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Functional properties of tarhana enriched with whey concentrate

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Abstract. Whey concentrate is often sold as a nutritional supplement and include proteins, minerals, vitamins and other components (low levels of fat and low levels of lactose). Whey concentrates is well known for their high nutritional value and versatile functional properties in food products. The aim of this study was to enrich tarhana by using whey concentrate (WC) instead of yoghurt. Foaming capacity and foam stability, water and oil absorption capacity, emulsifying activity as a functional properties, colour properties and sweetness, body-texture, colour-appearance, mouthfeel, acerbity, homogeneity, consistency and overall acceptability as a sensorial characteristics of tarhana samples were determined. The highest foaming capacity values were obtained with 50% WC substitution, but 50% WC addition gave the lowest foam stability values. Oil absorption capacity and emulsifying activity values of tarhana samples were decreased by increasing WC levels. Tarhana samples containing WC were lighter according to colour values than the control tarhana samples made with yoghurt. Tarhana soup prepared with 12.5% WC addition was similar to the control in homogeneity and overall acceptability.

Key words: tarhana, whey concentrate, color, foaming capacity, water absorption capacity, sensorial characteristics.

INTRODUCTION

Tarhana, which is prepared by fermenting drain derivates combined with yoghurt and other flavoring ingredients, and drying and grinding into granulated form. Tarhana powder, a semi ready traditional food product in Turkey, is used in soup making (İbanoğlu et al., 1995; Dağlıoğlu, 2000). It is a good source of proteins, vitamins and minerals, and therefore is used largely for feeding people of all age in the form of soup (Tarakçı et al., 2004; Bilgiçli et al., 2006). Tarhana powder has an acidic sour taste with a yeasty flavor due to the its low pH (3.4–4.4) and it also has low moisture content (6–10%) which is a poor medium for pathogens and spoilage organisms (İbanoğlu & İbanoğlu, 1997; Dağlıoğlu, 2000; Erkan et al., 2006).

Whey is a major by-product of dairy industries in manufacturing cheese, casein etc. Whey solids contain half of the precious milk solids, and are not yet fully utilized in various food formulations. Thus, large quantities of whey are drained off and disposed as waste (Khamrui & Rajorhia, 1998). Whey products contain proteins, a wide variety of minerals, vitamins and other constituents such as lactose and lipids. Whey proteins are the best quality proteins available. They have high protein efficiency ratio (PER =

3.6) and possess all essential amino acids. Whey proteins are used as food ingredients because of their unique nutritional and functional characteristics like emulsifying, gelling, thickening, foaming and water binding capacity (Kinsella & Whitehead, 1989). An important functional property of whey proteins is the ability, under appropriate conditions, to form heat induced gel structures capable of immobilize large quantities of water and other food components (Hermansson & Akesson, 1975). They can modify some or all of the organoleptic, visual, hydration, surfactant, structural, textural and rheological properties of food, resulting in improved consumer acceptance of the food product. Whey proteins in their native state are highly soluble in food and beverage systems and are used for applications such as whipping/foaming. They act at oil/water interfaces to form and stabilize emulsions. In their undenatured form, whey proteins have the ability to form rigid, heat-induced irreversible gels that hold water, fat and provide structural support. In addition, they play an important role in controlling the texture of many food products, and are used to modify the rheological properties of foods (Harper, 2000; Hudson et al., 2000).

Quality tarhana soup has to be good in homogeneity and mouth feeling in sensory properties, with phase separation as long as possible. Yoghurt used in tarhana products is very well in sensory properties in consumer acceptance and is a healthy and nutritious food (Tamime & Robinson, 1999,; McKinley, 2005). In literature soy yoghurt (Koca et al., 2002) corn flour and whey (Tarakçı et al., 2004), rye, maize, soy bean (Hafez & Hamada, 1984, Öner et al., 1993, Köse & Çağındı, 2002), oat and barley (Tamime et al., 1997, Erkan et al., 2006) wheat germ and bran (Bilgiçli et al., 2006) buckwheat (Bilgiçli, 2009) whole wheat meal and bulgur (Toufeili et al., 1998) were used intead of cow's milk yoghurt and wheat flour.' And also in our another study, Ertaş et al. (2009) reported that it is possible to use of whey concentrate (WC) instead of yoghurt as an ingredient in tarhana making, with its high mineral and lactose contents and low fat and acidity. The purpose of this study was to enrich tarhana by using WC instead of yoghurt and, to determine the effect of WC addition on the functional and sensory properties of tarhana samples and to use waste material in tarhana production instead of yoghurt as a dairy by product.

MATERIALS AND METHODS

Materials

The ingredients used in tarhana preparation were purchased from local markets in Konya, Turkey. To prepare tarhana, commercial wheat flour (Selva Food Industry Inc.) with a crude protein content of 11.54% (Nx5.7, w w^{-1}, dry basis), pepper *(Capsicum annuum)* paste had 22% total dry solids (TDS) and medium sized dry onions *(Allium cepa)* were used. The spices used were in powder form (i.e., salt, paprika *(Capsicum annuum)*). The yoghurt was full-fat strained yoghurt (concentrated, 'Süzme' yoghurt) made of cow's milk. WC and yoghurt were obtained from ENKA Dairy Plant, in Konya, Turkey. WC is a byproduct of 'white cheese' production as rennet coagulated and non-cooked curd type cheese, like 'feta'. WC is produced with the integration of nano-filtration (15–20% TDS) for pre-concentration, and falling film evaporators (60–65% TDS).

Preparation of tarhana samples

To prepare control tarhana sample at laboratory conditions, wheat flour (200 g), yoghurt (80.0 g, having approximately 25 g of total solid content corresponding 12.5% [w w^{-1}] based on the 200 g flour), pepper paste (20 g), finely chopped onions (30 g), paprika (4 g), and salt (2 g) were mixed using a Hobart mixer for 5 min at the highest speed with distilled water (100 ml) added.

The other tarhana samples supplemented with WC were prepared as described above, with the additions of WC of 12.5% (40.84 g), 25.0% (81.68 g) and 50.0% (163.36 g) (w w^{-1}), instead of yoghurt. The resultant mixtures were placed in sealed plastic container and fermented at 30 ºC for 7 days.

During the fermentation, the mixture was mixed manually at every 12 hr intervals. Each fermented mixture was divided into 2 cm diameter pieces by hand, placed on aluminum trays and dried at 55 ºC for 48 hr to 6% moisture (w w^{-1}, dry basis) in an air convection oven (Özköseoğlu PFS-9, Turkey). The dried samples were ground into granulated form in a hammer mill (FN-3100 Laboratory Mill; Perten Instruments AB) equipped with 1 mm opening screen. Tarhana samples were kept in closed glass containers at room temperature until used for analysis.

Chemical properties

The AOAC methods were used for the determination of total solid content (%), crude protein (N x 6.38), crude fat (%), ash content, titratable acidity (as % lactic acid), pH and salt (%) for yoghurt and WC (AOAC, 2000).

Color measurement

Color measurement was performed on tarhana powder using a Hunter Lab Color Quest II Minolta CR 400 (Konica Minolta Sensing, Inc., Osaka, Japan). The L^*, a^* and b^* were determined according to the CIELab color space system, where L^* corresponds to light/dark chromaticity, a^* to green/red chromaticity and b^* to blue/yellow chromaticity with illuminate D63 as reference. From a^* and b^* values, the hue angle ($\tan^{-1} b^* a^{*-1}$) and chroma (SI) ($(a^{*2}+b^{*2})^{1/2}$) were calculated.

Foaming capacity and foam stability

The method of Hayta et al., (2002) was used for foaming capacity and foam stability. 10 g tarhana powder was dispersed in 25 ml distilled water and stirred for 20 min by means of a magnetic stirrer. The mixture was centrifuged (Nüve, NF 800 R) at 4000 × g for 20 min. Supernatant obtained was filtered (Whatman No. 1) and transferred to a Waring blender and whipped for 2 min at high-speed setting. The solution was slowly poured into a cylinder, and the volume of the foam was recorded after 10 s. Foaming capacity was expressed as the volume (mL) of gas incorporated per mL of solution. Foam stability was recorded as the time passed until the half of the original foam volume had disappeared.

Water and oil absorption capacity

The method of Hayta et al., (2002) was used for determination of water and oil absorption capacity of tarhana powder. Tarhana powder (5.0 g) with 25 ml distilled water or with 25 ml sunflower oil was mixed at 25°C in 50 mL centrifuge tubes. Dispersions were stirred and then centrifuged. Water and oil absorption capacity values were expressed as grams of water or oil absorbed per gram of tarhana.

Emulsifying activity

Tarhana powder (10 g) was dispersed in 25 ml distilled water at 25°C and stirred for 20 min and then centrifuged at 4000 × g for 20 min. Supernatant obtained were mixed with equal volumes of sunflower oil and homogenized for 5 min at low-speed setting in a Waring blender. The homogenized mixture was transferred into a measuring cylinder. Emulsifying activity was expressed as percent volume of the emulsified layer in total volume of the mixture (Hayta et al., 2002).

Sensorial characteristics

To determine sensory properties of tarhana soup, 25 g tarhana powder (dry basis) was mixed with 250 ml distilled water (10°C) and simmered for 10 min over medium heat with constant stirring. Seven panelists from Food Engineering Department who were familiar with tarhana soup were asked to score the tarhana soups in terms of sweetness, body-texture, colour-appearance, mouth feel, acerbity, homogeneity, consistency and overall acceptability using 10 point hedonic scale with 1–2 dislike, 5–6 acceptable, 9–10 like extremely. The samples were coded with numbers and served to the panelists at random to guard against a bias.

Statistical Analysis

The data obtained was summarized by one way ANOVA according to factorial design application. Costat software was used to perform the statistical analysis. Duncan's multiple range tests were used to differentiate among the mean values. Standard deviations were calculated using the same software (Costat, 1990).

RESULTS AND DISCUSSION

Analytical Results

The chemical compositions of the yoghurt and WC used in tarhana formulation were presented in Table 1. The solid amount of WC was twofold of the yoghurt's. The protein amount and acidity values of WC were lower than those of yoghurt. The fat

Table 1. Compositions and chemical properties of the yoghurt and WC used in tarhana formulation[1]

Components[2]	Yoghurt	WC
Total dry solids %	30.50 ± 0.07	61.19 ± 0.08
Crude protein (N x 6.38) %	7.50 ± 0.24	5.83 ± 0.31
Crude fat %	3.80 ± 0.06	1.00 ± 0.05
Ash content %	2.20 ± 0.04	3.70 ± 0.02
Titratable acidity (as lactic acid) %	1.80 ± 0.03	0.13 ± 0.02
pH	4.10 ± 0.04	5.48 ± 0.02
Salt %	nd [3]	3.48 ± 0.07

[1] Values represent the mean of triplicate determinations for each sample, [2] based on dry matter, [3] nd: not determined.

content of WC is about 1/3 of that of yoghurt. In ash contents, WC was superior due to mineral content. In mineral content, WC has more Ca, K, Mg, Na and P and Zn contents than yoghurt (data not shown), and WC is superior for crude ash and salt (NaCl) involvement. Also chemical and nutritional advantages of this study are mentioned in our previous study (Ertaş et al., 2009).

Color of tarhana powder

The attractiveness and brightness of tarhana powder and its soup in the color coming from the natural ingredients, is one of the main quality factors. Color values of the tarhana samples were shown in Fig.1. The color parameters, L^*, a^* and b^* values ranged between 71.45–78.11; 7.19–9.13; and 20.49–24.28 respectively. The results agree with those of previous studies conducted by Bilgiçli & Elgün (2005), and Erkan et al. (2006). WC addition showed the higher L^* and lower a^* values than yoghurt addition. The color parameters a^* and b^* tended to decrease, whereas parameter L^* tends to increase with increasing WC levels. WC addition led to more bright and attractive color (reddish orange tarhana color depending on the tarhana formulation) to tarhana powder. The chroma value (colour intensity or saturation) of control was 25.94, which was higher than those of 12.5% WC (23.09), 25.0% WC (22.16) and 50% WC (22.07). The highest hue angle value was obtained with 50% WC addition.

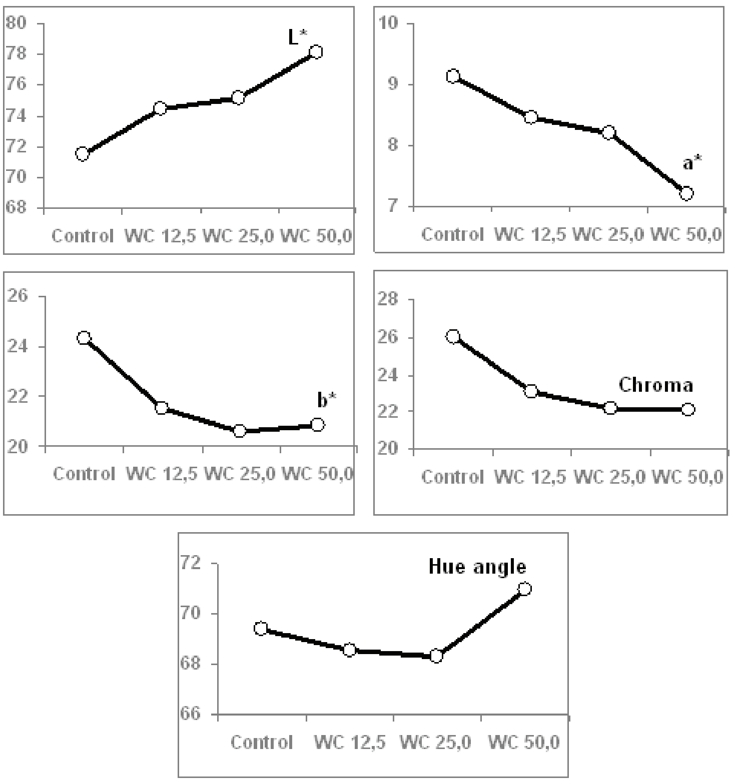

Figure 1. The effects of WC (%) on the color of tarhana solid (L^* = brightness, a^* = redness, b^* = yellowness, Chroma = $((a^{*2}+b^{*2})^{1/2})$, Hue angle = $(\tan^{-1} b^*/a^*)$.

Foaming capacity and stability

The all functional properties of the tarhana samples were presented in Table 2. The foaming capacity and stability of tarhana samples as a measure of viscose structure stability ranged between 0.55–0.77 (ml ml^{-1}). Significant differences ($P < 0.01$) were observed in the foaming capacity of tarhana samples with different WC content. The WC addition in tarhana samples increased the foaming capacity while decreasing foam stability of the samples. Some food proteins are competent of forming good foams and their capacity to form and save stable foams depends on the type and concentration of proteins, the degree of denaturation, pH, ions, and processing methods (Işık and Gökalp, 1996; Dağlıoğlu, 2000). 50% WC addition into tarhana recipe formed the least foam stability. Sosulski & McCurdy, (1987), reported that the loss of soluble low-molecular weight proteins is responsible to less foam stability. In this study, lower foam stability values were determined WC added tarhana samples compared to control. It may be due to the low-molecular weight proteins of WC than casein proteins of yoghurt

Water absorption capacity

In viscous foods, the water absorption capacity is an important functional property (Sosulski et al., 1976). The water absorption capacity ranged from 0.41–0.73 ml g^{-1}. (Table 2). Bilgiçli (2009) reported that water absorption capacity values of tarhana samples enriched with buckwheat flour ranged from 0.50 to 0.63ml g^{-1}. WC addition decreased the water absorption capacity of the tarhana samples. This functional property depends on the protein content but mainly on the physical interactions between water and protein (Cheftel et al., 1989).

Table 2. The effect of WC (%) on the functional properties of tarhana solid[1,2]

Samples	FC (ml ml^{-1})	FS (min)	WAC (ml g^{-1})	OAC (ml g^{-1})	EA (%)
Control	$0.55 \pm 0.01^{c\,**}$	$7.09 \pm 0.05^{a\,**}$	$0.73 \pm 0.01^{a\,**}$	$0.76 \pm 0.01^{b\,*}$	$94.05 \pm 0.81^{ab*}$
WC 12.5	0.62 ± 0.02^{bc}	2.21 ± 0.03^{b}	0.56 ± 0.03^{b}	0.93 ± 0.04^{a}	95.82 ± 0.05^{a}
WC 25.0	0.69 ± 0.01^{ab}	0.42 ± 0.05^{c}	0.44 ± 0.01^{c}	0.82 ± 0.04^{ab}	93.79 ± 0.05^{b}
WC 50.0	0.77 ± 0.02^{a}	0.29 ± 0.02^{c}	0.41 ± 0.02^{c}	0.77 ± 0.02^{b}	93.52 ± 0.06^{b}

[1]Means with different superscripts in the same column are significantly different ($P < 0.01$).
[2]Values are the average of triplicate measurements on duplicate sample ± standard deviation.
[3] FC – Foaming Capacity, FS – Foam Stability, WAC – Water Absorption Capacity, OAC – Oil Absorption Capacity, EA – Emulsifying Activity, $^{*}P < 0.05$, $^{**}P < 0.01$.

The low water absorption capacity values can be explained by structural changes in starch and proteins present in tarhana ingredients (Pyler, 1982). The control tarhana sample with yoghurt gave the highest water absorption capacity values (0.73 ml g^{-1}). This can be attributed to the high casein content and acidity of yoghurt used in tarhana production (Table 1). Casein with gel structure absorbs and binds much more water than the serum proteins, and proteolytic activity can cause more swelling capacity of the dough components in acidic medium of the yoghurt (Muir et al., 2000). Similar results were also reported by some researchers (Çelik et al., 2005). Hayta et al. (2002), reported the water absorption capacity of yoghurt between 0.45–2.28 ml g^{-1} in tarhana made with different drying methods.

Oil absorption capacity

This property is important in the prevention of phase separation and in sensory properties. Moreover, oil absorption capacity shows the degree of hydrophobicity of the food system. It is provide that fat distribution as homogeneous due to the increase of fat globules stuck tarhana granules in tarhana. Oil absorption capacity of tarhana samples varied between 0.76 to 0.93 ml g^{-1} (Table 2). 12.5% WC added tarhana samples gave the highest oil absorption capacity (0.93 ml g^{-1}). Also 25% of WC addition gave higher oil absorption capacity than that of yoghurt added control samples.

Emulsifying activity

The emulsifying activity related to the area of stabilized oil droplets at interface. Therefore it is a function of the oil content and protein concentration (Hayta et al., 2002). In this research, the mean value of emulsifying activity of tarhana samples was 94.29 %. Hayta et al. (2002) and Çelik et al. (2005) reported that emulsifying activity of tarhana samples were 82.6 to 90.0% and 89.0 to 91.5% respectively. As shown in Table 2, 12.5 % WC addition gave the highest emulsifying activity values (95.82%), which were also higher than the values of control samples. More than 12.5% WC supplementation into tarhana formulation decreased the emulsifying activity sharply. WC supplementation up to 12.5% levels was more satisfying than yoghurt addition. The probable factors in these results are the increase in the foaming and oil absorption capacities of tarhana samples with 12.5% WC level (Table 2). Decreasing the foam stability at over the 12.5% WC addition level in tarhana formulation, can cause to release sticking the fat globules stuck foam and a phase separation problem. The correlation coefficients given in Table 3 show that the oil absorption capacity of tarhana solid is the most effective factor on emulsifying activity.

Table 3. Correlation coefficients among the functional properties of tarhana solids

	FC [1]	FS [2]	WAC [3]	OAC [4]	EA [5]
FC	1				
FS	-0.876**	1			
WAC	-0.939**	0.974**	1		
OAC	-0.122	-0.256	-0.068	1	
EA	-0.472	0.119	0.300	0.835**	1

[1] FC - Foaming capacity, [2] FS - Foam stability, [3] WAC - Water absorption capacity, [4] OAC - Oil absorption capacity, [5] EA - Emulsifying activity, **Correlation is significant at the 0.01 level (2-tailed).

Sensory properties of tarhana

The sensory properties of tarhana soups were illustrated in Fig. 2. The results of the sensory evaluations showed that utilization of WC in tarhana preparation resulted acceptable soup properties compared to traditional yoghurt used tarhana. The samples containing WC was lighter according to color values than the control tarhana samples with yoghurt. Tarhana soup prepared with 12.5% WC addition was similar to the control in homogeneity and overall acceptability. High levels of WC increased sweetness and decreased the overall acceptability, but not contributed to the other parameters. Tarhana soups with 12.5% WC were more liked by panelists than control and further WC added tarhana samples. Also tarhana soups with 25% WC have acceptable scores in terms of all sensory properties.

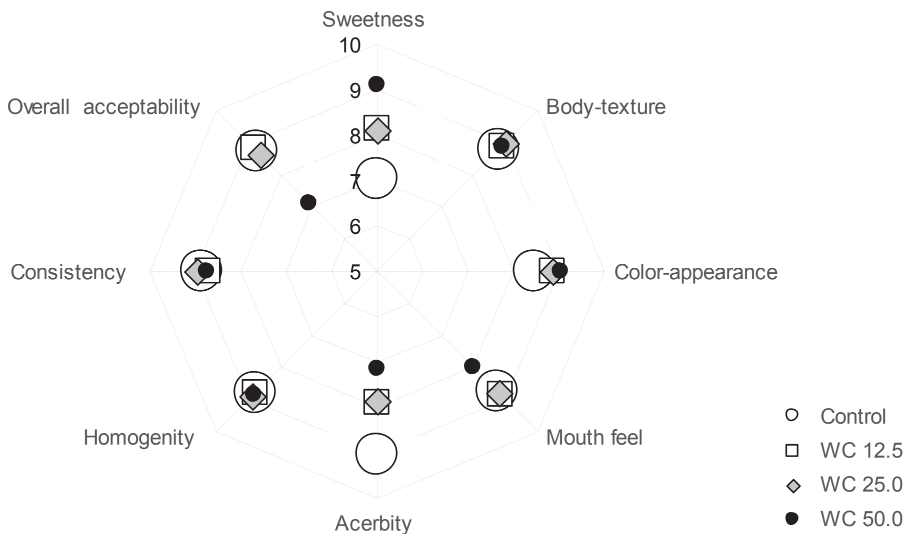

Figure 2. The effects of WC (%) on the sensory properties of tarhana soup.

Tarakçı et al. (2004) reported that higher amounts of whey added tarhana samples gave higher body, smell, flavour and overall acceptability values than the other samples. The control samples gave higher acerbity values than WC added samples. Panelists expressed an enhancing sweet taste for the soups with increased amounts of WC.

CONCLUSIONS

Tarhana samples were successfully produced by WC supplementation. The results of this research showed that 25% level WC can be used instead of yoghurt in tarhana production. WC addition decreased the color a* and b* values of tarhana samples while the parameter L* tends to increase with increasing WC levels. WC addition gave more bright and attractive color to tarhana solids than that of the control samples. WC addition increased the foam capacity and gave higher oil absorption capacity values than that of control sample. Utilization of WC in tarhana preparation resulted in acceptable soup properties up to 25% level in dry basis. In further studies, lactic acid bacteria can be added to improve the natural microbial flora of WC in tarhana formulation.

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