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A new approach for the utilization of barley in food products: Barley tarhana

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Abstract

One hulless and two hulled barley samples were used to produce tarhana samples with relatively high β-glucan content. Chemical and sensory properties of the tarhana samples were investigated and compared with the traditional wheat tarhana. Although some of the β-glucan may be destroyed during fermentation, the results indicated that barley flours can be used to produce tarhana with relatively high β-glucan content. Effect of tarhana production on the electrophoretic properties of proteins was evaluated in this study by using SDS–PAGE. Relative band intensities of tarhana samples were generally less intense than those of respective flour samples probably due to the hydrolysis of proteins during fermentation. The use of barley flours affected the color and RVA soup index values of tarhana samples. However, the overall sensory analysis results indicated that utilization of barley flours in tarhana formulation resulted in acceptable soup properties in terms of most of the sensory properties.

Keywords: Tarhana; Barley; β-Glucan; SDS–PAGE; Sensory properties; RVA

1. Introduction

Fermented cereal–yoghurt mixtures play an important role in the diets of many people in the Middle East, Asia, Africa and some parts of Europe (Ibanoğlu & Ibanoğlu, 1999). Tarhana, a popular traditional fermented food product in Turkey, is prepared by mixing yoghurt, wheat flour, yeast, and a variety of vegetables and spices (tomatoes, onions, salt, mint, paprika) followed by fermentation for 1–7 days. Lactic acid bacteria and yeast are responsible for the acid formation during fermentation. After fermentation the mixture is sun dried and ground. Tarhana has an acidic and sour taste with a yeasty flavor and is used for soup making (Ibanoğlu & Ibanoğlu, 1997). Because of the low moisture content (about 10%) and low pH, it can be stored for 2–3 years (Ozbilgin, 1983). There are some other products similar to tarhana such as kishk in Egypt, and Kushuk in Iraq and tahonya/talkuna in Hungry and Finland (Hafez & Hamada, 1984; Siyamoğlu, 1961). Methods for preparation for such mixtures may vary from one place to another, but cereals and yoghurt are always the two major components. The amount and type of ingredients used in tarhana production may affect its nutritional content and sensory attributes (Ibanoğlu, Ainsworth, Wilson, & Hayes, 1995). In general, tarhana is produced with white-wheat flour. However, whole meal flour, semolina or both can also be used (Anonymous, 1981).

Apart from having a nutritive value comparable to wheat, barley is unique among cereals containing high concentrations of β-glucan which is known to have the effect of cholesterol lowering effect (McIntosh, Whyte, McArthur, & Nestel, 1991; Newman, Lewis, Newman, Boik, & Ramage, 1989), regulating blood

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glucose level and insulin response in diabetics (Cavallero, Empilli, Brighenti, & Stanca, 2002) and even reducing risk of cancer (Jacobs, Marquart, Slavin, & Kushi, 1998). Although barley is the fourth most important cereal in the world in terms of total production after wheat, rice and corn (Jadhav, Lutz, Ghorpade, & Salunkhe, 1998), only a small 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 (Bhatty, 1999; Bilgi & Çelik, 2004; Köksel, Edney, & Özkaya, 1999).

The objectives of this study were to produce a high β-glucan food product using barley flour and investigate its chemical and sensory properties. Effect of tarhana production on the electrophoretic properties of proteins was also evaluated by SDS–PAGE.

2. Materials and methods

2.1. Materials

Two hulled Turkish barley samples (cvs. Tarm, Tokak) and an advanced hulless barley line (C-738) used in this study were obtained from the Field Crops Improvement Center, Ankara, Turkey. The barley samples were tempered to 14.5% moisture content and milled in a laboratory mill (Bühler, Germany). Wheat flour, yoghurt and fresh baker's yeast were obtained from the Pilot Plant of Hacettepe University, Food Engineering Department. Tomato paste, green and red peppers, onion, salt and spices were purchased from local markets in Ankara, Turkey. Barley flour 1 obtained from cv. Tarm was used to prepare barley tarhana 1 and barley flour 2 obtained from cv. Tokak was used to prepare barley tarhana 2. In addition to these, wheat/barley tarhana was prepared by using the wheat flour and barley flour 2 at the ratio of 1:1.

2.2. Preparation of tarhana

Tarhana samples were prepared according to the method of Ibanoğlu et al. (1995) with some modifications. The ingredients used in tarhana preparation are given in Table 1. To prepare tarhana samples, onions, green and red peppers were chopped in a food processor (Raks-MR 1001, Turkey). Tomato paste, paprika and salt were added and the mixture was blended. Flour, yoghurt and yeast were added to the mixture and blended until complete homogenization. The resulting mixture was taken into covered containers and incubated at 30 °C for fermentation for 5 days. Samples were taken initially, during the course of fermentation and at the end of the fermentation for the determination of acidity and pH. After fermentation, the tarhana was dried at room temperature and then ground and sieved to pass a 1 mm screen.

Table 1
Recipe used for preparation of tarhana samples

Ingredients	Amount (g)
Flour[a]	750
Yoghurt (from cow's milk)	600
Tomato paste	112
Green pepper	75
Red pepper	75
Onion	180
Yeast	15
Paprika	15
Salt	60

[a] Wheat, barley or hulless barley flour.

2.3. Analytical methods

Moisture, ash and crude fat contents of flour and tarhana samples were determined according to AACC Methods (AACC, 1990). Nitrogen content of the samples were determined by the Kjeldahl Method (AACC, 1990) and converted to protein content by a factor of 5.7 for wheat and 6.25 for barley samples. pH was determined according to the method of Ibanoğlu et al. (1995). Acid formation during fermentation and in tarhana samples was determined according to Turkish Tarhana Standard (Anonymous, 1981) and expressed as a percent of total lactic acid. β-Glucan contents of barley flours and tarhana samples were determined by the McCleary Enzymatic Method (McCleary & Glennie-Holmes, 1985; McCleary & Codd, 1991) by using Megazyme β-glucan and Glucose Assay Kits (Megazyme Ltd., Australia).

2.4. SDS–PAGE analysis

Protein extraction was done according to the method of Ng and Bushuk (1987). SDS–PAGE was performed according to the method of Ng and Bushuk (1987) as modified by Fu and Sapirstein (1996). The gels were stained overnight with Coomassie Brillant Blue G-250 according to Ng and Bushuk (1987). SDS–PAGE was performed in a cooled slab gel unit (Hoefer Scientific Instruments, San Fernando, CA). The dried protein fractions were dissolved in 1.0 ml of buffer solution (pH 6.8) containing 0.063 mol/l Tris–HCl, 2% (w/v) SDS, 7% (v/v) 2-mercaptoethanol, 20% (w/v) glycerol and 0.01% (w/v) Pyronin Y. Apparent molecular weights were estimated using the wide range molecular weight markers (Sigma, St. Louis, MO, USA).

Table 2
Temperature-speed change in cooled sample RVA profile

Time (hour:min:sec)		Value
00:00:00	Temperature	80 °C
00:00:00	Speed	960 rpm
00:00:10	Speed	160 rpm
00:05:00	Temperature	80 °C

Idle temperature: 80 ± 1 °C.
End of test: 5 min.
Time between readings: 2 s.

2.5. Sensory analysis

Soups made from the wheat and barley tarhana samples were subjected to sensory evaluation. Seven people who were familiar with tarhana were asked to score the tarhana soups in terms of color, taste, odor, mouth feel and consistency using a five-point scale, with 1 being "dislike extremely" and 5 being "like extremely". Tarhana soups were prepared by mixing 40 g tarhana sample with 500 ml water and simmering for 10 min with constant stirring. The cooked samples were served to the panelists at 80 °C in random order.

2.6. RVA™ soup method

A Rapid Visco Analyzer (RVA–4) (Newport Scientific, NSW, Australia) with data analysis software (Thermocline) was used to analyze soup samples. The last viscosity values of tarhana soups prepared in this study has been determined by RVA soup method, cooled sample profile (Anonymous, 1998). The reported values are the means of two replicates. Details of cooled sample profile are given in Table 2.

2.7. Color measurement

The color of tarhana samples was measured using the $L^*a^*b^*$ color space (CIELAB space) with Minolta Spectrophotometer CM-3600d. The L^* value indicates lightness, the a^* and b^* values are the chromaticity coordinates (a^*, from green to red; b^*, from blue to yellow). The reported values are the means of two replicates.

2.8. Statistical analysis

The data were analyzed for variance using the MSTAT statistical package (Anonymous, 1988). When significant differences were found, the Least Significant Difference (LSD) test was used to determine the differences among means.

3. Results and discussion

3.1. Chemical characteristics of flour and tarhana samples

Chemical characteristics of barley and wheat flour samples are presented in Table 3. The ash content of wheat flour was lower than the other samples used (0.68%), while hulless barley flour had the highest value (1.31%). The hulless barley flour had the highest protein content of 13.4% and barley flour 1 had the lowest protein content of 8.0%. The fat content of the samples ranged from 1.54% to 1.92%. The yoghurt used was made from cow's milk and had fat and protein contents of 3.15% and 3.9%, respectively.

Chemical characteristics of tarhana samples are also presented in Table 3. The moisture content of tarhana samples varied between 7.6% and 9.0%. It was previously reported that the variation in moisture content of tarhana samples was due to the properties of ingredients used in the formulation and the drying method (Temiz & Pirkul, 1991). The ash contents of tarhana samples were between 1.71% and 2.48%. Wheat tarhana sample had the lowest ash content while the hulless barley tarhana had the highest value as expected from the ash contents of respective flours.

Table 3
The chemical composition of flour and tarhana samples

Tarhana samples	Moisture[a] (%)	Ash[a,b] (%)	Protein[b] (%)	Fat[b] (%)	Acidity (%)	pH[a]
Wheat flour	14.4 ± 0.07	0.68d	11.6b	1.54c	–	–
Barley flour 1	10.7 ± 0.06	0.86c	8.0e	1.62c	–	–
Barley flour 2	11.8 ± 0.04	1.03b	10.4d	1.92b	–	–
Hulless barley flour	11.9 ± 0.08	1.31a	13.4a	1.90b	–	–
LSD ($p < 0.05$)	–	0.101	0.403	0.142		
Wheat tarhana	8.2 ± 0.05	1.71d	15.0b	3.40c	1.4b	4.59 ± 0.014
Barley tarhana 1	9.0 ± 0.06	1.98c	10.1e	3.39c	1.3bc	4.60 ± 0.000
Barley tarhana 2	7.6 ± 0.13	2.07b	13.0d	4.13b	1.4b	4.69 ± 0.014
Hulless barley tarhana	7.6 ± 0.14	2.48a	15.9a	4.65a	1.6a	4.73 ± 0.000
Wheat/barley tarhana	8.3 ± 0.20	1.92c	13.6c	4.08b	1.2c	4.81 ± 0.007
LSD ($p < 0.05$)	–	0.088	0.304	0.215	0.18	–

Means with the same letter within a column are not significantly different by least significant difference (LSD) analysis.
[a] Mean ± standard deviation.
[b] Dry basis.

Barley tarhana 1 had the lowest protein content (10.1%) while the hulless barley tarhana had the highest protein content (15.9%). It has been reported in some studies that the main reason for variation in protein content of tarhana may be the type and amount of yoghurt used in tarhana preparation (Temiz & Pirkul, 1991; Yücecan, Kayakırılmaz, Başoğlu, & Tayfur, 1988). Besides these, the properties of different cereal and legume flour samples could also affect the protein content (Köse & Çağındı, 2002; Oner, Tekin, & Erdem, 1993). Since the type and amount of yoghurt samples used in this research were the same for all tarhana samples, it can be concluded that the reason for the variation of protein contents is the type of flour samples used in tarhana preparation. Both barley tarhana 1 and wheat tarhana had the lowest crude fat content of around 3.4%. The observed differences in fat contents of tarhana samples are probably due to the different fat contents of flour samples used in the formula.

The acidity values of tarhana samples were between 1.2% and 1.6%. Wheat/barley tarhana had the lowest acidity value whereas hulless barley tarhana had the highest one. Hulless barley tarhana also had the highest acidity value prior to the fermentation as well as during the course of the fermentation (data not presented). Wheat and hulled barley tarhana samples had comparable acidity values. Tarhana samples used in this research had pH values between 4.59 and 4.81.

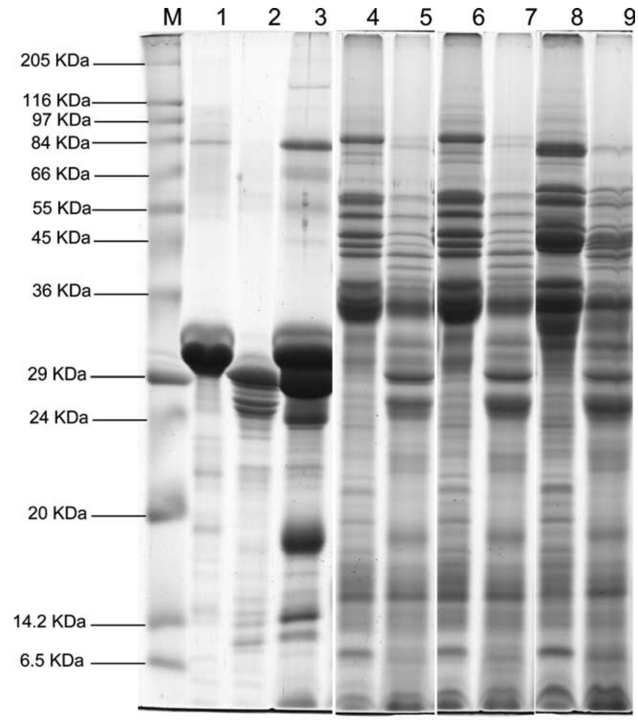

Fig. 1. SDS–PAGE patterns of tarhana samples. M, protein markers; 1, α-casein; 2, β-casein; 3, yoghurt; 4, barley flour 1; 5, barley tarhana 1; 6, barley flour 2; 7, barley tarhana 2; 8, hulless barley flour; 9, hulless barley tarhana.

3.2. SDS–PAGE patterns of barley flour and tarhana samples

SDS–PAGE patterns of barley flour, yoghurt and tarhana samples are presented in Fig. 1. α-Casein and β-casein proteins were also used for comparison. Effect of tarhana production on the electrophoretic properties of proteins was for the first time evaluated in this study by using SDS–PAGE. In this electropherogram, relative mobilities of protein bands of Tokak and Tarm barley flours were similar (Fig. 1, lanes 4 and 6). Relative mobilities of tarhana samples produced from these barley flours were also quite similar to each other (Fig. 1, lanes 5 and 7). However, electrophoretic patterns of hulless barley flours was quite different from those of other cultivars (Fig. 1, lanes 8 and 9) causing a different electrophoretic pattern in hulless barley tarhana. Relative band intensities of tarhana samples were generally less intense than those of respective flour samples. The reduction in relative band intensities might be due to the hydrolysis of proteins during fermentation. It is suggested in previous studies that lactic acid bacteria can hydrolyze the proteins in the fermentation medium by their proteolytic enzymes (Steinkraus, 1997; Temiz & Pirkul, 1991). Two protein bands were observed in the electropherograms of tarhana samples around 29 and 24 kDa which did not exist in the flour samples. These protein bands are thought to be the α-casein and β-casein proteins of the yoghurt sample since they had same relative mobilities with the α-casein and β-casein standards.

3.3. β-Glucan contents of flour and tarhana samples

β-Glucan contents of flour and tarhana samples are presented in Table 4. β-Glucan contents of the barley flours were significantly different from each other and also from the wheat flour ($p < 0.05$). Among barleys, hulless barley flour had the highest β-glucan content (4.25%) and barley flour 1 had the lowest value (2.80%). The β-glucan content of barley was reported to be between 2% and 10% (Aman & Graham, 1987) and the results obtained from this study fall in the same range. It is reported that some barley cultivars have low and some have high β-glucan contents (Bhatty, 1999). Storsley, Izydorczyk, You, Biliaderis, and Rossnagel (2003) suggested that hulless barley is a good source of non-starchy polysaccharides, especially β-glucan and pentosans. In this research, the hulless barley sample was used to increase β-glucan content of tarhana.

There are statistically significant ($p < 0.05$) differences between β-glucan contents of tarhana samples. Wheat tarhana sample had the lowest β-glucan content

Table 4
β-Glucan contents of flour and tarhana samples

Flour samples	β-Glucan (%)[a]	Tarhana samples	β-Glucan (%)[a]
Wheat flour	0.43d	Wheat tarhana	0.28e
Barley flour 1	2.80c	Barley tarhana 1	2.40c
Barley flour 2	3.38b	Barley tarhana 2	2.90b
Hulless barley flour	4.25a	Hulless barley tarhana	3.55a
		Wheat/barley tarhana	1.39d
LSD ($p < 0.05$)	0.142	LSD ($p < 0.05$)	0.232

Means with the same letter within a column are not significantly different by least significant difference (LSD) analysis.
[a] Dry basis.

(0.28%) while the hulless barley tarhana had the highest value (3.55%) as expected from the β-glucan content of respective flours (Table 4). In other words, a parallel relationship exists between the β-glucan contents of flour samples and those of tarhana samples. On the other hand, β-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 β-glucan contents of cereal flours during fermentation. The main reason for decrease in β-glucan content has been thought to be the degradation of β-glucan by lactic acid bacteria during fermentation (Skrede, Storebakken et al., 2002; Skrede et al., 2003).

3.4. Sensory analysis

Sensory analysis results of soups made from tarhana samples are presented in Table 5. The effect of different cereal flours on the color and taste of tarhana soups was statistically significant ($p < 0.05$). Color values obtained by sensory analysis of the tarhana soups varied between 5.00 and 3.43. Taste property of tarhana soups had values between 4.15 and 3.00. The color and taste values of barley tarhana soups were generally comparable to that of wheat tarhana soup except hulless barley tarhana soup. On the other hand, the color and taste values of hulless barley tarhana soup were comparable with those of other barley containing tarhana soups.

Table 5
Sensory analysis results of tarhana soups

Tarhana samples	Color	Taste	Odor	Mouthfeel	Consistency
Wheat tarhana	5.00a	4.15a	3.86	3.86	4.58
Barley tarhana 1	4.15ab	3.43ab	3.29	3.29	3.86
Barley tarhana 2	3.58b	3.58ab	3.72	3.72	4.43
Hulless barley tarhana	3.43b	3.00b	3.15	3.15	4.01
Wheat/barley tarhana	4.29ab	3.86ab	3.86	3.86	4.01
LSD ($p < 0.05$)	0.887	0.974	–	–	–

Means with the same letter within a column are not significantly different by least significant difference (LSD) analysis.

The effects of different flours on the odor, mouthfeel and consistency values of tarhana soups were not statistically significant. In other words, all of the soups were comparable in terms of odor, mouthfeel and consistency values. 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. However, sensory quality of soups prepared from barley flour can be improved by further studies.

Table 6
RVA soup index values of tarhana samples

Tarhana samples	RVA soup index (RVU)
Wheat tarhana	24.3a
Barley tarhana 1	19.5bc
Barley tarhana 2	21.1ab
Hulless barley tarhana	16.9c
Wheat/barley tarhana	22.2ab
LSD ($p < 0.05$)	3.81

Means with the same letter are not significantly different by least significant difference (LSD) analysis.

3.5. RVA ™ soup method

The last viscosity values (RVA soup index) of tarhana soups are presented in Table 6. Viscosity is an important quality criterion in soups. The viscosity values of tarhana soups showed variation between 16.9 and 24.3 RVU. RVA soup index values of wheat tarhana, barley tarhana 2 and wheat/barley tarhana samples were not significantly different. RVA soup index values of hulless barley tarhana and barley tarhana 1 samples were comparable. Since different cereal flours used in tarhana preparation vary in their water absorption properties, viscosity values can be different from each other. Although there were some statistically significant differences in the RVA soup index values of different tarhana samples, the differences were not substantial to affect the related sensory characteristics drastically. All of the soups were comparable in terms of mouthfeel and consistency values as determined by sensory analysis (Table 5).

3.6. Color measurements

The color of tarhana samples measured using the $L^*a^*b^*$ color space (CIELAB space) are presented in Table 7. The differences between color values of tarhana samples were significant. Barley tarhana 1 had the highest L^* value (78.51). The L^* values of hulless barley tarhana and wheat tarhana were comparable. Redness, a^*, was recorded between 3.14 and 6.46 and yellowness, b^*, was found to be between 16.89 and 20.12. The a^*

Table 7
Color analysis of tarhana samples

Tarhana samples	L^*	a^*	b^*
Wheat tarhana	75.06b	6.46a	20.12a
Barley tarhana 1	78.51a	3.14c	17.77c
Barley tarhana 2	71.72d	3.62c	16.89c
Hulless barley tarhana	75.58b	3.57c	16.97c
Wheat/barley tarhana	72.78c	5.12b	18.97b
LSD ($p < 0.05$)	0.745	0.765	0.929

Means with the same letter within a column are not significantly different by least significant difference (LSD) analysis.
*L, whiteness; a, redness, greenness; b, yellowness and blueness.

and b^* values of wheat tarhana were the highest when compared to the rest of the samples. The use of barley flours affected the color values of tarhana samples. In contrary to the color values of tarhana samples determined using spectrophotometer, sensory color values of tarhana soup samples containing barley flours were not significantly different and most of the soups were comparable in terms of sensory color values.

4. Conclusion

Barley is suitable for a wide range of food applications and it can be processed into a number of palatable, nutritious food products. However, to the best of our knowledge there are no studies on the utilization of barley in tarhana production. Hence, in this study it was decided to utilize barley flour in tarhana formulation in order to produce a new food product with a relatively high β-glucan content. The results showed that barley flour can be used alone or together with wheat flour in tarhana production. The level of β-glucan in tarhana samples was lower than that of barley flours. The decrease in β-glucan content due to fermentation has been stated in previous studies (Chavan & Cadam, 1989). Although some of the β-glucan may be destroyed during fermentation, it can be concluded that barley flours can be used to produce tarhana with relatively high-glucan content; furthermore, β-glucan contents comparable to that of original barley flour can be achieved.

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. Slightly lower values in some of the sensory properties (color and taste) of the barley tarhanas might decrease the acceptability of these tarhana soups as compared to traditional wheat based tarhana. However, the slightly lower acceptability can be compensated by the health benefits of barley products and sensory quality of soups prepared from barley flour can be improved by further studies.

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References

AACC. (1990). *Approved methods of the american association of cereal chemists* (8th ed.). USA: St. Paul, MN.

Aman, P., & Graham, H. (1987). Analysis of total and insoluble mixed-linked (1 → 3), (1 → 4)-β-D-glucans in barley and oats. *Journal of Agricultural and Food Chemistry, 35*, 704–709.

Anonymous (1981). *TSE tarhana standard TS 2282*. Ankara: Türk Standartlar Enstitüsü.

Anonymous (1988). *User's guide to MSTAT-C, a software program for the design, management and analysis of agronomic research experiments*. USA: Michigan State University.

Anonymous. (1998). *Applications manual for the rapid Visco™ analyser*. Australia: Warriewood NSW 2102.

Bhatty, R. S. (1999). The potential of hull-less barley. *Cereal Chemistry, 76*(5), 589–599.

Bilgi, B., & Çelik, S. (2004). Solubility and emulsifying properties of barley protein concentrate. *European Food Research and Technology, 218*, 437–441.

Cavallero, A., Empilli, S., Brighenti, F., & Stanca, A. M. (2002). High (1 → 3,1 → 4)-β-glucan barley fractions in bread making and their effects on human glycemic response. *Journal of Cereal Science, 36*, 59–66.

Chavan, J. K., & Cadam, S. S. (1989). Nutritional improvement of cereals by fermentation. *Critical Reviews in Food Science and Nutrition, 28*, 349–400.

Fu, B. X., & Sapirstein, H. D. (1996). Procedure for isolating monomeric proteins and polymeric glutenin of wheat flour. *Cereal Chemistry, 73*(1), 143–152.

Hafez, Y. S., & Hamada, A. S. (1984). Laboratory preparation of a new soy-based kishk. *Journal of Food Science, 49*, 197–198.

Ibanoğlu, S., Ainsworth, P., Wilson, G., & Hayes, G. D. (1995). The effect of fermentation conditions on the nutrients and acceptability of tarhana. *Food Chemistry, 53*, 143–147.

Ibanoğlu, E., & Ibanoğlu, S. (1997). The effect of heat treatment on the foaming properties of tarhana, a traditional Turkish cereal food. *Food Research International, 30*(10), 799–802.

Ibanoğlu, E., & Ibanoğlu, S. (1999). Foaming properties of white wheat flour–yoghurt mixture as affected by fermentation. *Journal of Cereal Science, 30*, 71–77.

Jacobs, D. R., Jr., Marquart, L., Slavin, J., & Kushi, L. H. (1998). Whole-grain intake and cancer: an expanded review and meta-analysis. *Nutrition and Cancer, 30*(2), 85–96.

Jadhav, S. J., Lutz, S. E., Ghorpade, V. M., & Salunkhe, D. K. (1998). Barley: chemistry and value-added processing. *Critical Reviews in Food Science, 38*(2), 123–171.

Köse, E., & Çağındı, Ö. S. (2002). An investigation into the use of different flours in tarhana. *International Journal of Food Science and Technology, 37*, 219–222.

Köksel, H., Edney, M. J., & Özkaya, B. (1999). Barley bulgur: effect of processing and cooking on chemical composition. *Journal of Cereal Science, 29*, 185–190.

McCleary, B. V., & Glennie-Holmes, M. (1985). Enzymic quantification of (1 → 3), (1 → 4)-β-D-glucan in barley and malt. *Journal of the Institute of Brewing, 91*, 285–295.

McIntosh, G. H., Whyte, J., McArthur, R., & Nestel, P. J. (1991). Barley and wheat foods: influence on plasma cholesterol concentrations in hypercholesterolemic men. *American Journal of Clinical Nutrition, 53*(5), 1205–1209.

McCleary, B. V., & Codd, R. (1991). Measurement of (1 → 3), (1 → 4)-β-D-glucan in barley and oats: a streamlined enzymic procedure. *Journal of the Science of Food and Agriculture, 55*, 303–312.

Newman, R. K., Lewis, S. E., Newman, C. W., Boik, R. J., & Ramage, R. T. (1989). Hypochoesterolemic effect of barley foods on healthy men. *Nutritional Reports International, 39*, 749–760.

Ng, P. K. W., & Bushuk, W. (1987). Glutenin of marquis wheat as a reference for estimating molecular weights of glutenin subunits by sodium dodecyl sulfate-polyacrylamide gel electrophoresis. *Cereal Chemistry, 64*, 324–327.

Oner, D. M., Tekin, R. A., & Erdem, T. (1993). The use of soybeans in the traditional fermented food-tarhana. *Lebensmittel-Wissenschaft Und-Technologies-Food Science and Technology, 4*, 1–2.

Ozbilgin, S. (1983). The chemical and biological evaluation of tarhana supplemented with chickpea and lentil. PhD Thesis. Cornell University, Ithaca, USA.

Siyamoğlu, B. (1961). Türk tarhanalarının yapılışı ve terkibi üzerinde bir araştırma. Ege Üniversitesi Ziraat Fakültesi Yayınları: 44, E. Ü. Matbaası, 75 s.

Skrede, G., Herstad, O., Sahlstrøm, S., Holck, A., Slinde, E., Skrede, A., et al. (2003). Effects of lactic acid fermentation on wheat and barley carbohydrate composition and production performance in the chicken. *Animal Feed Science and Technology, 105*, 135–148.

Skrede, G., Storebakken, T., Skrede, A., Sahlstrøm, S., Sørensen, M., Shearer, K. D., et al. (2002). Lactic acid fermentation of wheat and barley whole meal flours improves digestibility of nutrients and energy in Atlantic salmon (*Salmo salar* L.) diets. *Aquaculture, 210*, 305–321.

Steinkraus, H. K. (1997). Classification of fermented foods: worldwide review of household fermentation techniques. *Food Control, 8*(5/6), 311–317.

Storsley, J. M., Izydorczyk, M. S., You, S., Biliaderis, C. G., & Rossnagel, B. (2003). Structure and physicochemical properties of β-glucans and arabinoxylans isolated from hull-less barley. *Food Hydrocolloids, 17*, 831–844.

Temiz, A., & Pirkul, T. (1991). Farklı bileşimlerde üretilen tarhanaların kimyasal ve duyusal özellikleri. *Gıda, 16*(1), 7–13.

Yücecan, S., Kayakırılmaz, K., Başoğlu, S., & Tayfur, M. (1988). Tarhanaların besin değeri üzerine bir araştýrma. *Türk Hijyen ve Deneysel Biyoloji Dergisi, 45*, 47–51.