acidity values of sauced and sauce-free vegan tarhanas by the additive concentration were found to be statistically significant ($p \leq 0.05$).

Table 5. a_w, pH and total acidity values of vegan tarhanas

	a_w		pH		Total Acidity (%)	
RP Addition Rate (%)	RPSVT	RPVT	RPSVT	RPVT	RPSVT	RPVT
Control	0.53±0.00^{f}	0.36±0.00^{c}	5.68±0.01^{d}	5.95±0.00^{d}	10.83±0.47^{a}	10.50±0.41^{a}
0.5	0.49±0.00^{e}	0.39±0.00^{g}	5.68±0.01^{d}	5.93±0.01^{d}	11.50±0.82^{ab}	10.83±0.24^{ab}
1.0	0.34±0.00^{b}	0.40±0.00^{f}	5.65±0.00^{c}	5.90±0.00^{d}	12.50±0.71^{ab}	12.33±1.03^{abc}
1.5	0.42±0.00^{d}	0.39±0.00^{e}	5.64±0.01^{c}	5.88±0.00^{c}	14.00±0.41^{bc}	12.33±1.65^{abc}
2.0	0.35±0.00^{c}	0.37±0.00^{d}	5.61±0.01^{b}	5.85±0.00^{c}	15.50±0.41^{cd}	12.33±1.03^{abc}
2.5	0.26±0.00^{a}	0.21±0.00^{a}	5.45±0.01^{a}	5.64±0.00^{b}	15.50±1.22^{cd}	13.00±0.41^{bc}
3.0	0.35±0.00^{b}	0.22±0.00^{b}	5.45±0.01^{a}	5.56±0.00^{d}	17.00±0.82^{d}	13.67±1.03^{c}

Values are given as mean ± standard deviation. Different letters indicate significant difference between groups in the same column ($p \leq 0.05$).

The statistical results for protein, fat, and salt content of all RP added vegan tarhana samples produced here are presented in Table 6. The differences in protein, fat, and salt contents of sauced and sauce-free vegan tarhana samples by additive concentration were found to be statistically significant ($p \leq 0.05$).

Table 6. Protein, fat and salt values of vegan tarhanas

RP Addition Rate (%)	Protein (%)		Fat (%)		Salt (%)	
	RPSVT	RPVT	RPSVT	RPVT	RPSVT	RPVT
Control	9.68±0.03^{a}	10.38±0.02^{a}	4,23±0,26^{a}	2.40±0.16^{a}	2.31±0.07^{a}	2.24±0.12^{c}
0.5	11.21±0.08^{b}	10.51±0.03^{b}	3,14±0,03^{b}	1.19±0.01^{b}	2.57±0.01^{b}	2.05±0.03^{b}
1.0	11.78±0.02^{c}	11.46±0.03^{c}	2,99±0,01^{b}	1.16±0.02^{b}	2.75±0.03^{c}	1.91±0.01^{b}
1.5	11.96±0.07^{d}	11.62±0.02^{d}	1,95±0,03^{c}	0.72±0.06^{c}	2.94±0.01^{d}	1.51±0.01^{a}
2.0	12.86±0.02^{e}	11.71±0.03^{r}	1,36±0,02^{d}	0.59±0.01^{cd}	3.14±0.03^{de}	1.43±0.02^{a}
2.5	13.05±0.03^{f}	11.83±0.02^{f}	0,60±0,16^{e}	0.48±0.01^{d}	3.24±0.02^{ef}	1.40±0.00^{a}
3.0	13.18±0.02^{f}	12.48±0.02^{g}	0,13±0,05^{f}	0.38±0.02^{d}	3.34±0.03^{f}	1.35±0.02^{a}

Values are given as mean ± standard deviation. Different letters indicate significant difference between groups in the same column ($p \leq 0.05$).

SEM images of RP, RPSVT, and RPVT samples under X250 magnification are presented in Figures 1 and 2.

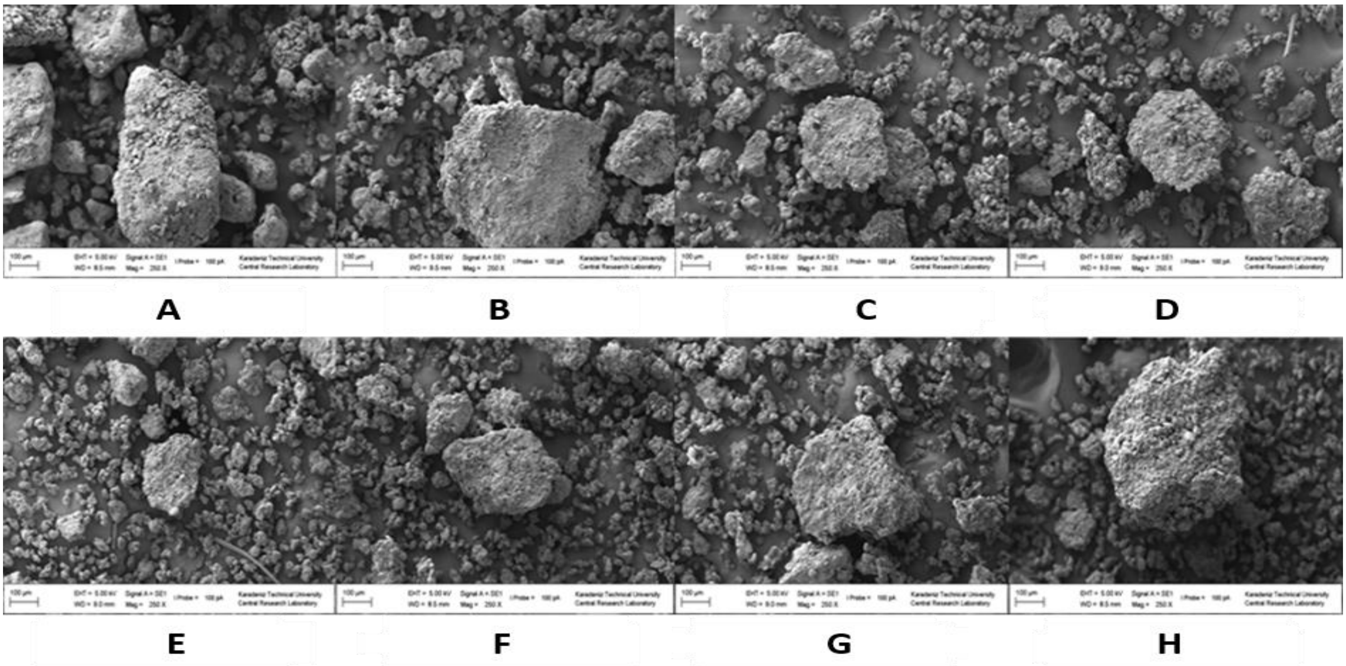

Figure 1. SEM images of RP and all vegan tarhanas (250x). A: RP, B: Control, C: D: E: F: G: H: 0.5%, 1, 1.5, 2, 2.5, 3 RPSVT

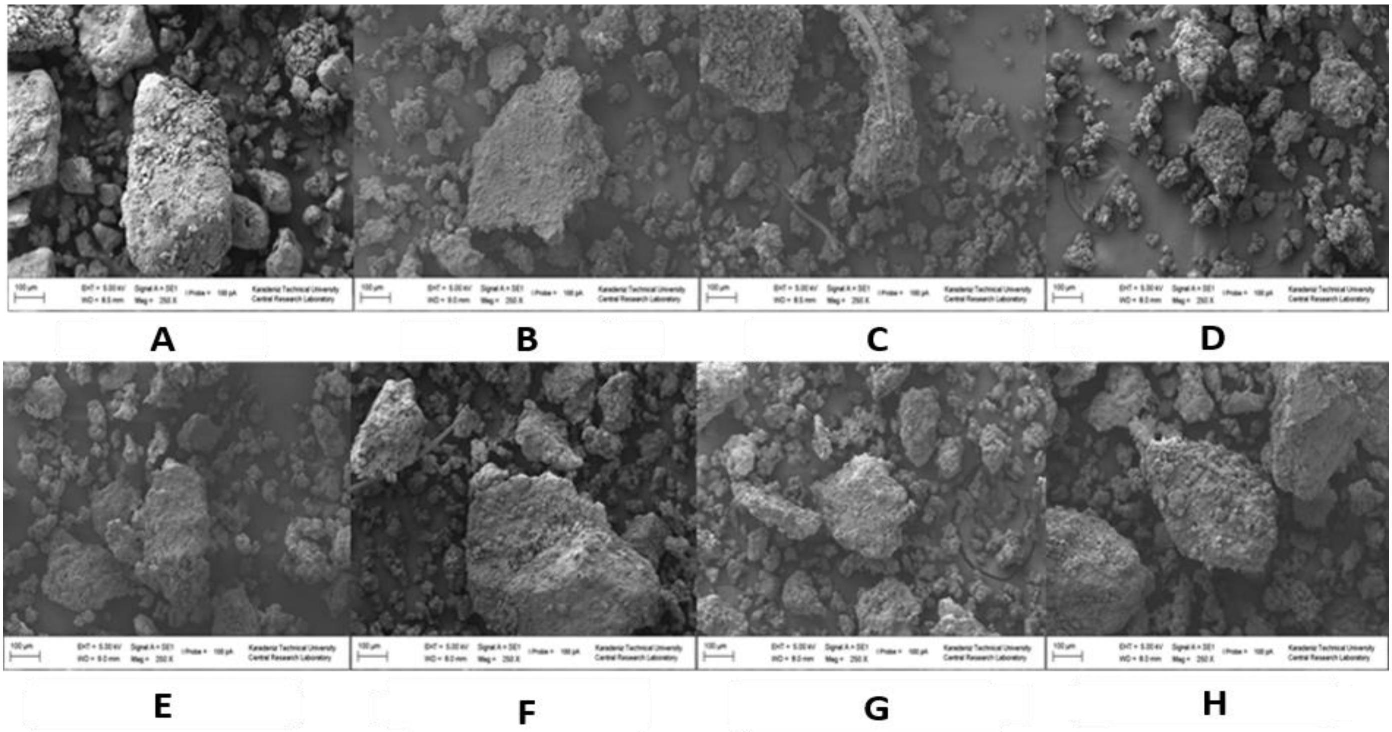

Figure 2. SEM images of RBP and all vegan tarhanas (250x). A: RP, B: Control, C: D: E: F: G: H: 0.5%, 1, 1.5, 2, 2.5, 3 RPVT

Statistical analysis results of total phenolic content (TPC), antioxidant capacity, and total dietary fiber content values of sauced and sauce-free RP-added vegan tarhana samples are presented in Table 7. Of vegan tarhanas added with RP at different concentrations, TPC values ranged between 17.25 and 41.3 mg GAE/100 g, antioxidant capacity between 1.46 and 2.28 µM TE/g TA, and total dietary fiber content between 1.47 and 5.01%. The difference in sauced and sauce-free vegan tarhanas' TPC, antioxidant capacity, and total dietary fiber content values by additive concentration was found to be statistically significant ($p \leq 0.05$).

Table 7. TPC, antioxidant capacity and total dietary fiber values of vegan tarhanas

	Phenolic Substance (mg GAE/100 g)		Antioxidant Capacity (μM TE/g)		Total Dietary Fiber (%)	
RP Addition Rate (%)	RPSVT	RPVT	RPSVT	RPVT	RPSVT	RPVT
Control	30.41±0.15[a]	17.25±0.07[a]	1.46±0.03[a]	1.59±0.02[a]	1.96±0.02[a]	1.47±0.02[a]
0.5	31.26±0.27[b]	23.45±0.6[b]	1.55±0.03[b]	1.93±0.01[b]	2.24±0.01[b]	2.11±0.02[b]
1.0	32.00±0.12[b]	25.00±0.24[c]	1.65±0.03[c]	1.98±0.02[b]	2.72±0.01[c]	2.12±0.02[b]
1.5	36.24±0.58[c]	29.29±0.79[d]	1.93±0.02[d]	2.07±0.07[c]	3.08±0.01[e]	2.27±0.01[c]
2.0	36.91±0.39[c]	30.04±0.28[d]	1.95±0.01[d]	2.18±0.03[d]	3.99±0.01[f]	2.40±0.01[d]
2.5	37.07±0.70[c]	31.32±0.35[e]	2.02±0.01[e]	2.21±0.02[d]	5.00±0.00[g]	3.10±0.02[e]
3.0	41.30±0.63[d]	32.23±0.35[f]	2.04±0.02[e]	2.28±0.02[e]	5.01±0.02[g]	3.42±0.01[f]

Values are given as mean ± standard deviation. Different letters indicate significant difference between groups in the same column (p≤0.05).

Statistical results of microbiological characteristics of RP added vegan tarhana samples are presented in Table 8. For vegan tarhanas added with different concentrations of RP, TMAB count was found to be 3.82-4.19 log CFU/g and TYM count to be 3.48 – 3.97 log CFU/g. No coliform or *S.aureus* could be found in either group. The difference in TMAB and TYM counts and coliform and *S. aureus* values of sauced and sauce-free vegan tarhanas was found to be statistically significant (p≤0.05).

Table 8. Microbiological properties of vegan tarhana samples (log CFU/g)

RP Addition Rate(%)	RPSVT		RPVT	
	TMAB	TYM	TMAB	TYM
Control	4.18±0.03[c]	3.97±0.03[c]	4.01±0.02[c]	3.85±0.06[c]
0.5	4.19±0.08[c]	3.97±0.02[c]	3.85±0.03[a]	3.48±0.03[a]
1.0	4.10±0.02[b]	3.70±0.02[b]	4.05±0.03[c]	3.81±0.02[c]
1.5	4.10±0.07[b]	3.61±0.15[ab]	3.85±0.02[a]	3.69±0.03[bc]
2.0	3.93±0.02[a]	3.48±0.01[a]	4.02±0.03[c]	3.81±0.02[c]
2.5	3.94±0.03[a]	3.92±0.02[c]	3.94±0.02[b]	3.62±0.03[b]
3.0	3.94±0.02[a]	3.79±0.04[bc]	3.82±0.02[a]	3.61±0.02[b]

Values are given as mean ± standard deviation. Different letters indicate significant difference between groups in the same column (p≤0.05).

Sensorial Analysis Results

During the sensorial panels of soups prepared using RP added vegan tarhanas, the products were presented to the panelists by randomly coding with 3-digit numbers [33]. Sensorial analysis diagrams of RPSVT and RPVT are presented in Figures 3 and 4.

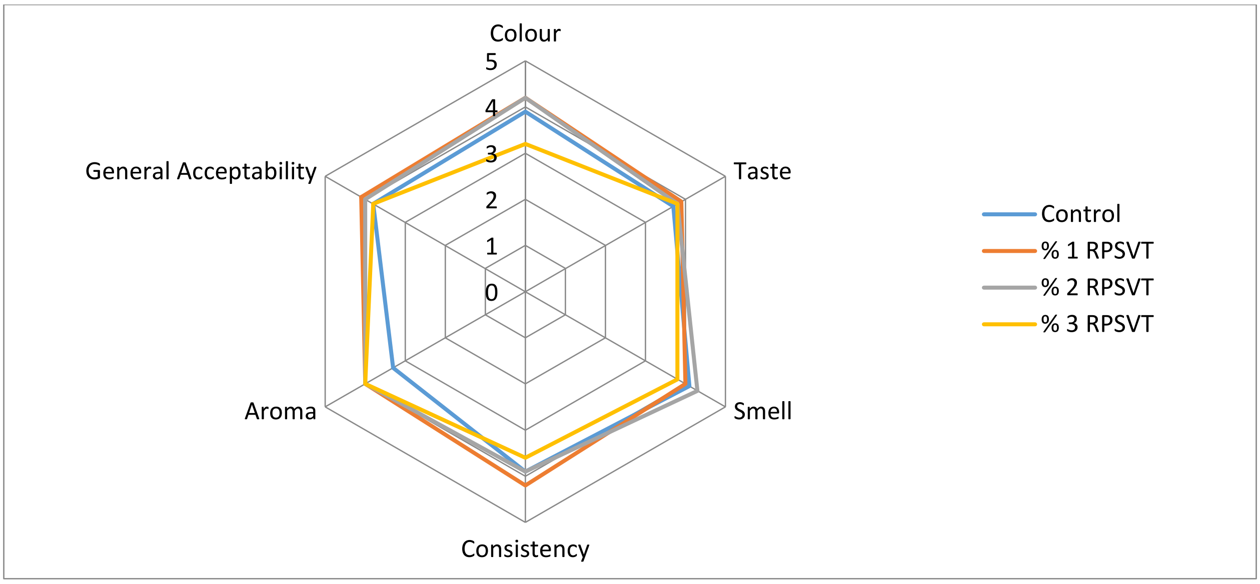

Figure 3. Sensory data graph of RPSVT vegan tarhana

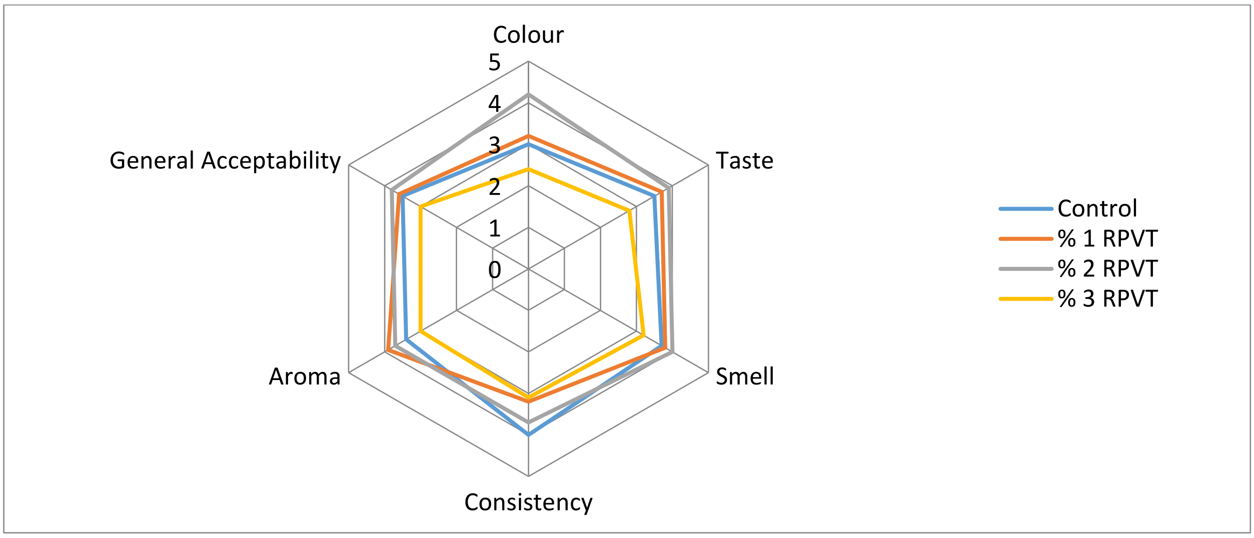

Figure 4. Sensory data graph of RPVT vegan tarhanas

DISCUSSION

Given the results obtained, it was determined that, as a result of RP addition, RPSVT and RPVT vegan tarhana samples' L* and a* values decreased, RPVT' b* values increased, and RPSVT' b* values decreased. In previous studies, it was reported that L* value and protein characteristics were related to each other and L* value might decrease with increasing protein concentration [34]. In many studies, it was found that there were differences between color values and L* values ranged between 58 and 80 [35,36]. The results were similar to the L* values (73.04 – 87.44) reported for homemade tarhana samples collected by Ovando-Martinez and coauthors [37] from different cities.

The results obtained from the analyses were found to be lower than a* (19.4 – 20.7) values found by Gül [38]. The low a* value found in sauced and sauce-free vegan tarhana samples might be explained by the oxidation reaction, which occurs due to the exposure of carotenoids to the factors such as temperature, oxygen, and light during the drying process [39]. Similarly, in another study carried out using wheat flour, b* value of tarhana was found to be 20.12 [12].

It was determined that the water-holding capacity of sauced and sauce-free vegan tarhana samples increased with increasing RP additive concentration. This increase can be explained by the difference between starch molecules and protein structures in the tarhana composition [36]. The results achieved here are similar to the water-holding capacity results (1.07-1.46 ml/g) reported by Durmuş [32] for the tarhanas added with corn flour by using 3 different hydrocolloids.

It was observed that the foaming capacity of sauced and sauce-free vegan tarhanas decreased with the increasing concentration of RP additive. These decreases in foaming capacities of control and RP added tarhana samples are thought to originate from the protein concentration increasing with RP. In a previous study carried out by Kıtan [40], foaming capacity values of tarhanas added with quinoa flour (0.04-0.08 mL/mL) were similar to the results achieved here (sauced 0.13-0.03 mL/mL and sauce-free 0.15-0.09 mL/mL).

Given the tarhana standard, the moisture content should be 10% at the maximum [18]. Given the results achieved, it can be stated that the dry matter and moisture content of all vegan tarhanas met the standards. Besides that, it was also determined that the ash content of sauced and sauce-free vegan tarhanas increased with the increasing concentration of RP additive. The results (8.82-6.21% for RPSVT and 5.66-5.88% for RPVT) achieved here were higher than those reported by Demir [41] for tarhana added with whole wheat flour (4.37-4.55%) and it can be stated that this difference might arise from the differences in drying methods and characteristics of raw materials used.

In a study carried out by Şemşioğlu [42], the ash contents of tarhanas added with various berry-like fruits (1.89-5.02%) were different in comparison to the present results (2.55-4.25% for sauced and 2.58-3.61% for sauce-free) and it can be stated that this difference might be related with the varieties and amounts of raw materials used.

Total acidity values of RP added vegan tarhanas were generally related to the pH levels. pH values of RPVT were found to be higher than those of RPSVT. This difference might arise from the increase in acidity because of tomato sauce. It was found that the total acidity values of all RP added vegan tarhana samples (10.83-17.00 and 10.50-13.67) met the tarhana standards (between 10 and 35) [18]. Total acidity of tarhanas produced was in a similar range to the total acidity (10.2-28.4) of tarhanas produced in a study carried out by Esimek [43].

Comparing the previous studies to the present results, differences were observed in aw values [44]. These differences can be explained by the drying methods and water contents of raw materials used. pH values of tarhanas produced (5.68-5.45 and 5.95-5.56) were found to be higher than those reported by Esimek [43] (3.62 and 4.75). In general, the reason for these higher pH values might be the absence of LAB, which is found in yogurt, in vegan tarhana.

It can be seen that the high protein content of RP (8.75%) influenced the RP added vegan tarhanas [18]. In all samples, protein contents of control samples and those added with 0.5%, 1.0%, and 1.5% RP (9.68%, 11.21%, 11.78%, and 11.96%, respectively) were lower than the values specified in tarhana standards (min. 12%) and the protein contents of RPSVT added with 2.0%, 2.5%, and 3.0% RP (12.86%, 13.05%, and 13.18%, respectively) were found to be higher. For RPVT samples, the protein contents of control samples and those added with 0.5%, 1.0%, 1.5%, 2.0%, and 2.5% RP (10.38%, 10.51%, 11.46%, 11.62%, 11.71%, and 11.83%, respectively) were lower than the values specified in tarhana standards (min. 12%) but only the protein content of 3.0% RPVT (12.48%) was higher than the standard. Comparing the present results to the protein contents (2.73%-15.37%) reported by Şemşioğlu [42], it was determined that there were differences. This difference might be explained by the active role of vegetable foods in the protein content of vegan tarhana rather than animal foods (such as yogurt).

The decrease in fat content of RP added vegan tarhanas (4.23-0.13% for RPSVT and 2.40-0.38% for RPVT) together with increasing additive concentration might be explained by the low fat content of RP (0.99%) as seen in Table 1. Similarly, in a previous study carried out by Tamer and coauthors [45], it was reported that fat content of homemade tarhanas was generally lower than 5.10%. Given the tarhana standards [18] (maximum salt content 10%), it can be seen that all the RP added vegan tarhana samples met the standards in terms of salt content (2.31-3.34% for RPSVT and 2.24-1.35% for RPVT). It was found that the salt content of RPSVT samples increased with increasing RP additive concentration, whereas the salt content of RPVT samples decreased. The insufficient acidity in sauce-free vegan tarhanas might have negatively affected the salt content. The present results were compared to those reported in a previous study and similar salt content values (increased from 1.74% to 3.08% in the first 8 days) were determined [46].

In Figure 1 and 2, there are the micrographs of RP, all vegan tarhanas added with different concentrations of RP (control 0%, 0.5%, 1%, 1.5%, 2%, and 3%) taken under x250 magnification by using a SEM. Particle distributions can be seen. While control tarhana and RP-added tarhanas had similar appearances consisting of large and small particles from the volumetric aspect, particle density increased with increasing additive concentration. In all tarhana versions, small (100 µm) particles were observed to be irregular. The present study results were similar to those reported by Göncü [47].

Industrially produced tarhanas' TPC (1.27-28.18 µg GAE/g) and homemade tarhanas' TPC (0.55-42.67 µg GAE/g) reported in a previous study carried out by Çağındı and coauthors [48] were different in comparison to the present results (30.41-41.30 for RPSVT and 17.25-32.23 for RPVT samples). It was observed that RP addition at different concentrations slightly increased TPC values of vegan tarhana samples. It might be because RP addition concentrations were low or phenolic compounds disintegrated during the fermentation of vegan tarhana. Antioxidant capacity results of tarhanas added with hazelnut pulp reported in a study carried out by Oğurlu [49] (0.15-0.42 mMol Trolox /g) were higher than the present results (1.46-2.04 for sauced samples and 1.59-2.28 for sauce-free samples). It was observed that RP addition at different concentrations slightly increased antioxidant capacity values of vegan tarhana samples. It might be because RP addition concentrations were low or radical compounds disintegrated during the fermentation of vegan tarhana. Total dietary fiber content of vegan tarhanas (1.96-5.01 for RPSVT samples and 1.47-3.42 for RPVT samples) increased with increasing concentration of RP addition. However, a higher level of increase was observed in RPVT samples in comparison to RPSVT. This difference suggests the fibrous structure of tomatoes. These results are similar to the total dietary fiber values of tarhana samples (3.0-4.2%) examined by O'Callaghan and coauthors [50] .

According to the tarhana standards, TMAB count in tarhana sample should be $1x10^4$ CFU/g and TYM count should be $1x10^3$ CFU/g [18]. In a study carried out by Işık [13] by using wastes of sauce production, TMAB count of tarhanas (3.13–6.79 log CFU/g) was higher than the values found in the present study (4.18-3.94 log CFU/g for sauced samples and 4.01-3.82 log CFU/g for sauce-free samples) and they were higher than the lower threshold and lower than the upper threshold. Lower TMAB count of RP added vegan tarhana samples in comparison to the previous studies might be because of the lower pH value. TYM counts found in the present study (3.97-3.79 log CFU/g for sauced samples and 3.85-3.61 log CFU/g for sauce-free samples) were lower than TYM values (4.72-5.53 log CFU/g) reported by Göncü and Çelik [31] examining tarhanas added with red, yellow, and green lentil flour. Lower TYM count of RP added vegan tarhana samples in comparison to the previous studies might be because of the lower pH value.

The general acceptability values of all vegan tarhana samples produced in the study as a result of the sensory evaluation ranged between 3.00±0.67-4.10±0.74. The general acceptability values of the RPSVT samples were determined to be between 3.80±0.79-4.10±0.74. The general acceptability values of the RPVT samples were found to be between 3.00±0.67-3.80±0.79. While RPSVT vegan tarhana sample with 1% had the highest general acceptability values with 4.10±0.74, it was seen that 3% RPVT vegan tarhana sample had the lowest values of general acceptability characteristics with 3.00±0.67. In general, when the sensory evaluation scores of all vegan tarhanas are taken into account, it is seen that 3% RPVT vegan tarhana received the lowest scores in terms of color, smell, taste, consistency, aroma and general acceptability. It can be stated that 1% RPSVT vegan tarhanas got the highest score as a result of the evaluation of consistency, color, aroma and general acceptability.

CONCLUSION

In the present study, by using red beet *(Beta vulgaris var. Cruenta*) powder at different concentrations (control, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%), it was aimed to diversify the versions of tarhana, which has had a place in our traditional culture, in order to increase the diversity of vegan products and the physicochemical, microbiological, textural, bioactive, and sensorial characteristics of the products were examined.

It was determined that ash, total acidity, protein, water holding capacity, total dietary fiber, total phenolic content and antioxidant capacity increased in proportion to the red beet powder concentration in all tarhanas. It was determined that the highest score in terms of sensory properties (consistency, taste, aroma and general acceptability) was given to vegan tarhana with 1.0% red beet powder and tomato sauce. In terms of color and odor characteristics, it was determined that the highest score was in vegan tarhana with tomato sauce with 2.0% red beet powder added. The microbiological properties of vegan tarhana were found to be in accordance with the standards. *Staphylococcus aureus* and coliform group bacteria could not be detected in any of the vegan tarhana. When all vegan tarhanas are compared with the studies in the literature, it can be said that they have similar physicochemical and bioactive properties.

In conclusion, although many characteristics of all red beet powder added vegan tarhana were similar to those of traditional tarhana, it is an alternative to the traditional tarhana for vegan individuals.

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