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The effect of different parameters on the 'Tarhana' food properties: a review of some literature data

Aikaterini Georgala*

Laboratory of Dairy Research, Department of Food Science & Human Nutrition,Agricultural University of Athens, 75 IeraOdos Str., 11855, Athens, Greece

Abstract

Fermented foods are known from ancient times and play an important role inpeople's diet in many parts of the world. Traditional fermented cereal foods are widelyused in the diet of people in the Middle East, Asia, Africa and some parts of Europe.The technology of making Tarhana food as well as the type of milk and cereal used areof the main factors that influence its properties. The 'Tarhana' in Turkey and the 'Kishk' in Syria, Jordan, Lebanon and Egypt are known to be the oldest and mostwidely used fermented milk-cereal foods in these areas. This work is a review on the effect of different parameters on tarhana food properties.

Introduction

Traditional dried fermented milk/cereal foods are widely used in the diet of people in the Middle East, Asia, Africa and some parts of Europe [1]. These products have high nutritive value and interesting organoleptic characteristics. Similar products are produced: 'Kishk' in Egypt, Syria, Lebanon and Jordan, 'Kushuk' in Iraq, 'Tarhana' in Turkey, 'Trahanas' in Greece and Cyprus and 'Tarhonya/Talkuna' in Hungary and Finland. Methods for preparing these products vary from place to place but cereals and fermented milk are always the major components [2,3].

Although the production of Tarhana product varies from region to region [4], tarhana is produced by mixing cereal flour, yoghurt, baker's yeast (Saccharomyces cerevisiae) and a variety of cooked vegetables (tomatoes, onions, green peppers and red peppers), salt and spices (mint, thyme, dill, tarhana herb etc.). Afterwards, lactic and alcoholic fermentation is taken place for one to seven days [1,4-6]. The fermented slurry is then air-dried and a high nutritive product is taken [3]. Tarhana has an acidic and sour taste with a yeasty flavor and is mainly used for soup making although it can be consumed as a snack after being dried [1].

Methods for tarhana preparation vary from one place to another, but cereals and yoghurt are always the two major components. Since there is no standard production method, nutritional properties of Tarhana strictly depend on ingredients and their ratios in the recipe.

Most of the tarhana consumed in Turkey is home-made. Tarhana is prepared at homes by ways that have been learned from mother to grandmother since old times. However, it is also produced at the industrial level. In commercial production there are two methods for tarhana making. First method is called straight method and ingredients in the recipe is mixed and kneaded, fermented, dried and finally sieved. Second method is called sour dough method that contains three steps, each one has a different recipe [4]. There is a growing interest in producing tarhana on an industrial scale, especially ready-to-use form.

This work is a review on the effect of different parameters such as added ingredients, fermentation and storage conditions etc. on the 'Tarhana' food properties.

Effect of the added ingredients on Tarhana properties

The ingredients that are used for making tarhana could affect its nutritional and sensory properties [5]. The added ingredients are known to vary from place to place. Cereal flour (mainly wheat flour) is mixed with yoghurt, baker's yeast (Saccharomyces cerevisiae) and a variety of cooked vegetables (tomatoes, onions, green pepper etc.), salt and spices (mint, thyme, dill, tarhana herb etc.) followed by fermentation for one to seven days [4,6]. In the central and eastern part of the Turkey, one or more ingredients such as milk, soybean, lentil, chickpea, corn flour and egg are also added [4].

In literature, it has been reported that tarhana or tarhana like products were enriched by soybean, lentil and chickpea, germ and bran [7,8] whole wheat meal and bulgur [9], corn and barley [10,11].

The nutritional value of wheat germ proteins is comparable to animal proteins and wheat germ is a very good source of free sugars and mineral content when compared to wheat flour. Wheat bran can be used in food products due to its high fiber content and antioxidant properties. In general, tarhana is produced with white-wheat flour. However, whole meal flour, semolina or both can also be used. Wheat flour is sometimes replaced by bulgur (parboiled, cracked wheat kernel) and sour is used instead of wheat flour.

Apart from having a nutritive value comparable to wheat, barley is unique among cereals containing high concentrations of b-glucan which is known to have the effect of cholesterol lowering effect, regulating blood glucose level and insulin response in diabetics and even reducing risk of cancer.

Although barley is the fourth most important cereal in the world in terms of total production after wheat, rice and corn, only a small

***Correspondence to:** Aikaterini Georgala, Laboratory of Dairy Research, Department of Food Science & Human Nutrition, Agricultural University of Athens, 75 IeraOdos Str., 11855, Athens, Greece, E-mail: georgala@aua.gr

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amount of barley is used for human consumption. Taste and appearance factors along with its poor baking quality have limited the use of barley in human foods. However, in recent years there has been a growing research interest for the utilization of barley in a wide range of food applications.

The type of yoghurt is known to affect tarhana properties with stirred yoghurt to give a better acidity to tarhana product, while set yoghurt increase its protein content. Usually, in tarhana production yoghurt is mixed with wheat flour in a ratio 1:2. However, there are also tarhana products in which yoghurt ratio to flour is 1:1.

Cereal flours in Tarhana production

The use of different cereal flours in tarhana production

The use of soybean flour, rye flour and maize flour in tarhana production: Soybeans are known to have a high protein content and a high lysine level. The latter exceeds human's needs study the use of soybeans in the production of tarhana [12,13]. Tarhana was produced from yoghurt and wheat flour. The latter was replaced totally or partially with soybean flour. This study showed that a highly nutritional product was taken (Table 1). The use of soybean flour increased significantly the protein content of tarhana from 160.5 g/kg in 20% soy-tarhana product to 335.6 g/kg in 100% soy-tarhana product (Table 1). Except soy-fortified tarhana samples two other wheat-based Turkish tarhanas (Polarti and Kirsehir tarhanas) were studied for their chemical composition (Table 1). Consideringthe protein content and well-balanced amino acid profile as the product contains animal, soybean and wheat-based proteins, the addition of soybean flour improves the nutritional value of tarhana to a great extent. With this specific production technique, there was no beany off flavour problem. Comparatively high sensory scores indicated that tarhana was an excellent choice for soybean utilization in traditional foods.

Kose and Cagindi, examined the addition of different cereal flours in the tarhana making process. These tarhana products were compared with wheat flour tarhana [14]. All the cereal flours used in tarhana production were purchased from commercial sources. The moisture content of the examined samples was between 10.2 and 11.9%, ash value was 1.10-2.39%, protein value 8.8-22.5% (Table 1).

All the cereal flours used in tarhana production were purchased from commercial sources. The moisture content of the examined tarhana samples was between 10.2 and 11.9%, ash value was 1.10-2.39%, protein value 8.8-22.5% (Table 1). The highest ash and protein contents were found in tarhana sample named S10 where the ratio of soybean to wheat flour was 25:75 (Table 1). The different chemical composition of rye, maize, soybean and wheat flour (Table 1) seems to be responsible for the different composition of the final products.

The soybean flours used in tarhana production increased ash as well as protein content of the product while the addition of maize flour decreased them. However, the addition of rye flour seemed to increase the ash content of tarhana food (Table 1). In contrast, when maize flour was used the protein content of tarhana food was decreased. Acidity values were found to be between 1.5 and 1.7 % with no significant differences among the samples. Finally, tarhana soups made of wheat-maize flour mixtures had lower scores in terms of flavour and smell, mouth-feel and overall acceptability.

The use of barley flour in tarhana production

Erkan et alexamined the use of one Huless and two hulled barley flours in tarhana production. Although some of the b-glucan may be destroyed during tarhana fermentation, the results of Erkan et al., showed that barley flours can be used to produce tarhana with relatively high b-glucan content [11]. Wheat flour had the lowest ash value (0.68%) of the flour samples used, while Huless barley flour had the highest one (1.31%) (Table 1). The Huless barley flour sample had the highest protein content (13.4%) and the barley flour 1 sample had the lowest protein content (8.0%) (Table 1). The fat content of flour samples ranged between 1.54% and 1.92% (Table 1). The yoghurt used was made from cow's milk and had fat and protein contents of 3.15% and3.9%, respectively. The moisture content of tarhana samples was between 7.6% at Barley tarhana 2 sample and 9.0% at Barley tarhana 1 sample (Table 1). The ash contents of tarhana samples were between 1.71% at wheat tarhana sample and 2.48% at Huless barley tarhana (Table 1). Wheat tarhana sample had the lowest ash content (1.71%) while the Huless barley tarhana had the highest value (2.48%) as expected from the ash contents of respective flours (Table 1).

Barley tarhana 1 sample had the lowest protein content (10.1%) while the Huless barley tarhana sample had the highest protein content (15.9%) (Table 1). The main reason for the variation of protein contents is the type of flour samples used in tarhana preparation since the type and amount of yoghurt are common in all tarhana samples examined. Both barley tarhana 1 and wheat tarhana had the lowest crude fat content of 3.39% and 3.40%, respectively (Table 1). The observed differences in fat contents of tarhana samples are probably due to the different fat contents of flour samples used in the formula (Table 1).

The acidity values of tarhana samples were between 1.2% (wheat barley tarhana sample) and 1.6% (Huless barley tarhana sample) (Table 1). Wheat and hulled barley tarhana samples had comparable acidity values (table 1). Tarhana samples used in this research had pH values between 4.59 (wheat tarhana sample) and 4.81 (wheat barley tarhana sample) (Table 1).

Wheat tarhana sample had the lowest b-glucan content (0.28%) while the Huless barley tarhana had the highest value (3.55%) as expected from the b-glucan content of respective flours (Table 6). In other words, a parallel relationship exists between the b-glucan contents of flour samples and those of tarhana samples. On the other hand, b-glucan contents of tarhana samples were lower than those of flour samples. It was reported that there has been a decrease in total and soluble b-glucan contents of cereal flours during fermentation. The main reason for decrease in b-glucan content has been thought to be the degradation of b-glucan by lactic acid bacteria during fermentation. The results of the overall sensory analysis showed that utilization of barley flours in tarhana preparation resulted in acceptable soup properties in terms of most of the sensory properties.

The use of buckwheat flour in tarhana production

Buckwheat (BW) is known for its functional properties. Buckwheat (BW), pseudo-cereal, protein consists of well-balanced, amino acids with high biological value. Buckwheat is a good source of many essential minerals, polyunsaturated fatty acids, vitamins B1, B2 and E and flavonoid and as does not contain gluten it is a major ingredient in a daily diet of the celiac patients. BW is known to reduce high blood pressure, prevent oedema and hemorrhagic diseases and reduces the risk of arteriosclerosis.

The effect of different buckwheat flour ratio addition on the tarhana properties. Compared to wheat flour, buckwheat flour is produced from the whole groat it had higher content of ash, fat, cellulose, mineral and phytic acid ($p<0.05$) as compared to wheat flour (Table 2). Particularly,

Table 1. Chemical composition of tarhana samples on dry basis

Product	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Salt (%)	Total acidity (%)	pH	Reference
Polarti Tarhana (Wheat based)	6.52	-	14.09	-	-	2.05	3.32	[13]
Kirhesir Tarhana (Wheat based)	8.94	-	13.65	-	-	1.5	3.02	[13]
20% Soy-Tarhana	6.07	-	16.05	-	-	2.45	3.22	[13]
50% Soy-Tarhana	5.55	-	22.83	-	-	2.5	3.28	[13]
100% Soy-Tarhana	8.88	-	33.56	-	-	2.0	3.20	[13]
Standard tarhana sample (named S1)	7.7	3.8	16.2	7.4	-	1.8	4.8	[5]
Tarhana sample with increased yoghurt (named S2)	9.5	4.5	16.7	7.6	-	2.0	4.4	[5]
Tarhana sample without salt (named S3)	6.9	3.3	16.0	1.8	-	2.1	4.3	[5]
Tarhana sample with whole meal flour (named S4)	5.9	5.7	19.2	8.2	-	1.8	4.8	[5]
Homemade tarhana (named S5)	10.6	3.6	15.6	4.5	-	2.1	4.5	[5]
Commercially produced tarhana (named S6)	12.1	5.3	12.9	2.9	-	1.9	4.5	[5]
Standard tarhana (S1) (yoghurt: wheat flour ratio=0.5)	7.7	3.8	16.2	7.4	5.9	1.8	4.80	[1]
Tarhana with increased yoghurt (S2) (yoghurt: wheat flour ratio=1.0)	9.5	4.5	16.7	7.7	5.7	2.0	4.42	[1]
Tarhana without salt (S3) (yoghurt: wheat flour ratio=0.5)	6.9	3.5	16.0	1.8	2.2	2.5	4.21	[1]
Tarhana	10.2	5.4	16.0	6.2	3.8			[4]
Wheat flour	13.90	-	10.90	0.49	-	-	-	[14]
Rye flour	11.60	-	7.70	1.07	-	-	-	[14]
Maize flour	13.70	0.90	4.90	0.47	-	-	-	[14]
Soybean flour	4.80	0.60	31.60	6.55	-	-	-	[14]
Yoghurt	78.10	4.80	10.38	1.40	-	1.61	-	[14]
Tarhana-Sample S1 (100% Wheat flour)	10.70		14.50	1.26				[14]
Tarhana-Sample S2 (Rye/wheat flour ratio: 25/75)	10.50		13.80	1.35				[14]
Tarhana-Sample S3 (Rye/wheat flour ratio: 50/50)	10.20		13.00	1.43				[14]
Tarhana-Sample S4 (100% Rye flour)	11.70		10.50	1.58				[14]
Tarhana-Sample S5 (Maize/wheat flour: 25/75)	10.50		12.80	1.23				[14]
Tarhana-Sample S6 (Maize/wheat flour: 50/50)	10.20		11.10	1.19				[14]
Tarhana-Sample S7 (100% Maize flour)	11.00		8.80	1.10				[14]
Tarhana-Sample S8 (Soybean/wheat flour: 5/95)	10.90		16.10	1.49				[14]
Tarhana-Sample S9 (Soybean/wheat flour: 15/85)	11.40		19.30	1.94				[14]
Tarhana-Sample S10 (Soybean/wheat flour: 25/75)	11.90		22.50	2.39				[14]

Product	Moisture (%)	Fa (%)	Protein (%)	Ash (%)	Salt (%)	Total acidity (%)	pH	Reference
Tarhana (0 days FP -Control sample)	70.0					7.8	4.6	[19]
Tarhana (4 days FP)	69.3					22.7	4.0	[19]
Tarhana-Effect of drying temperature (DT)								[19]
Tarhana (Control sample)	69.1					22.7	4.0	[19]
Tarhana (500C DT)	10.0					22.9	4.30	[19]
Tarhana (600C DT)	10.0					23.0	4.38	[19]
Tarhana (700C DT)	10.0					23.1	4.45	[19]
Tarhana	61.05		16.79	8.94	6.48			[18]
Standard tarhana-Sample S1 (without tarhana herb addition)	10.2		12.61	5.22		1.8	4.38	
Tarhana-Sample S2 (with 0.5% tarhana herb addition)	10.0		12.63	5.30		2.3	3.71	
Tarhana-Sample S3 (with 1.0% tarhana herb addition)	10.6		12.68	5.33		2.2	3.91	
Tarhana-Sample S4 (with 1.5% herb addition)	10.4		12.64	5.51		2.2	3.94	
Dried tarhana (50% yoghurt rate, 0h fermentation time)	12.89	2.35	14.50	8.55				
Dried tarhana (50% yoghurt rate, 0h fermentation time)	12.56	2.34	14.48	8.61				
Dried tarhana (50% yoghurt rate, 48h fermentation time)	12.38	2.37	14.52	8.61				
Dried tarhana (50% yoghurt rate, 48h fermentation time)	13.40	3.09	15.60	8.75				
Dried tarhana (50% yoghurt rate, 96h fermentation time)	13.41	3.10	15.58	8.78				
Dried tarhana (50% yoghurt rate, 96h fermentation time)	13.42	3.14	15.52	8.79				
Frozen tarhana (75% yoghurt rate, 0h fermentation time)	42.10	2.30	14.55	8.55				
Frozen tarhana (75% yoghurt rate, 0h fermentation time)	42.41	2.33	14.48	8.61				
Frozen tarhana (75% yoghurt rate, 48h fermentation time)	41.55	2.28	14.52	8.51				
Frozen tarhana (75% yoghurt rate, 48h fermentation time)	45.10	3.15	15.50	8.80				
Frozen tarhana (75% yoghurt rate, 96h fermentation time	45.50	3.12	15.54	8.86				
Frozen tarhana (75% yoghurt rate, 96h fermentation time)	45.52	3.09	15.57	8.82				

Wheat flour	14.4	1.54	11.6	0.68		-	-	[11]
Barley flour 1	10.7	1.62	8.0	0.86		-	-	[11]
Barley flour 2	11.8	1.92	10.4	1.03		-	-	[11]
Huless barley flour	11.9	1.90	13.4	1.31		-	-	[11]
Wheat tarhana	8.2	3.40	15.0	1.71		1.40	4.59	[11]
Barley tarhana 1	9.0	3.39	10.1	1.98		1.30	4.60	[11]
Barley tarhana 2	7.6	4.13	13.0	2.07		1.40	4.69	[11]
Huless barley tarhana	7.6	4.65	15.9	2.48		1.60	4.73	[11]
Wheat/barley tarhana	8.3	4.05	13.6	1.92		1.20	4.81	[11]

Product		**Fat (%)**				**Protein (%)**				**Ash (%)**							Reference
Tarhana	YW_0	YW_1	YW_2	YW_3	YW_0	YW_1	YW_2	YW_3	YW_0	YW_1	YW_2	YW_3	YW_0		YW_2	YW_3	[10]
Tarhana W	3.59	2.76	2.42	1.60	15.30	15.09	14.68	14.08	1.89	2.47	2.84	3.30	18.50	19.50	23.75	26.75	[10]
Tarhana C	8.01	6.79	6.19	5.57	14.96	14.02	13.55	13.08	2.84	3.16	3.54	3.91	29.55	31.25	24.20	26.20	[10]
Tarhana W+C	5.83	5.36	4.57	4.16	15.62	14.91	14.47	14.01	2.23	2.78	2.64	3.44	24.95	23.75	28.77	31.15	[10]

Tarhana W : Tarhana made with wheat flour. Tarhana C : Tarhana made with corn flour. Tarhana W+C: Tarhana made with wheat +corn flour. YW_0: 300g yoghurt + 0g whey used in tarhana production. YW1: 200g yoghurt + 200g whey used in tarhana production. YW_2 : 100g yoghurt+400 g whey used in tarhana production. YW_3: 0g yoghurt +600g whey used in tarhana production.

Product	**Moisture (%)**	**Fat (%)**	**Protein (%)**	**Ash (%)**	**Total acidity (%)**	**pH**	Reference
Wheat flour	11.19		11.6				[8]
Malt flour	9.61		8.64				[8]
Yoghurt	78.65		26.7				[8]
Tomato paste	71.09		16.3				[8]
Onion	91.35		7.85				[8]
Yeast	70.98		47.5				[8]
Red pepper	5.75		10.7				[8]
Dough			13.8				[8]
Tarhana			16.1				[8]
Dough (0% Yeast level)			13.1				[8]
Dough (2.5% Yeast level)			13.6				[8]
Dough (5% Yeast level)			14.1				[8]
Tarhana (0% Yeast level)			15.0				[8]
Tarhana (2.5% Yeast level)			16.3				[8]
Tarhana (2.% Yeast level)			17.1				[8]
Dough (0% Malt level)			13.7				[8]
Dough (2% Malt level)			13.8				[8]
Dough (4% Malt level)			13.5				[8]
Tarhana (0% Malt level)			15.9				[8]
Tarhana (2% Malt level)			16.2				[8]
Tarhana (4% Malt level)			16.3				[8]
Dough (0% Phytase level)			13.5				[8]
Dough (0.05% Phytase level)			13.9				[8]
Dough (0.5% Phytase level)			13.6				[8]
Tarhana (0% Phytase level)			16.0				[8]
Tarhana (0.05% Phytase level)			16.2				[8]
Tarhana (0.5% Phytase level)			16.1				[8]
Wheat flour	12.3	1.1	10.62	0.51	0.36	6.10	[7]
Wheat germ	10.8	8.5	26.5	4.18	1.26	6.77	[7]
Wheat bran	13.9	4.7	13.65	4.32	0.65	6.90	[7]
Tarhana (0% wheat germ)	10.56	6.20	14.50	1.35	1.73	4.25	[7]
Tarhana (10% wheat germ)	10.01	6.73	15.82	1.76	2.40	4.49	[7]
Tarhana (25% wheat germ)	9.91	8.50	19.25	2.33	2.57	4.74	[7]
Tarhana (50% wheat germ)	9.85	9.37	20.10	3.26	3.76	5.10	[7]

Tarhana (10% wheat bran)	9.93	6.40	14.63	1.69	2.10	4.40	[7]
Tarhana (25% wheat bran)	9.31	6.73	15.03	2.23	2.13	4.65	[7]
Tarhana (50% wheat bran)	10.01	7.55	15.98	2.93	2.29	5.09	[7]
Wheat flour		0.8	11.4	0.52			
Buckwheat flour (BWF)		2.9	12.3	1.95			
Tarhana (0% BWF ratio)		6.11	16.4	1.68	2.00		
Tarhana (20% BWF ratio)		6.51	16.8	1.92	2.12		
Tarhana (40% BWF ratio)		7.09	17.2	2.13	2.36		
Tarhana (60% BWF ratio)		7.40	17.4	2.43	2.60		
Tarhana (80% BWF ratio)		7.89	18.0	2.77	2.65		
Tarhana (100% BWF ratio)		8.20	18.2	3.04	2.83		

	Fermentation time (h)	Total acidity (%)	pH
Tarhana (0% wheat germ)	0	1.11	4.6
	4	1.25	4.5
	8	1.45	4.45
	24	1.56	4.30
	72	1.73	4.25
Tarhana (10% wheat germ)	0	1.33	4.8
	4	1.39	4.59
	8	1.56	4.64
	24	1.89	4.52
	72	2.40	4.49
Tarhana (25% wheat germ)	0	1.39	5.16
	4	1.59	4.92
	8	1.95	4.88
	24	2.30	4.76
	72	2.57	4.74
Tarhana (50% wheat germ)	0	1.50	5.53
	4	1.86	5.38
	8	2.17	5.34
	24	3.17	5.15
	72	3.76	5.10
Tarhana (0% wheat bran)	0	1.10	4.57
	4	1.22	4.54
	8	1.42	4.43
	24	1.55	4.28
	72	1.77	4.24
Tarhana (10% wheat bran)	0	1.33	4.76
	4	1.42	4.59
	8	1.50	4.58
	24	1.67	4.43
	72	2.09	4.40
Tarhana (25% wheat bran)	0	1.39	5.03
	4	1.50	4.86
	8	1.67	4.82
	24	1.84	4.71
	72	2.12	4.65
Tarhana (50% wheat bran)	0	1.51	5.31
	4	1.59	5.21
	8	1.75	5.19
	24	1.92	5.13
	72	2.29	5.09

Tarhana W : Tarhana made with wheat flour. Tarhana C : Tarhana made with corn flour. Tarhana W+C: Tarhana made with wheat +corn flour. YW_0: 300g yoghurt + 0g whey used in tarhana production. YW1: 200g yoghurt + 200g whey used in tarhana production. YW_2 : 100g yoghurt+400 g whey used in tarhana production. YW_3: 0g yoghurt +600g whey used in tarhana production.

Product	Fermentation time (h)	Total acidity (%)	pH
Tarhana (0% wheat germ)	0	1.11	4.6
	4	1.25	4.5
	8	1.45	4.45
	24	1.56	4.30
	72	1.73	4.25

Tarhana (10% wheat germ)	0	1.33	4.8
	4	1.39	4.59
	8	1.56	4.64
	24	1.89	4.52
	72	2.40	4.49
Tarhana (25% wheat germ)	0	1.39	5.16
	4	1.59	4.92
	8	1.95	4.88
	24	2.30	4.76
	72	2.57	4.74
Tarhana (50% wheat germ)	0	1.50	5.53
	4	1.86	5.38
	8	2.17	5.34
	24	3.17	5.15
	72	3.76	5.10
Tarhana (0% wheat bran)	0	1.10	4.57
	4	1.22	4.54
	8	1.42	4.43
	24	1.55	4.28
	72	1.77	4.24
Tarhana (10% wheat bran)	0	1.33	4.76
	4	1.42	4.59
	8	1.50	4.58
	24	1.67	4.43
	72	2.09	4.40
Tarhana (25% wheat bran)	0	1.39	5.03
	4	1.50	4.86
	8	1.67	4.82
	24	1.84	4.71
	72	2.12	4.65
Tarhana (50% wheat bran)	0	1.51	5.31
	4	1.59	5.21
	8	1.75	5.19
	24	1.92	5.13
	72	2.29	5.09

the minerals of Mg, K, P and Zn content of BWF was found to be rich as compared to that of wheat flour (Table 2).

Concerning tarhana samples the highest ash, protein, fat and cellulose contents were obtained with 100% BWF addition (Table 1). On the contrary, the lowest starch content of tarhana samples was obtained with 80-100% BWF addition (Table 1). High BWF addition levels improved the acidity of tarhana samples (Table 1). Phytic acid content of tarhana increased with 80-100% BWF addition level. Mineral composition of BWF was richer than wheat flour except Ca (Table 2). With the addition of BWF to tarhana the minerals K, Mg, P, Fe and Zn increased by 1.16-1.56 times, 1.67-4.44 times, 1.26-2.32 times, 1.14-1.60 times and 1.22-1.73 times, respectively (Table 2).

The effect of wheat germ/bran on tarhana properties

Bilgicli et al., studied the effect of wheat germ/bran addition on the chemical and nutritional quality of tarhana, a fermented wheat flour-yoghurt product [8]. Wheat bran is known its high fibre content and its antioxidant properties. In order to improve its nutritional value Tarhana was supplemented with wheat germ and wheat bran. Wheat flour was replaced with 10%, 25% and 50% wheat germ or bran. Tarhana samples with wheat germ or bran were compared with a control sample made without the addition of wheat germ or bran. The results showed that increasing wheat germ/bran amount in tarhana sample resulted in an expected increase in crude protein, ash (Table 1) and mineral content (Table 2) in tarhana food. On the other hand, they had greater amounts of phytic acid in comparison to wheat flour (Table 3). The final pH of the samplesincreased as the amount of wheat germ/bran added to the samples increased although the titratable acidity of tarhana enriched samples was found to be high as well (Table 1). Increasing wheat germ/bran amount into tarhana formulation increased the phytic acid (PA) content of the samples (Table 3). The PA content of tarhana samples almost doubled with the addition of 50% wheat germ/bran (Table 3). The results of the present study showed that wheat germ and wheat bran were successfully incorporated into tarhana formulations.

Bilgicli & Ibanoglou studied the effect of wheat germ and wheat bran on the fermentation activity and phytic acid content of tarhana [7]. The fermentation activity of acidic fermentation can be monitored by acidity and/or pH measurements. Tarhana was supplemented with wheat germ/bran to improve its nutritional value. The total titratable acidity (as lactic acid) and phytic acid (PA) content of tarhana samples supplemented with wheat germ/bran were studied over a three-day fermentation. The acidity of the samples increased sharply during the first day of fermentation and then increased gradually up to the third day of fermentation. Addition of wheat germ/bran to tarhana resulted in increased pH values of the samples. Wheat germ/bran addition increased the total titratable acidity of samples before fermentation (zeroth hour) and lead to samples with higher pH values since the wheat germ/bran used in this study have higher acidity values than wheat flour (Table 1). Similarly, the final acidity of samples after fermentation

Table 2. Mineral content of tarhana product and tarhana ingredients

Product	**Minerals**							Reference
	Ca	Ca	Mg	Zn	Zn	K	K	
	Total (mg/100g)	HCL-E (%)	Total (mg/100g)	Total (mg/100g)	HCL-E (%)	Total (mg/100g)	HCL-E (%)	
Wheat flour	26	51.7	94.4	1.12	34.8	302	67.2	[8]
Malt flour	48	85.6	132	1.62	77.2	360	83.4	[8]
Yoghurt	898	80.7	102	1.02	70.6	1159	84.6	[8]
Tomato paste	146	56.6	208	1.75	58.9	5050	86.6	[8]
Onion	245	48.0	111	1.31	26.7	1766	81.6	[8]
Yeast	116	60.7	127	8.56	76.1	2557	81.1	[8]
Red pepper	120	48.8	254	1.20	50.8	3479	77.6	[8]
Dough	146	76.1	156	1.0	55.6	651	79.7	[8]
Tarhana	155	80.2	164	1.2	73.9	734	92.6	[8]
Dough (0% Yeast level)	144	74.9	155	0.96	46.3	626	76.9	[8]
Dough (2.5% Yeast level)	146	76.5	156	1.02	59.8	655	80.2	[8]
Dough (5% Yeast level)	147	76.9	157	1.07	60.7	671	81.4	[8]
Tarhana (0% Yeast level)	148	79.1	157	1.07	66.7	681	91.2	[8]
Tarhana (2.5% Yeast level)	157	80.4	166	1.24	77.1	744	92.8	[8]
Tarhana (2.% Yeast level)	161	81.0	169	1.36	77.9	775	93.8	[8]
Dough (0% Malt level)	145	75.7	156	0.99	55.0	659	79.5	[8]
Dough (2% Malt level)	146	76.0	155	1.01	54.8	640	79.7	[8]
Dough (4% Malt level)	146	76.2	156	1.03	56.9	654	80.0	[8]
Tarhana (0% Malt level)	155	80.0	164	1.21	73.0	730	90.7	[8]
Tarhana (2% Malt level)	156	79.9	164	1.22	73.9	735	92.2	[8]
Tarhana (4% Malt level)	155	80.5	164	1.23	74.8	736	94.8	[8]
Dough (0% Phytase level)	146	75.8	156	1.01	54.7	639	78.6	[8]
Dough (0.05% Phytase level)	146	75.9	156	1.01	55.6	656	79.2	[8]
Dough (0.5% Phytase level)	145	76.4	156	1.02	56.47	656	81.4	[8]
Tarhana (0% Phytase level)	155	80.0	163	1.22	72.0	733	90.7	[8]
Tarhana (0.05% Phytase level)	155	80.0	164	1.22	74.1	733	92.2	[8]
Tarhana (0.5% Phytase level)	157	80.3	164	1.23	75.6	734	94.8	[8]
								[8]

Product	**Ca (mg/100g)**	**Mg (mg/100g)**	**Zn (mg/100g)**	**K (mg/100g)**	**Mn (mg/100g)**	**Cu (mg/100g)**	**Fe(mg/100g)**	**P (mg/100g)**	
Tarhana (0% wheat germ)	460.1	78.3	0.98	652.3	0.59	0.00	1.98		[7]
Tarhana (10% wheat germ)	495.3	119.1	1.82	812.2	1.91	0.00	2.99	244.3	[7]
Tarhana (25% wheat germ)	522.5	153.0	2.50	930.0	3.51	0.04	4.12	341.8	[7]
Tarhana (50% wheat germ)	591.5	222.2	5.10	1192.9	6.54	0.20	7.86	514	[7]
Tarhana (10% wheat bran)	4.81	111.0	1.26	758.3	1.18	0.00	2.61	230	[7]
Tarhana (25% wheat bran)	540.9	159.9	1.93	948.7	2.08	0.09	3.85	283.2	[7]
Tarhana (50% wheat bran)	615.3	227.3	3.06	1200	3.58	0.32	5.83	411.1	[7]
Product	**Ca (mg/100g)**	**Mg (mg/100g)**	**Zn (mg/100g)**	**K (mg/100g)**	**Mn (mg/100g)**	**Cu (mg/100g)**	**Fe(mg/100g)**	**P (mg/100g)**	
Tarhana (0% BWF ratio)	100.4	61.05	1.56	384.6			2.52	246.2	
Tarhana (20% BWF ratio)	100.2	101.7	1.91	444.6			2.88	309.9	
Tarhana (40% BWF ratio)	100.2	151.0	2.13	526.1			3.07	382.7	
Tarhana (60% BWF ratio)	99.8	203.8	2.33	553.1			3.40	481.4	
Tarhana (80% BWF ratio)	99.6	240.5	2.46	580.7			3.69	556.1	
Tarhana (100% BWF ratio)	99.5	271.3	2.70	600.1			4.02	571.6	

Product	**Ca (mg/100g)**	**Mg (mg/100g)**			**Zn (mg/100g)**		**K (mg/100g)**		**Mn (mg/100g)**		**Cu (mg/100g)**		**Fe(mg/100g)**						[4]
Tarhana	109	78			1.8		114		612		450		3.6						[4]
Product	**Ca (mg/100g)**	**Mg (mg/100g)**			**Zn (mg/100g)**		**K (mg/100g)**		**Mn (mg/100g)**		**Cu (mg/100g)**		**Fe(mg/100g)**		**Na (mg/100g)**				[18]
Fresh wet tarhana	267.9	158.2			4.40		594.8		3.23		1.0		9.7		2149.2				[18]
Tarhana	YW_0	YW_1	YW_2	YW_3	YW_0	YW_1	YW_2	YW_3	YW_0	YW_1	YW_2	YW_3	YW_0	YW_1	YW_2	YW_3	YW_0	YW_1	[10]
Tarhana W	92.72	81.28	69.44	67.72	76.17	64.40	78.75	76.66	1.75	1.59	1.68	1.21	1.37	2.12	2.04	2.14	263.52	275.49	[10]
Tarhana C	39.95	31.97	34.39	34.39	106.5	117.64	133.75	124.40	4.09	4.50	3.57	4.53	3.79	4.16	3.37	3.79	432.50	455.19	[10]
Tarhana W+C	36.38	49.44	60.09	63.74	125.95	99.78	100.10	116.25	2.45	3.33	3.55	3.18	2.90	2.77	3.33	3.28	377.50	363.23	[10]

with higher wheat germ/bran added were higher (Table 1). The initial pH value of the wheat germ/bran were found higher compared to wheat flour (Table 1). The pH value of tarhana samples before fermentation increased as the amount of wheat germ/bran added increased (Table 1). Although the titratable acidity of tarhana enriched samples were relatively high, the corresponding pH values were found to be high as well (Table 1). It may be possible that titratable acidic compounds in the samples may not be fully dissociated in the water during the analysis, giving high pH values or that the proteins present in the wheat germ and bran have buffering effect preventing the changes in pH at low level. The low pH is known to make tarhana unattractive to pathogenic and spoilage microorganisms.

The phytic acid (PA) content of tarhana mixture increased as wheat germ/bran amount added to tarhana increased (Table 3). During fermentation period phytic acid content of the mixture was reduced up to 72h. More than 80% of phytic acid content present in the samples was desructed at the end of 24 h fermentation (Table 3). Thereduction of the phytic acid content can be attributed to the activity of indigenous phytases present in the fermentation mixture.

Table 3. Phytic acid content of Tarhana product and Tarhana ingredients

Product	Phytic acid	
Wheat flour	145	
Buckwheat flour (BWF)	1565	
Tarhana (0% BWF ratio)	21.20	
Tarhana (20% BWF ratio)	20.13	
Tarhana (40% BWF ratio)	25.12	
Tarhana (60% BWF ratio)	33.12	
Tarhana (80% BWF ratio)	112.12	
Tarhana (100% BWF ratio)	165.34	
Wheat flour	487.0	[8]
Malt flour	56.7	[8]
Yoghurt	-	[8]
Tomato paste	-	[8]
Onion	-	[8]
Yeast	-	[8]
Red pepper	18.1	[8]
Dough	138	[8]
Tarhana	22.1	[8]
Dough (0% Yeast level)	153	[8]
Dough (2.5% Yeast level)	137	[8]
Dough (5% Yeast level)	126	[8]
Tarhana (0% Yeast level)	26.8	[8]
Tarhana (2.5% Yeast level)	20.6	[8]
Tarhana (5% Yeast level)	18.9	[8]
Dough (0% Malt level)	148	[8]
Dough (2% Malt level)	132	[8]
Dough (4% Malt level)	136	[8]
Tarhana (0% Malt level)	23.7	[8]
Tarhana (2% Malt level)	22.1	[8]
Tarhana (4% Malt level)	20.5	[8]
Dough (0% Phytase level)	159	[8]
Dough (0.05% Phytase level)	151	[8]
Dough (0.5% Phytase level)	105	[8]
Tarhana (0% Phytase level)	23.8	[8]
Tarhana (0.05% Phytase level)	22.8	[8]
Tarhana (0.5% Phytase level)	19.7	[8]
Tarhana (0% wheat germ)	20.2	[7]
Tarhana (10% wheat germ)	22.3	[7]
Tarhana (25% wheat germ)	30.5	[7]
Tarhana (50% wheat germ)	39.8	[7]
Tarhana (10% wheat bran)	20.5	[7]
Tarhana (25% wheat bran)	32.7	[7]
Tarhana (50% wheat bran)	45.2	[7]
Tarhana (0% BWF ratio)	21.20	
Tarhana (20% BWF ratio)	20.13	
Tarhana (40% BWF ratio)	25.12	
Tarhana (60% BWF ratio)	33.12	
Tarhana (80% BWF ratio)	112.12	
Tarhana (100% BWF)	165.34	

Product	Fermentation time (h)	Phytic acid
Tarhana (0% wheat germ)	0	235.0
	4	189.5
	8	105.0
	24	30.5
	72	20.2
Tarhana (10% wheat germ)	0	285.5
	4	231.5
	8	125.0
	24	45.6
	72	22.5
Tarhana (25% wheat germ)	0	441.5
	4	412.7
	8	215.0
	24	48.9
	72	30.4
Tarhana (50% wheat germ)	0	769.0
	4	724.1
	8	370.5
	24	60.3
	72	39.5
Tarhana (0% wheat bran)	0	242.5
	4	199.6
	8	99.6
	24	35.7
	72	20.0
Tarhana (10% wheat bran)	0	294.5
	4	252.4
	8	138.0
	24	50.90
	72	20.50
Tarhana (25% wheat bran)	0	554.5
	4	407.8
	8	216.0
	24	55.5
	72	32.7
Tarhana (50% wheat bran)	0	915.5
	4	743.6
	8	298.5
	24	70.3
	72	45.10

The effect of yoghurt level and yoghurt: flour ratio on tarhana properties

Daglioglu (2000) studied the composition and nutritive value of tarhana. The nutrient value of tarhana depends upon yoghurt and flour ratios as well as other ingredients added to this product. Tarhana was found to have a high protein content (Table 1). The combination of flour and yoghurt proteins makes tarhana a precise amino acid source. The average moisture content of the tarhana was 10.2%, fat 5.4%, salt 3.8% and ash 6.2% (Tables 1) while fibre and carbohydrate values were 1% and 60%, respectively (Table 6). Flour and yoghurt ratio as well as the type of yoghurt affect its calcium content. Tarhana was found to be a good source of calcium, iron and zinc and of some other minerals (Table 2). The rate of iron in tarhana samples is depended of the amount of flour used in tarhana making. However, its mean value was found to be 3.6 mg/100g (Table 2).

Ibanoglu et al., studied the effect of different ingredients on the fermentation activity in tarhana [1]. Three different formulations were prepared: (1) tarhana with a yoghurt to wheat flour ratio of 0.5 with 80.0 g saltkg-1 wheat flour used (standard tarhana named S1); (2) tarhana with a yoghurt to wheat flour ratio of 1.0 with 80.0 g saltkg-1 wheat flour used (named S2) and; (3) tarhana with a yoghurt to wheat flour ratio of 0.5 without salt (named S3). Lactic acid concentration of tarhana prepared without salt (sample named S3) was 2.5% and this value was higher when compared with the same composition of tarhana prepared with salt, samples named S1 and S2 where lactic acid was 1.8% and 2.0%, respectively. However, the ash content of tarhana without salt was the lowest due to the absence of salt in the sample, reducing the ash content (Table 1). Tarhana samples with increased yoghurt (S2) had higher lactic acid content than standard tarhana (named S1) (Table 1). Fermentation activity was high during the first day of fermentation and decreased thereafter. This study showed that tarhana which is fermented for more than one day requires the addition of extra yoghurt and/or wheat flour to keep the fermentation activity high and achieve a more acidic and sour taste. For this purpose, some extra yoghurt and/or wheat flour could be used after the first day of fermentation and no salt should be added to the formulation.

The effect of different parameters-yoghurt content, fermentation time and preservation method-on chemical composition, lactic acid and other organic acids content during fermentation of tarhana dough.

Concerning the effect of yoghurt level, in tarhana production 50% yoghurt level is the most common amount used. However, using 75% yoghurt resulted in tarhana product with higher moisture levels (Table 1). Although using the higher percentage of yoghurt results in more lactic acid, the higher moisture and oil content would create a risk for a long-term shelf life of tarhana. Also, the samples with 75% yoghurt had higher oil level that is undesirable as it could be deteriorized by heat, light or oxygen and give a rancid taste to the final product.

Lactic acid was the major organic acid determined in tarhana (Table 5). Other organic acids produced are acetic, propionic and pyruvic acids and small amounts of citric acid, mainly come from the vegetables used in the preparation of tarhana [16]. Lactic acid was the 60%-73% of total organic acids and trace levels of citric acid were found. During 96h fermentation of dried tarhana samples, lactic acid increased from 1.06 to 1.53 g/100g, acetic acid from 0.24 to 0.49 g/100g, pyruvic acid from 0.19 to 0.40 g/100g and total organic acids from 1.50 to 2.42 g/100g (Table 5).

The use of corn flour and yoghurt replacement by whey concentration on tarhana properties

Tarakci et al., examined the effect of flour type (wheat flour or corn flour) and yoghurt+whey (YW) combinations on the properties of tarhana food [10]. Tarhana samples with added corn flour (CF) had the lowest protein level and the highest ash level (Table 1). However, tarhana with added corn flour has the highest fibre concentration. There were differences in starch concentrations of tarhana samples due to the different starch content of corn and wheat samples (Table 6). The fat concentration of tarhana with added corn flour was approximately 4% higher than tarhana samples with added wheat flour (Table 1). The same sample has also the highest acidity probably because of the higher fat content. Protein and fat content of tarhana decreased with increasing whey concentration in the formulation due to the difference in protein and fat content of yoghurt and whey (Table 1). The higher whey concentration in the formulation increased the acidity of tarhana samples possibly due to the higher lactose concentration in whey.

The mineral analysis showed that in general replacing yoghurt by whey did not significantly affect the mineral composition of tarhana samples (Table 2). Concerning the type of flour used, tarhana with added wheat flour had a higher calcium (Ca) content than the other two samples (Table 2). However, as a result of the bran material, P, Zn, Mg and Fe contents were higher in tarhana samples with added corn flour (Table 2).

The results of this study showed that the replacement of wheat flour by corn flour increased the ash content and acidity values of tarhana and decreased starch content. On the other hand, the replacement of yoghurt by whey decreased the protein, fat and starch contents and increased ash content and acidity values.

The effect of phytase sources on tarhana properties

Bilgicli et al., examined the effect of different phytase sources (bakers' yeast, barley malt flour and microbial phytase) on phytic acid content (PA) and HCl-extractability (HCl-E) of the minerals Ca, Mg, Zn and K during the tarhana production process [7]. The average phytic acid (PA) values of wheat flour, tarhana dough and tarhana were 487, 138 and 22.1 mg/100g, respectively (Table 3). When wheat flour was used as raw material, the phytic acid loss (PAL) was 70.7% in dough and 95.3% in tarhana. The PA contents of dough and tarhana were reduced after addition of the yeast, malt and phytase (Table 3).

Total Ca increased from 146 mg/100 g in tarhana dough to 155 mg/ 100 g in tarhana (Table 2) as a result of fermentation loss. Yoghurt was the main source of Ca with 898 mg/100 g Ca content (Table 2). Total Ca and HCl-E of Ca amounts are increased a little by the addition of the phytase sources in both dough and tarhana samples (Table 2). The total Ca amount increased from the control to 5% yeast level and from 144 to 147 mg/100 g in the dough, and from 148 to 161 mg/100 g in tarhana (Table 2). The addition of 2.5% baker's yeast resulted in a marked increase of calcium amount. Additional yeast (5%) did not affect the total amount and HCl-E of Ca (Table 2).

Total Mg was 156 mg/100g in the dough and increased to 164 mg/100g in tarhana product (Table 2). The values of HCl-E Mg were 83.6% in the dough and 86.4% in tarhana (Table 2). The main source of the Mg of the tarhana were tomato paste (208 mg/100 g) and red pepper (254 mg/100 g) (Table 2). Baker's yeast addition is the most effective factor, as a phytase source, for the total Mg and HCl-E of Mg values (Table2). Total Mg and HCl-E of Mg values of tarhana were increased from the control to 5% yeast addition from 157 to 169 mg/100 g and from, 85.2 to 86.9%, respectively.

The total amount of Zn and HCl-E of Zn were 1.0 mg/100 g and 55.6 % in dough, respectively (Table 2). However, in tarhana samples the values of total Zn and HCl-E of Zn increased to 1.2 mg/100 g and 73.9 %, respectively, as a result of fermentation. An increase in HCl-E amount of Zn was showed by the addition of baker's yeast, barley malt and microbial phytase (Table 2). Baker's yeast is the richest Zn source among tarhana ingredients with the amount of total Zn and HCl-E of Zn to be 8.56 mg/100 g and 76.1%, respectively (Table 2). The yeast addition was rather more effective than those of the barley malt and microbial phytase. In tarhana samples, bekers yeast addition, up to 5% versus control, increased the amount of total Zn from 1.07 mg/100 g to 1.36 mg/100 g and of HCl-E of Zn from 66.7% and 77.9%, respectively (Table 2).

The total K amount increased from 651 mg/100 g in the dough to 734 mg/100 g in tarhana and HCl-E of K from 79.7 % in the dough to 92.6 % in tarhana (Table 2).The total protein amount (TPA) of the dough was 13.8% while of tarhana product 16.1% (Table 1). When the yeast level was increased the total protein amount of tarhana was also increased due to its high protein content (47.5%) (Table 1). The richest K source among tarhana ingredients was tomato paste with 5050 mg/100 g total amount and 86.6% HCl-E of K (Table 2). By the addition of bakers' yeast, barley malt and microbial phytase the HCl-E of K values of tarhana increased up to 93.8%, 94.8% and 94.8%, respectively (Table 2).

The effect of added spices on tarhana properties

Several spices like mint, thyme, dill and tarhana herb are used as flavoring agents in tarhana food. Degirmencioglu et al. (2005) studied the influence of tarhana herb (Echinophorasibthorpiana) on tarhana fermentation [4]. Tarhana herb has a pleasant flavor and stimulates the growth of some microorganisms. The fermentation activity of tarhana was investigated by monitoring the lactic acid bacteria (LAB) and yeast populations when tarhana herb was used as additive. Four samples of tarhana were prepared. One without tarhana herb (standard tarhana) and three with the addition of dry-ground tarhana herb (0.5, 1.0 and 1.5% level, based on flour weight). The tarhana dough was fermented at 25oC for 4 days. Titrable acidity levels of all samples of dough increased during fermentation while pH decreased. Significant differences in pH and acidity level were observed between the tarhana sample without tarhana herb (TH) and the samples with tarhana herb of the present study. The lowest acidity level and the highest pH value was determined in tarhana dough without the addition of tarhana herb (Table 1). However, the highest titrable acidity level and the lowest pH was obtained at the end of fermentation in tarhana dough with 0.5% tarhana herb. Moisture contents of all samples were below 11%. As moisture content of tarhana is low it can be stored for long time 2 or 3 years. Crude protein contents of all samples were between 12.61 and 12.68% (Table 1) showing that tarhana is a good source of proteins for children and elderly people. Concerning microbial population, it can be said that tarhana herb (Echinophorasibthorpiana) prevented the decrease in the counts of lactic acid bacteria and in the populations of yeast during the first two days of fermentation.

The effect of fermentation and storage conditions on tarhana properties

The lactic acid bacteria from yoghurt and Saccharomyces cerevisiae from baker's yeast are the main microorganism responsible for tarhana fermentation [16]. These microbes produce during fermentation lactic acid, ethanol, carbon dioxide and some other flavor compounds like aldehydes and ketones and give tarhana its characteristic flavor [4,6] The dough at fermentation is called as wet tarhana. Afterwards, the dough is dried in the sun or by dryer as a lump, nugget or thin layers to obtain dry tarhana. Finally, it is ground to powders smaller than 1mm [5]. Organic acids composed in fermentation period lower the pH and after fermentation excess moisture is removed by drying. Because of the low pH (3.8-4.2) and the low moisture content (6-10%) the final product is a poor medium for pathogens and spoilage organisms and can be stored for 2-3 years [4,17]. Sun drying is a slower but a more common and economical approach for traditional tarhana production. The critical moisture value is 13-15% for the inhibition of undesirable microbial growth in dry recipes produced from wheat flour.

The effect of fermentation time and storage temperatures on tarhana properties

Erbas et al., studied the daily changes that take place in organic and fatty acid composition of tarhana dough during its 3-day fermentation phase [15]. At the end of the 3-days fermentation period the fresh wet tarhana (FWT) was dived into five pieces. One piece (named C) was dried in the sun, stored for a 6-monts period, ground and stored at ambient temperature as a control dough. The other four pieces were wet tarhana stored at ambient temperature (named N tarhana), wet tarhana with sodium benzoate (1000mg/kg) stored at ambient temperature (named A tarhana), wet tarhana stored at 4oC (named F-tarhana) and wet tarhana with salt (6.5g/100g) stored at ambient temperature (named S-tarhana). The monthly changes that take place in organic and fatty acid composition of the above five different types of tarhana during their 6-month storage was also studied. The fermentation time had a significant effect on pH, titratable acidity, lactic, pyruvic, acetic, propionic and citric acid concentrations. During the 3-day tarhana fermentation period, titratable acidity increased from 26.50 to 41.4 g/kg, while lactic acid increased from 13.58 to 20.26 g/kg, propionic acid increased from 2.44 to 7.58 g/kg, pyruvic acid increased from 0.16 to 0.58 g/kg and citric acid decreased from 6.39 to 3.58 g/kg (Table 5). However, it was observed that drying process caused tarhana to lose a significant amount of its organic content. Lactic acid which appeared to be the dominant organic acid during tarhana fermentation was however reduced by approximately 25% during the drying process.

In fresh wet tarhana lactic acid was found in the highest concentration while acetic and propionic acids were second and third. Lactic acid was found to be about 2.5 times more than acetic acid (Table 5). The amount of lactic acid increased by about 50% by the end of fermentation. The production of lactic, acetic and propionic acids in tarhana dough is attributed to homo and hetero fermentative LAB in yoghurt, lactic, acetic and propionic acid bacteria found in flour, and propionic acid bacteria that use existing lactic acid as substrate. The concentration of citric acid in tarhana samples (coming from vegetables, especially from tomato) decreased during fermentation (Table 5). The decrease in citric acid content during fermentation is attributed to its usage as a substrate in secondary reactions during fermentation. Citric acid is used up during metabolic activities of LAB and baker's yeast and some metabolites (such as acetone and diacetyl) are consequently produced.

The way in which tarhana is stored significantly influences its organic acids. The total sum of organic acids in the control tarhana dried in the sun, ground and stored at ambient temperature was found to be lower than the sums of the four rest tarhana samples named N, A, F and S, except for pyruvic acid (Table 5). The tarhana sample named N was found to have the highest lactic acid content as fermentation havepartially continued at ambient temperature (Table 5). Citric and pyruvic acid amounts were significantly affected by time spent in storage while lactic, acetic and propionic amounts were not affected (Table 5). The study of fatty acids in tarhana fermentation and storage showed that fermentation time and storage type/period do not have any significant effect on their concentration except for butyric acid. During fermentation butyric acid content increased from 3.64% to 5.60%. This profound increase may have arisen from formation of free butyric acid during lactic acid fermentation and enzymatic transformation of amino acids to butyric acid. In dry tarhana the amount of butyric acid was lower than in wet tarhana (Table 7) due to its evaporation during the drying process. Tarhana samples contained approximately 14% unsaturated fatty acids and 86% saturated fatty acids. The major fatty acid in tarhana was palmitic acid (40.13%).

The effect of fermentation time and storage period on tarhana properties

Erbas et al., studied the chemical properties of wet and dry tarhana during a storage period of 6 months. Also, some chemical properties of tarhana dough in fermentation stage of production was investigated [18]. The fermentation time increased acid content and decreased pH value of tarhana sample due to the formation of organic acids with the fermentation of sugars by mostly lactic acid bacteria. However, as crude protein, fiber and ether extract cannot efficient decomposed to others materials by fermentation, there was no significant effect of fermentation time on them contents as well as on ash and salt tarhana contents. Average chemical composition of the fresh wet tarhana dough at the end of fermentation was moisture 61.05%, crude protein 16.79, ash 8.94 and salt 6.48 g/100g dry matter (Table 1), while crude fiber, ether extract, acetaldehyde and diacetyl were 2.83, 3.92, 136.3 and 18.0 g/100g dry matter, respectively. The fresh wet tarhana samples contained various minerals (Table 2) since it was produced from wheat, yoghurt, vegetable and spices.

The effect of fermentation and drying on vitamin content and gross composition of Tarhana

Ekinki studied the effect of fermentation (30 °C for 4 days) and drying (50, 60 and 70 °C) on the water -soluble vitamin content of tarhana [19]. After a 4-day fermentation of tarhana dough the mixture was dried in a hot air oven at 50 °C for 48 h, 60 °C for 40h and 70 °C for 35 h and finely ground to a particle size of<400μm.

The water-soluble vitamins ascorbic acid, niacin, pantothenic acid, pyridoxine, thiamine, folic acid and riboflavin were examined by

HPLC method. The results showed that both fermentation and drying temperature affected significantly the water-soluble vitamin content of tarhana (Table 4). Generally, the fermentation period of 4 days had an increasing effect on the water-soluble vitamin contents of tarhana, while drying a decreasing one. Also, oven-drying of the samples at 70 °C, after fermentation, caused important losses in water-soluble vitamins of the samples when compared with the 50 and 60 °C oven-drying treatments (Table 4).

Concerning the water-soluble vitamin content of tarhana, Ekinki developed a reversed-phase high-performance liquid chromatographic procedure for the determination of ascorbic acid, niacin, pantothenic acid (vitamin B5), pyridoxine (vitamin B6), thiamine (vitamin B1), folic acid and riboflavin (vitamin B2) in tarhana samples [20]. The results are shown in Table 4.

Ibanoglu et al, evaluated a laboratory method for the production of tarhana [5]. Four different tarhana formulations were prepared: 1) tarhana with two parts white wheat flour, one part of yoghurt and salt (standard tarhana, named S1), 2) tarhana with two parts whole meal flour, one part of yoghurt and salt (named S2), 3) tarhana with one part of white wheat flour, one part of yoghurt and salt (named S3) and 4) tarhana with two parts white wheat flour, one part of yoghurt and without salt (named S4). The laboratory produced tarhana samples (named S1, S2, S3 and S4) were compared with those of authentic homemade (named S5) and commercially produced tarhana (named S6). The chemical composition of laboratory produced samples (after drying and grinding) as well as of homemade and commercially produced samples are shown in Table 1. The moisture content of commercial tarhana sample (named S6) was higher (12.1%) than the moisture content of laboratory produced samples (named S1, S2, S3 and S4) with values that ranged from 5.9% to 9.5 % and the homemade tarhana (named S5) in which moisture content was 10.6% (Table 1). Except the tarhana sample made without salt (named S3) it was found that the commercial sample named (S6) hadthe lowest ash content among the examined samples (Table 1). The reason of the high ash content of homemade and laboratory tarhana samples (Table 1) could be the high concentrations of flavoring agents used such as mint, paprika etc. which are high in ash content. Commercial tarhana sample (named S6) had the lowest protein content (12.9%) while tarhana sample made with whole meal flour (named S4) had the highest one (19.2%) (Table 1).

Ibanoglu et al. (1995) also studied the changes in pH, titrable acidity and vitamin (thiamine, riboflavin and vitamin B12) content during the

Table 4. Vitamins in Tarhana Product

Product	Ascorbic acid	Niacin	Pantothenic acid	Pyridoxine	Thiamine (Vitamin B1)	Folic acid	Riboflavin (Vitamin B2)	Vitamin B12	Reference
Standard tarhana sample (named S1)					1.5^{a}		0.8^{a}	1.5b	[5]
Tarhana sample with increased yoghurt (named S2)					1.5^{a}		1.1^{a}	2.1^{b}	
Tarhana sample without salt (named S3)					1.6^{a}		0.9^{a}	1.2^{b}	
Tarhana sample with wholemeal flour (named S4)					2.9^{a}		1.1^{a}	1.2^{b}	
Homemade tarhana (named S5)					0.6^{a}		0.4^{a}	2.0b	
Commercially produced tarhana (named S6)					0.5^{a}		0.6^{a}	1.0^{b}	
Tarhana					0.01^{c}		0.08^{c}		[10]
Tarhana	17.8^{d}	12.4^{d}	5.3^{d}	0.38^{d}	4.7^{d}	0.40^{d}	1.8^{d}		[19]

	Treatment						Vitamins			
Product	Days of fermentation (dF)		Ascorbic acid	Niacin	Pantothenic acid	Pyridoxine	Thiamine (Vitamin B1)	Folic acid	Rivoflavin (Vitamin B2)	Refernce
Standard tarhana sample (named S1)	0 dF						1.9a		1.0 a	[5]
	1 dF						1.9 a		1.0 a	
	2dF						2.0 a		1.0 a	
	3dF						2.0 a		1.0 a	
	4dF						2.1 a		1.0 a	
Tarhana sample with increased yoghurt (named S2)	0 dF						1.9 a		1.4 a	[5]
	1 dF						2.0 a		1.4 a	
	2dF						2.0 a		1.5 a	
	3dF						2.0 a		1.5 a	
	4dF						2.0 a		1.5 a	
Tarhana sample without salt (named S3)	0 dF						1.8 a		1.2 a	[5]
	1 dF						1.9 a		1.2 a	
	2dF						1.9 a		1.2 a	
	3dF						1.9 a		1.3 a	
	4dF						1.9 a		1.3 a	
Tarhana sample with wholemeal flour (named S4)	0 dF						3.5 a		1.4 a	[5]
	1 dF						3.6 a		1.5 a	
	2dF						3.6 a		1.6 a	
	3dF						3.6 a		1.6 a	
	4dF						3.6 a		1.5 a	

	Days of fermentation (dF)						Thiamine (Vitamin B1)		Rivoflavin (Vitamin B2)	
Tarhana	Control (0 dF) *		15.5d	10.2d	4.2d	0.32d	4.3d	0.38d	**1.7d**	[19]
	1d F**		15.9d	12.8d	4.5d	0.29d	4.3d	0.44d	2.0d	
	2 d F		16.1d	14.3d	4.7d	0.30 d	4.3d	0.46d	2.2d	
	3 d F		16.3d	14.5d	4.8d	0.32d	4.4d	0.48d	2.3d	
	4 d F		16.3d	14.6d	4.8d	0.30d	4.4d	0.47d	2.3d	
	Drying temperature (DT)	Time (h)								
	Control	0	16.3d	18.4d	4.8d	0.30d	4.4d	0.48d	2.9d	[19]
	50°C DT**	45	16.1d	17.9d	4.7d	0.29d	3.6d	0.45d	2.7d	
	60°C DT	40	15.9d	17.2d	4.4d	0.25d	3.1d	0.43d	2.4d	
	70°C DT	35	14.0d	16.1d	4.0d	0.23d	2.6d	0.40d	2.1d	

0, 1, 2, 3, 4 dF : Days of fermentation.
50°C, 60°C, 70°C : drying temperatures
a : Values in µg/g. b: Values in µg/kg. c: Values in mg/100g. d: Values in mg/kg.

Table 5. Organic acid content of Tarhana samples

Organic acids (g/kg on dry matter)							
Samples	**Lactic acid**	**Acetic acid**	**Propionic acid**	**Citric acid**	**Pyruvic acid**	**Ratio (Lactic acid/total organic acids)**	Reference
Tarhana (0 Fd)	13.59	4.85	2.45	6.40	0.16	0.49	[15]
Tarhana (1 Fd)	16.74	6.05	4.83	4.74	0.23	0.51	[15]
Tarhana (2Fd)	18.67	6.44	6.88	3.99	0.31	0.51	[15]
Tarhana (3Fd, FWT)	20.26	7.79	7.58	3.58	0.58	0.51	[15]
Tarhana N	21.61	8.35	7.69	3.39	0.48		[15]
Tarhana A	20.96	8.13	7.70	3.06	0.47		[15]
Tarhana F	20.14	8.03	7.67	3.33	0.47		[15]
Tarhana S	18.84	7.32	7.28	3.13	0.47		[15]
Tarhana C	15.75	5.08	5.05	3.07	0.64		[15]
Tarhana 0*#				3.58	0.58		[15]
Tarhana 1*				3.33	0.52		[15]
Tarhana 2*				3.28	0.51		[15]
Tarhana 3*				3.21	0.51		[15]
Tarhana 4*				3.03	0.50		[15]
Tarhana 5*				2.97	0.52		[15]
Tarhana 6*				2.95	0.51		[15]

Organic acids (g/100g)					
Samples	**Lactic acid**	**Acetic acid**	**Pyruvic acid**	**Total organic acids**	
Dried Tarhana (50% yoghurt rate, 0h fermentation time)	1.06	0.24	0.19	1.50	
Dried Tarhana (50% yoghurt rate, 48h fermentation time)	1.22	0.37	0.31	1.90	
Dried Tarhana (50% yoghurt rate, 96h fermentation time)	1.26	0.43	0.36	2.05	
Dried Tarhana (75% yoghurt rate, 0h fermentation time)	1.25	0.26	0.21	1.72	
Dried Tarhana (75% yoghurt rate, 48h fermentation time)	1.48	0.42	0.34	2.24	
Dried Tarhana (75% yoghurt rate, 96h fermentation time)	1.53	0.49	0.40	2.42	
Frozen Tarhana (50% yoghurt rate, 0h fermentation time)	0.87	0.20	0.16	1.23	
Frozen Tarhana (50% yoghurt rate, 48h fermentation time)	1.00	0.32	0.26	1.58	
Frozen Tarhana (50% yoghurt rate, 96h fermentation time)	1.03	0.38	0.32	1.73	
Frozen Tarhana (75% yoghurt rate, 0h fermentation time)	1.01	0.21	0.17	1.39	
Frozen Tarhana (75% yoghurt rate, 48h fermentation time)	1.21	0.37	0.30	1.88	
Frozen Tarhana (75% yoghurt rate, 96h fermentation time)	1.26	0.44	0.36	2.06	

0, 1, 2, 3 Fd : Days of fermentation, FWT: Fresh wet tarhana, end of fermentation. N: The wet tarhana stored at ambient temperature. A: The wet tarhana with sodium benzoate (1000mg/kg) stored at ambient temperature. F: The wet tarhana stored at 4°C, S: The wet tarhana with salt (6.5g/100g) stored at ambient temperature. C: Dried and milled tarhana stored at ambient temperature. 0*# : End of the fermentation (third day) was evaluated as 0 month storage period. 1*, 2*, 3*, 4*, 5*, 6* : Months of storage period.

fermentation of laboratory made samples (named S1, S2, S3 and S4). The pH and titratable acidity of tarhana samples did not change after the third day in a course of a 4-day fermentation. The final pH and acidity expressed as percent lactic acid of tarhana were found to be in the range of 4.3-4.8 and 1.2-2.3 (dry basis), respectively. The addition of salt to tarhana lowered the acid formation rate during fermentation leading to a higher pH. The vitamin (thiamine, riboflavin and vitamin B12) content of laboratory, homemade and commercially produced samples as well as the changes in vitamin content during fermentation of the laboratory tarhana samples (named S1, S2, S3 and S4) are shown

Table 6. Cellulose, starch, carbohydrate, fibre and b-glucan content of Tarhana product and Tarhana ingredients

Product	Cellulose		Starch	Carbohydrate (g/100g)	Fibre (g/100g)	β-glucan	Reference
Tarhana				60.0	1.0		[4]
Tarhana					2.38		[8]
Wheat flour						0.43	[11]
Barley flour 1						2.80	[11]
Barley flour 2						3.38	[11]
Huless barley flour						4.25	[11]
Wheat tarhana						0.28	[11]
Barley tarhana 1						2.40	[11]
Barley tarhana 2						2.90	[11]
Huless barley tarhana						3.55	[11]
Wheat/barley tarhana						1.39	[11]
Wheat flour	0.5		68.5				
Buckwheat flour (BWF)	1.2		53.8				
Tarhana (0% BWF ratio)	1.7		64.50				
Tarhana (20% BWF ratio)	1.8		59.50				
Tarhana (40% BWF ratio)	1.9		54.80				
Tarhana (60% BWF ratio)	2.1		48.40				
Tarhana (80% BWF ratio)	2.2		42.30				
Tarhana (100% BWF ratio)	2.2		40.20				
			Starch				
Tarhana	YW_0	YW_1	YW_2	YW_3			[10]
Tarhana W	65.28	62.71	61.56	59.38			[10]
Tarhana C	56.67	56.90	56.55	55.99			[10]
Tarhana W+C	62.34	59.56	58.10	57.35			[10]

Tarhana W : Tarhana made with wheat flour. Tarhana C: Tarhana made with corn flour. Tarhana W+C: Tarhana made with wheat +corn flour. YW_0: 300g yoghurt + 0g whey used in tarhana production. YW_1: 200g yoghurt + 200g whey used in tarhana production. YW_2 : 100g yoghurt+400 g whey used in tarhana production. YW_3: 0g yoghurt +600g whey used in tarhana production.

Table 7. Fatty acid composition of tarhana samples

Parameters	Butyric (C4:0)	Myristic (C14:0)	Myristoleic (C14:1)	Palmitic (C16:0)	Stearic (C18:0)	Oleic (C18:1)	Linoleic (C18:2)	Reference
Fermentation	4.6	16.4	0.5	40.1	25.0	12.7	0.9	[15]
Storage type	5.2	16.4	0.4	40.4	23.7	13.2	0.7	[15]
Storage period	5.2	16.4	0.4	40.4	23.7	13.2	0.6	[15]

in Table 4. Oven drying of tarhana caused approximately 20% loss of thiamine and riboflavin content of the laboratory samples, while no significant change was observed for vitamin B12 (Table 4). The thiamine and riboflavin content of commercial and homemade tarhana samples were found to be lower than in laboratory samples (Table 4). Although the drying method of commercial produced tarhana is unknown, the sun-dry of homemade tarhana may destroy the heat-labile vitamin thiamine and the light sensitive vitamin riboflavin.

The effect of fermentation and preservation methods on tarhana properties

The effect of different parameters-yoghurt content (50% or 75%), fermentation time and preservation method-on chemical composition, lactic acid and other organic acids content during fermentation of tarhana dough. Concerning the effect of fermentation time on tarhana properties, from 0 to 96 h the amount of lactic acid increased 18.8% for 50% yoghurt and 22.7% for 75% yoghurt. Total acidity was increased 36.1% and 40.6% for 50% and 75% yoghurt rate, respectively. The highest lactic acid content (1.53g/100g) was found in 96 h tarhana samples (Table 5). The crude protein content of all dried tarhana samples was between 14.48% and 15.6% (Table 1) who shows that tarhana is a good source of protein. Dryingand freezing are physical techniques for preservation. Drying reduces moisture and the lactic acid content of product is increased as water is removed. The results of the chemical analysis on dried and frozen tarhana samples are shown in Table 1. Although levels of moisture were similar between the 48 and 96 h fermentation and between the 50% and 75% yoghurt levels, there was a significant difference in moisture content between dried and frozen tarhana samples (Table 1). The average moisture levels of sun-dried samples were 13% and the average in frozen samples 44%. However, the preservative methods used in this study did not significantly influence the salt, protein and ash contents (Table 1). Freezing and sun-drying methods had different effects on the lactic acid content of tarhana samples. The highest acidity level was reached in sun-dried tarhana with 96h of drying. Dry tarhana contained an average of 22.3% higher lactic acid levels than frozen tarhana.

Conclusion

Tarhana is a very nutritive food and its nutritional value is increased by fermentation. The amounts and types of ingredients and fermentation conditions may vary from place to place in Turkey and affect Tarhana properties. The results of the present review showed that added ingredients as well as fermentation time and storage conditions had significant effects on tarhana properties. Tarhana is a good source of minerals with good bioavailibilities. The use of different flours effects its mineral content and other properties. Barley flour could be used to produce tarhana with relatively high glucan content. The use of soybean, corn and maize flour affect tarhana composition. The use of baker's yeast, barley malt and microbial phytase affects the nutrients and phytic acid content of tarhana. The water-soluble vitamin contents of tarhana food are affected by the fermentation and drying conditions. Lactic acid was the main organic acid found during tarhana fermentation. The composition of sun-dried and frozen tarhana samples differed.

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