RESEARCH ARTICLE

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Some Quality and Microbiological Traits of Tokat Tarhana Obtained from Different Wheat Cultivars Under Various Drying Conditions

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Abstract
This study was carried out to evaluate the variations in some quality traits of Tokat red pepper tarhana samples according to the cultivars and drying techniques. For this aim, five white grained bread wheat cultivars such as Altınöz, Candaş, Gökkan, Şahika, and Yakamoz were used as material. And, tarhana samples were dried under open air, airflow oven and vacuum. The study was conducted with three replications according to the split plot design in random plots. All quality traits showed statistically significant variations for the bread wheat cultivars (C), drying techniques (DT), and DT×C interactions. Thus, airflow oven showed the highest values among the drying techniques for the contents of ash (8.5892%), total titration acidity (27.433%) and salt (6.842%). On the other hand, open air drying technique presented the highest values for moisture (14.556%), pH (4.349) and the density of lactic acid bacteria (LAB) (1.4×10^4 CFU g^{-1} for M17 agar, 2.4×10^4 CFU g^{-1} for MRS agar. Also, Gökkan *cv* had the highest percents for all quality traits except LAB density. These findings showed that the most suitable bread wheat cultivar for Tokat red pepper tarhana was Gökkan *cv*, and the most favorable drying technique was open air drying. In addition, it is understood from the results that wheat cultivar and drying technique which used in tarhana production were essential factors. So, tarhana sector should choose the best wheat cultivar and drying technique to be used in tarhana production for consumer taste and healthy diet. From this study, it is understood that the open air drying is the most sustainable technique in terms of both production and consumption.
Keywords: Bread wheat, Flour, Quality traits, Tarhana

INTRODUCTION

When Tokat tarhana is mentioned, red pepper tarhana, named after Turkey's Tokat province, comes to mind. Of course, tarhana, which is enjoyed by almost everyone all over Turkey, is not limited to this region. When a detailed literature review is made, the origin of tarhana is from Central Asia to Anatolia; It will be understood that it spread widely from the Balkans to the Middle East. So and so, some researchers say that tarhana was passed to the Turks from Central Asia due to the relations of the Turks with the Chinese, and from there to Anatolia; they reported that it spread from Anatolia to the Balkans, Europe and the Middle East. While "Tarhana" finds a usage area with the same name in Türkiye; "Kishk" in Syria, Palestine, Jordan, Lebanon and Egypt; it is called "Kushuk" in Iraq and Iran; "Thanu" or "Tahonya"n Hungary; Known as "Talkuna" in Finland (Siyamoğlu, 1961; Merdol, 1968). It is known as "Trahanas" in Greece (Lazos et al., 1993). About 60 years ago, when two types of tarhana named "Göce" and "Aegean" were mentioned in Turkey (Siyamoğlu, 1961); today, it is reported that this number is

around 50 and this diversity is due to the changes in the raw material used locally and the differences in the way of presentation (Aksu et al., 2012).

Although its name and content are similar according to regions and countries; "Tarhana" is defined as follows according to the standard numbered 2282 of TSE (2004): "It is a nutrient obtained by drying, grinding and sifting wheat flour, wheat flour, semolina or their mixture with yoghurt, pepper, salt, onion, tomato and flavor-scented, harmless herbal substances after mixing and kneading and fermenting". In the same standard, four types of tarhana are defined as "göce tarhana", "flour tarhana", "mixed tarhana" and "semolina tarhana". These definitions have been determined depending on the use of semolina and wheat flour/crumbs in tarhana production. Mixed tarhana is obtained by using wheat flour/crushed or two different products from semolina, and semolina tarhana is obtained by using semolina instead of flour in its production (TSE, 2004). In Turkey, other tarhanas named according to their content and the region they are located in can be listed as follows: ball tarhana, Thrace, white tarhana, Gediz, cranberry, minced meat, Beyşehir, Göçmen, Kastamonu fresh tarhana, Sivas, Kahramanmaraş, Turnip tarhana, beet tarhana, milk tarhana, dough tarhana, meat tarhana, grape tarhana and sweet tarhana (Coşkun, 2014). In addition, the amount of yoghurt and salt added in tarhana production is also effective on the fermentation efficiency. It has been reported that the fermentation efficiency of tarhana increases with increasing the amount of substitute yogurt, but the time decreases with the addition of salt, and the use of lactic acid bacteria as probiotics in food production has increased in recent years (İbanoğlu and İbanoğlu, 1999).

The main foods used in tarhana production are yogurt and cereals. The type and amount of cereals and yoghurt used vary according to the region to which the tarhana belongs (Akbaş and Coşkun, 2006). Cereals are sources that we consume in our daily diet and meet our needs of carbohydrates, minerals, proteins, dietary fiber and vitamins. Nutritional values and sensory properties of milk and its products are higher when compared to cereal products. However, as a result of the fermentation of cereal grain and dairy products, a significant increase is observed in both sensory properties and nutritional values (Blandino et al., 2003). Flour Tarhana; it is a type of tarhana obtained by mixing yoghurt, onion, tomato pepper, salt and flavoring herbal products that are harmless to health, kneading with wheat flour and leaving to fermentation, then drying, grinding and finally sifting (Esimek, 2010). Dried or fresh ingredients such as tomatoes, onions, peppers are added to the mixture. These products are prepared by washing, cutting and sifting the main material of flour. Cooking is done for fresh vegetables. The thinning process is applied to the cooked and mixed materials (Atasoy, 2018). Although the materials used and their amounts vary according to the region, homemade or industrial tarhana production is generally done in four basic stages. These are: i) process of preparation and mixing, ii) fermentation, iii) drying and iv) grinding (Özdemir et al., 2007). Yogurt bacteria (*Lactobacillus delbrueckii subsp. bulgaricus*, *Streptococcus thermophilus*) and sourdough (*Saccharomyces cerevisiae*) perform the fermentation process in tarhana. With this process, the acidic and sour taste peculiar to tarhana is obtained. Ventilation should be provided in the room where the fermentation will take place and the temperature should be 30-35 °C. Thanks to the lactic acid bacteria formed during the fermentation, the pH of the environment is lowered and a bacteriostatic effect is created on pathogenic microorganisms. As the nutritional value of tarhana increases with fermentation, it also becomes an easy-to-digest product (Çopur et al., 2001).

In this research, which concerns tarhana in general, but specifically studied with Tokat red pepper tarhana, answers to the following questions were sought: First, what is the most suitable cultivar and the most suitable drying technique in terms of the quality characteristics examined? Second, has the drying technique×bread wheat cultivar interaction been found to be statistically significant on this quality criterion? After that, what is the best drying technique for the preservation of LAB in tarhana? Finally, which drying technique is most suitable for food safety?

MATERIALS AND METHODS

Material

Wheat grain materials were obtained from Republic of Türkiye, Ministry of Agriculture and Forestry, Eastern Mediterranean Agricultural Research Institute. All of the bread wheat cultivars used in the study are white grained, and their names are: Altınöz, Candaş, Gökkan, Şahika, and Yakamoz (Anonymous, 2023). The other materials used in the tarhana samples and their amounts were given in Table 1.

Table 1. The formulation of Tokat red pepper tarhana

Materials	Quantity (g)
Yogurt	130
Wheat flour	350
Tomatoe	200
Onion	100
Red pepper	400
Fresh dill	15
Salt	30
Fresh mint	15
Chickpea	15

Method

Tarhana production

Traditional tarhana production method based on spontaneous gradual fermentation method was applied to five bread wheat cultivars mentioned in the material. Firstly, vegetables such as onions, red peppers, and tomatoes were cut, followed by the cooking process by adding fresh mint and dill. Then, thinning was performed by shredding. Boiled chickpeas were then subjected to this process and included in the mixture. After this mixture was cooled, yoghurt, flour and salt were added and kneaded. This mixture was left to ferment for 5-7 days in a controlled manner by being ventilated at certain intervals, and then drying and grinding processes were started. For the drying process, three methods such as open air, airflow oven, and under vacuum were used.

Evaluated traits and the methodology

Of the investigated properties, moisture content was determined according to AACC (1990). TSE (2004) was used to determine the ash content. Protein content of tarhana samples was determined by Kjeldahl method (AACC, 1990) according to TS 2282 (TSE, 2004). The amount of nitrogen obtained was multiplied by the factor of 6.25 and the total protein was calculated as percent. Fat content of tarhana samples were calculated as percent by extraction with petroleum ether using automatic soxhlet device (AACC, 1990). The pH of the tarhana samples was determined according to TSE (2004). Total titration acidity was determined by the titration of tarhana samples (1 g) with 0.1 M NaOH concentration and expressed as percent lactic acid (Nes et al., 1996). Salt percentage of the samples were indicated by TSE (2004). For the density of lactic acid bacteria; 10 g of tarhana sample was homogenized in 90 mL of sterile physiological saline (SFS). Other dilutions were made by transferring 1 mL of the 10^{-1} dilution prepared in this way to 9 mL SFSs. It was sterilized by autoclaving before taking 0.1 mL from the appropriate diffusions. It was cooled down to 45-50 °C and poured into sterile petri dishes and inoculated on MRS Agar (for *Lactobacillus spp.*) and M17 Agar (for *Streptococcus* and *Lactococcus spp.*) media under aseptic conditions with 0.1 mL spread method. Petri dishes were incubated for 2 days at 30 °C for mesophiles and 40 °C for thermophiles under anaerobic conditions for MRS Agar, aerobic conditions for M17 Agar. At the end of the incubation, the colonies in the petri dishes were counted and expressed as CFU g^{-1}. Data except of lactic acid bacteria were evaluted by the JMP statistical program.

RESULTS AND DISCUSSION

The mean squares of cultivar, drying technique and the interaction of cultivar×drying technique obtained from variance analyzes of the investigated traits such as the contents of moisture, ash, protein, fat, pH, total titration acidity, and salt in Tokat tarhana are given in Table 2. According to Table 2; all sources of variation (cultivar, drying technique and the interaction of cultivar×drying technique) showed significant differences at $p<0.01$.

Moisture content

Tarhana is usually dried after fermentation to reduce its moisture content to less than 10% and to prevent clumping and microbial spoilage. Drying not only reduces moisture in tarhana, but also ensures that it has a bacteriostatic effect. The low humidity and relatively low pH inhibit the growth of pathogenic and spoilage microorganisms, resulting in a shelf life of more than one year. Tarhana is not hygroscopic and can be stored for 1-2 years without spoiling due to its low pH (3.50-5.00) and moisture content. It was stated by Erkan et al. (2006) that the difference in moisture content of tarhana samples was due to the properties of the components used in the formulation and the drying methods.

Mean values for moisture content in Tokat tarhana dried under various techniques and from some bread wheat cultivars were presented in Table 3. While the highest moisture content in the tarhana samples was obtained from the samples of open air drying (14.56%), the lowest humidity was determined in the samples of airflow oven drying (4.31%). When evaluated on the basis of the cultivars, the highest moisture content was determined in Gökkan *cv* with 9.22%, the lowest humidity was determined in Altınöz *cv* with 7.77%. Tarhana samples obtained from bread wheat varieties showed higher moisture in open air drying technique compared to

Table 2. The mean squares of cultivar, drying technique and the interaction of cultivar×drying technique obtained from variance analyzes of the investigated traits in Tokat tarhana.

Variation source	d_f	Mean of squares						
		Moisture	Ash	Protein	Fat	pH	TTA	Salt
Drying technique (DT)	2	437.997**	11.760**	6.211**	3.977**	0.010**	323.539**	6.719**
Error1	6	0.131	0.020	0.062	0.068	0.000	0.308	0.001
Cultivar (C)	4	2.584**	4.187**	5.890**	4.173**	0.028**	26.589**	3.076**
DT×C	8	4.203**	0.389**	1.082**	3.743**	0.004**	4.258**	0.232**
Error2	24	0.105	0.026	0.043	0.109	0.000	0.593	0.005
CV (%)		3.8	2.0	1.6	6.3	0.2	3.2	1.2

d_f: degree of freedom; CV: coefficient of variation; TTA: total titration acidity; **: significant at $p<0.01$

Table 3. The Mean values for moisture content in Tokat tarhana dried under various techniques and from some bread wheat cultivars (%).

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	14.980^{b*}	2.215^{gh}	6.165^{k}	7.787^{d}
Candaş	14.350^{c}	4.949^{h}	5.726^{i}	8.342^{bc}
Gökkan	15.971^{a}	4.246^{e}	7.451^{j}	9.222^{a}
Şahika	13.645^{d}	6.333^{gh}	5.905^{fg}	8.628^{b}
Yakamoz	13.833^{cd}	3.912^{f}	6.810^{j}	8.185^{c}
Mean	14.556^{a}	4.331^{c}	6.411^{b}	8.433
LSD_{DT}			0.324	
LSD_{C}			0.315	
$LSD_{DT×C}$			0.545	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and $LSD_{DT×C}$ show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying technique×cultivar interaction, respectively.

other drying techniques; it caused the KT×Ç interaction, in other words, the cultivars showed different moisture xontent in different drying techniques (Table 3).

ASH content

ASH refers to the inorganic residue remaining after the combustion or complete oxidation of organic matter in a food sample. Determining the ash content of a food is part of close analysis for nutritional assessment and is an important quality attribute for some food ingredients. In a study, the results of ash analysis in tarhana samples sold on the market varied between 1.91% and 3.97% (Göçmen et al. 2003). In the study of 27 homemade tarhanas produced in Isparta region, the ash analysis results were determined between 1.63% and 3.19% (Soyyigit, 2004). As the salt content increases, the ash values also increase. In addition, since the moisture content is different according to the drying techniques, the amount of ash in the products was different according to the drying techniques.

Mean values for ash content in Tokat tarhana dried under various techniques and from some bread wheat cultivars were presented in Table 4. While the highest ash content in tarhana samples was obtained from the airflow oven drying (8.592%), the lowest value was from the samples of open air drying (6.937%). Whean the mean values were evaluated on the basis of bread wheat cultivars, the highest ash content was determined in Gökkan *cv* with 9.136%, and the lowest ash was from Altınöz *cv* with 7.462%. Tarhana samples obtained from bread wheat cultivars showed higher ash content values in airflow oven drying technique compared to other drying techniques; so, DT×C interaction was occured, in other words, the cultivars showed different ash contents in different drying techniques (Table 4).

Protein content

It has been reported in some studies that the main reason for the change in the protein content of tarhana may be the type and amount of yogurt used in making tarhana (Temiz and Pirkul, 1991). It has been reported that the average protein values obtained from 13 different tarhana samples taken from industrially produced areas are 14.49% (Şimşekli and Doğan, 2015). In our study, it was observed that the amount of protein changed in different bread wheat cultivars and drying techniques.

Mean values for protein content in Tokat tarhana dried under various techniques and from some bread wheat cultivars were presented in Table 5. In the tarhana samples, the highest protein was obtained from the samples that were dried in the airflow oven (13.543%) while the lowest protein was from the samples of open air drying (12.404%). When evaluated on the basis of cultivars, the highest protein was determined in Gökkan *cv* with 14.167%, and the lowest protein was indicated in Şahika *cv* with 12.339%. Tarhana samples obtained from bread wheat varieties showed higher protein in airflow oven drying technique than the other drying techniques; so, the inraction of DT×C was occured (Table 5).

Fat content

Fats, which have an important place in human nutrition; it provides heat and energy to the body. In a study conducted; they examined five different commercial tarhana samples. It has been reported that the fat ratios in the examined tarhana samples are between 2.70% and 5.40% (O'Callaghan et al., 2019). When we look at another study, five different tarhana samples were examined and it was reported that the fat content of these examined tarhana samples was between 1.00% and 9.00% (Özdemir et al., 2007).

Mean values for fat content in Tokat tarhana dried under various techniques and from some bread wheat cultivars were showed in Table 6. When Table 6 was evaluated; the highest fat content in tarhana samples was obtained from the samples dried under vacuum (5.867%), while

Table 4. The Mean values for ash content in Tokat tarhana dried under various techniques and from some bread wheat cultivars (%).

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	6.823^{gh*}	8.105^{de}	7.459^{f}	7.462^{c}
Candaş	6.731^{gh}	8.469^{c}	8.327^{cd}	7.842^{b}
Gökkan	7.501^{f}	10.147^{a}	9.761^{b}	9.136^{a}
Şahika	6.993^{g}	8.138^{de}	8.090^{de}	7.740^{b}
Yakamoz	6.636^{h}	8.099^{de}	7.914^{e}	7.550^{c}
Mean	6.937^{c}	8.592^{a}	8.310^{b}	7.946
LSD_{DT}			0.127	
LSD_{C}			0.157	
LSD_{DTxC}			0.273	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and LSD_{DTxC} show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying techniquexcultivar interaction, respectively.

Table 5. The Mean values for protein content in Tokat tarhana dried under various techniques and from some bread wheat cultivars (%).

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	11.373^{f*}	13.317^{c}	12.833^{de}	12.508^{d}
Candaş	12.490^{e}	12.743^{de}	13.460^{c}	12.898^{c}
Gökkan	12.883^{d}	14.780^{a}	14.837^{a}	14.167^{a}
Şahika	11.250^{f}	12.873^{d}	12.893^{d}	12.339^{d}
Yakamoz	14.023^{b}	14.003^{b}	13.437^{c}	13.821^{b}
Mean	12.404^{b}	13.543^{a}	13.492^{a}	13.146
LSD_{DT}			0.223	
LSD_{C}			0.201	
LSD_{DTxC}			0.348	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and LSD_{DTxC} show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying techniquexcultivar interaction, respectively.

Table 6. The Mean values for fat content in Tokat tarhana dried under various techniques and from some bread wheat cultivars (%).

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	5.507^{def*}	3.123^{i}	6.667^{ab}	5.099^{c}
Candaş	4.553^{gh}	5.440^{def}	6.487^{ab}	5.493^{b}
Gökkan	6.213^{bc}	5..680^{cde}	5.593^{cd}	5.939^{a}
Şahika	3.213^{i}	4.133^{h}	5.217^{ef}	4.188^{d}
Yakamoz	5.113^{f}	6.843^{a}	5.043^{fd}	5.667^{ab}
Mean	4.920^{b}	5.044^{b}	5.867^{a}	5.277
LSD_{DT}			0.234	
LSD_{C}			0.321	
LSD_{DTxC}			0.556	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and LSD_{DTxC} show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying techniquexcultivar interaction, respectively.

the lowest fat was found in the samples dried in open air (4.920%). From the analysed of cultivars for fat content, the highest value was determined in Gökkan *cv* with 5.939%, the lowest value in Şahika *cv* with 4.188%. Tarhana samples obtained from bread wheat cultivars showed higher oil in vacuum drying technique than the other drying techniques, resulting in DT×C interaction (Table 6).

pH value

Color, flavor, and texture are important quality attributes and major factors influencing food sensory perception and consumer acceptance. Most food products have a pH between 3.50 and 7.00. pH has a significant effect on pigments (eg chlorophyll, carotenoids, anthocyanins etc.) and is responsible for the color of fruit, vegetables and meat. Therefore, knowledge of pH is very important to produce safe, quality and value-added products. pH values of 13 tarhana samples produced and offered for sale in the Kahramanmaraş region varied between 3.00 and 4.22 (Yörükoğlu and Dayısoylu, 2016). In the tarhana production study using legume flour instead of wheat flour, pH values changed between 3.80-4.20 (Atasoy, 2018).

In tarhana samples, the highest pH was obtained from the samples dried in the open air (4.349), while the lowest pH was determined in the samples dried in the oven (4.298). When evaluated on the basis of cultivars, the highest pH was found in Gökkan *cv* with 4.370 and the lowest pH in Altınöz *cv* with 4.240. Tarhana samples obtained from bread wheat cultivars showed higher pH in open air drying technique compared to other drying techniques, causing DT×C interaction, in other words, cultivars show different pH values in different drying techniques (Table 7).

Table 7. The Mean values for pH value in Tokat tarhana dried under various techniques and from some bread wheat cultivars.

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	4.233^{h*}	4.237^{gh}	4.250^{g}	4.240^{d}
Candaş	4.360^{c}	4.270^{f}	4.300^{e}	4.310^{c}
Gökkan	4.397^{b}	4.353^{c}	4.360^{c}	4.370^{a}
Şahika	4.320^{d}	4.280^{f}	4.400^{b}	4.333^{b}
Yakamoz	4.433^{a}	4.350^{c}	4.350^{c}	4.378^{a}
Mean	4.349^{a}	4.298^{b}	4.332^{a}	4.326
LSD_{DT}			0.018	
LSD_{C}			0.009	
$LSD_{DT×C}$			0.015	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and $LSD_{DT×C}$ show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying technique×cultivar interaction, respectively.

Table 8. The Mean values for TTA in Tokat tarhana dried under various techniques and from some bread wheat cultivars (%).

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	20.000^{g*}	29.583^{ab}	27.250^{c}	25.611^{b}
Candaş	16.583^{i}	25.583^{de}	24.250^{f}	22.139^{d}
Gökkan	20.417^{g}	30.417^{a}	28.750^{b}	26.528^{a}
Şahika	20.250^{g}	24.750^{ef}	26.250^{cd}	23.750^{c}
Yakamoz	17.917^{h}	26.833^{cd}	26.833^{cd}	23.861^{c}
Mean	19.033^{c}	27.433^{a}	26.667^{b}	24.378
LSD_{DT}			0.496	
LSD_{C}			0.749	
$LSD_{DT×C}$			1.298	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and $LSD_{DT×C}$ show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying technique×cultivar interaction, respectively.

Table 9. The Mean values for salt content in Tokat tarhana dried under various techniques and from some bread wheat cultivars (%).

Cultivars (C)	Drying Techniques (DT)			Mean
	Open air	Airflow oven	Under vacuum	
Altınöz	5.483^{hi*}	6.310^{de}	5.813^{g}	5.869^{d}
Candaş	5.200^{j}	6.760^{c}	6.430^{d}	6.130^{b}
Gökkan	6.147^{f}	8.080^{a}	7.740^{b}	7.322^{a}
Şahika	5.530^{h}	6.420^{d}	6.190^{ef}	6.047^{c}
Yakamoz	5.373^{i}	6.640^{c}	6.260^{ef}	6.091^{bc}
Mean	5.547^{c}	6.842^{a}	6.487^{b}	6.292
LSD_{DT}			0.039	
LSD_{C}			0.075	
$LSD_{DT\times C}$			0.129	

*: There is no difference at the 0.05 probability level between the mean values with the same letter group. LSD_{DT}, LSD_{C}, and $LSD_{DT\times C}$ show the least significant differences between the mean values in terms of drying techniques, bread wheat cultivars and drying technique×cultivar interaction, respectively.

Table 10. The Mean values for lactic acid bacteria density in Tokat tarhana dried under various techniques and from some bread wheat cultivars (CFU g^{-1}).

Cultivars	Drying Techniques					
	Open air		Airflow oven		Under vacuum	
	M17	MRS	M17	MRS	M17	MRS
Altınöz	1.7×10^4	2.4×10^4	<10	<10	<10	<10
Candaş	2.1×10^4	3.1×10^4	<10	<10	<10	<10
Gökkan	0.8×10^4	0.3×10^4	<10	<10	<10	<10
Şahika	1.4×10^4	2.3×10^4	<10	<10	<10	<10
Yakamoz	1.0×10^4	4.0×10^4	<10	<10	<10	<10
Mean	1.4×10^4	2.4×10^4	<10	<10	<10	<10

CFU: Coloni-Forming Units; M17: aerobic agar medium; MRS: anaerobic agar medium

Total titration acidity (TTA)

The increase in acidity in foods is due to organic acids produced as a result of fermentation. This acidity not only adds flavor to tarhana, but also extends its shelf life. In a study, as a result of the examination of 27 home tarhana procured from Isparta region, the acidity values were determined between 4.91% and 36.62%. On average, it reached a value of 15.13% (Soyyigit, 2004).

The highest TTA in the tarhana samples was obtained from the samples of dried in the airflow oven (27.433%), while the lowest from the samples of dried in the open air (19.033%). When evaluated for the cultivars, the highest TTA was from Gökkan *cv* with 26.528%, and the lowest TTA was from Candaş *cv* with 22.139). Tarhana samples obtained from bread wheat cultivars showed higher TTA in airflow oven drying technique compared to other drying techniques; this stuation caused the DT×C interaction (Table 8).

Salt content

Salt; by inhibiting many enzymatic reactions in foods, it contributes to activating reactions that facilitate the characterization of color, texture and additionally flavor properties (Roy et al., 2021). In addition, salt added to food; it triggers the growth and development of yeast and fermented bacteria. Thus, it supports proteins and other binders in foods to achieve the desired texture. In a study, 13 tarhana samples in Kahramanmaraş region were examined and their physical and chemical analyzes were examined. It has been reported that the salt content of 13 tarhana samples is between 4.37-6.47% (Yörükoğlu, 2016).

From the evaluation of Table 9, the highest salt content in the tarhana samples was found in the oven-dried samples (6.842%); it is understood that the lowest salt content was obtained from the samples (5.547%) of open air dried. When the salt contents of tarhana samples were evaluated on the basis of cultivars, the highest salt was found in Gökkan *cv* with 7.322%, the lowest salt was determined in Altınöz *cv* with 5.699%. Tarhana samples obtained from bread wheat varieties showed higher salt content in airflow oven technique than other drying techniques; thus, DT×C interaction was formed (Table9).

Lactic acid bacteria density (LABD)

No lactic acid development was observed in the samples of tarhana produced in airflow oven drying and vacuum drying (Table 10). It is thought that the lactic acid bacteria under these conditions are killed because they are treated for a long time at 80 °C in an oven and at

60 °C in vacuum. LABD also changed according to the agar medium in which the bacteria grew and the wheat varieties used in tarhana. The highest LABD (2.4×10^4 cfu g^{-1}) was determined in MRS agar while the lowest density (1.4×10^4 cfu g^{-1}) was from M17 agar which they were as mean of wheat cultivars in open air drying (Table 10). Also, according to the wheat cultivars; the highest LABD values were 2.1×10^4 cfu g^{-1} (Candaş *cv*) in M17 agar; 4.0×10^4 cfu g^{-1} (Yakamoz *cv*) in MRS agar.

CONCLUSION

The findings of this study are generalizable qualification not only for Tokat red pepper tarhana, but also for all fermented products that require drying in which cereals such as tarhana are included. However, the effects of bread wheat cultivars and applied drying techniques on tarhana quality will be mentioned here. The results of the study can be summarized as follows: i) The bread wheat cultivars used in tarhana were found to be statistically effective on the investigated quality parameters. ii) The drying techniques applied showed significant differences for all quality parameters. iii) The wheat cultivars used showed significant differences in terms of quality traits in different drying techniques. In other words, the interaction of drying technique×wheat cultivar was found to be statistically significant. iv) While lactic acid bacteria density (LABD) is adversely affected by drying in the airflow oven and under vacuum; LAB could only survive in the drying environment in the open air. v) When LABD is evaluated in terms of drying in the open air; LAB production also varied on different agar media and different wheat cultivars. vi) For Tokat red pepper tarhana, it was concluded that Gökkan *cv* was the most suitable among the wheat varieties used. vii) If a generalization is to be made, the open air drying technique is a technique that should be considered in terms of food safety, as it is a drying method based on a renewable (solar) energy source, since it is based on sustainable production. viii) In tarhana, drying in the open air seems to be a most sustainable method for also consumption because of continuity of lactic acid bacteria production after drying, too.

COMPLIANCE WITH ETHICAL STANDARDS

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. However, SGÖ had MSc thesis and made the laboratory studies together with CB (her 2nd supervisor). BB undertook the article writing and the 1st supervisory role of SGÖ's thesis. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethics committee approval

Ethics committee approval is not required. This article does not contain any studies with human participants or animals performed by any of the authors.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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