

Utilisation of dairy by-products and β -glucan in erişte production

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Abstract

Three different dairy by-products (whey protein concentrate powder, WPC; whey powder, WP; and buttermilk powder, BP) and β -glucan (β G) concentrate were used in erişte formulation to improve nutritional properties of erişte. WPC, WP and BP were used at 0, 5, 7.5 and 10% levels and β G was used at 0, 3, 5 and 7% levels in erişte formulation according to $(3 \times 4 \times 4) \times 2$ factorial design. Some physical (colour and breaking strength), chemical (moisture, ash, protein, fat, cellulose, phytic acid and mineral contents), cooking and sensory properties of samples were investigated. Combination of β G with dairy by-products had a decreasing effect on breaking strength of erişte samples. β G gave darker samples in erişte colour. WPC, BP and β G addition significantly increased the protein, fat and cellulose contents of the samples, respectively. Both dairy by-products and β G increased mineral (calcium, magnesium and phosphorus) contents of the samples. The 10% dairy by-products supplementation instead of wheat flour increased cooking loss values of erişte samples from 4.41% to 7.16%. As a result of sensory evaluation, erişte samples containing BP gave the highest scores.

Keywords: dairy by-products, erişte, β -glucan, mineral, nutrition, protein

1. Introduction

Erişte is a traditional noodle commonly produced in Turkey. It is basically produced from soft or hard wheat flour, water and salt. In addition to these ingredients egg, milk and various additives can be added to the formulation. The basic process for production consists of blending and kneading of ingredients for the dough development, sheeting, resting, cutting and drying with different methods (under the sun, at room conditions or on a hot pan) (Bilgiçli, 2009; Özkaya *et al.*, 2001). Erişte quality is affected by production techniques such as the dough mixing time, sheeting procedure, resting time and drying methods (Özkaya *et al.*, 2001). Erişte is usually known home-made dish in Turkey (Ertas, 2014), and the popularity of erişte results from its simple preparation, long shelf life, covetable sensory properties and low cost.

Erişte and other noodle type products are rich in carbohydrate but they are insufficient in terms of protein content and amino acid balance. However, noodle type products are suitable for fortification and/or enrichment.

This problem could be solved by consuming noodles together with different foods that are rich in protein (Eydemir and Hayta 2009; Lee *et al.*, 2002). For this reason some dairy by-products (DBP) such as whey powder (WP), whey protein concentrate powder (WPC) and buttermilk powder (BP) are widely used in food industry.

Whey is the serum part which separates from the solids in the process of making cheese. Whey retains virtually all of the water-soluble vitamins and minerals of the milk, and most of its lactose and non-casein proteins (Bilgin *et al.*, 2006). Whey proteins have high quality protein with rich amino acid profile. Many whey products are available in the form of dry whole WP obtained by evaporation and spray drying, or WPC obtained by ultrafiltration and further spray drying. The amount of protein in WPC ranges from 30 to 75% (Secchi *et al.*, 2011).

The churning of cream during butter manufacture releases a liquid by-product commonly known as buttermilk. The spray-dried form of buttermilk is also known as buttermilk

solids or BP (Wong and Kitts, 2003). It contains all the water-soluble components of cream such as milk protein, lactose, minerals and more phospholipids than milk. Because of its emulsifying capacity and its positive impact on flavour, is widely used in the food industry (Sodini *et al.*, 2006).

β -glucan (β G) is indigestible polysaccharide occurring naturally in various organic sources especially oats and barley. They are important components of the dietary fibres consisting of β -D-glucopyranose units linked through (1 $\rightarrow$ 4) and (1 $\rightarrow$ 3) glycosidic bonds in cereals (Havrleťová *et al.*, 2011). Oats and barley contain significant amounts of β G usually around 3-5%, but some barleys as much as 12% or more located in the endosperm cell walls (Wood, 2002). It is classified generally as a soluble dietary fibre and possesses a number of functionalities with potential health benefits for example attenuates low density lipoprotein cholesterol levels and glycemic response and provides immune-stimulation, anti-inflammatory, antimicrobial effects (Aldughpassi *et al.*, 2012; Brennan and Clearly, 2005; Brummer *et al.*, 2012; Hallfrisch *et al.*, 2003; Mikušová *et al.*, 2014; Wolever *et al.*, 2010; Wood, 2007; Zeković *et al.*, 2005)

The aim of this study was to investigate the effects of DBP and β G supplementation on physical, chemical and sensory characteristics of Turkish noodles (erişte).

2. Materials and methods

Materials

Commercial white wheat flour, whole egg and salt were purchased from local markets from Konya, Turkey. WP, WPC and BP were obtained from ENKA Dairy and Food Products Co. (Konya, Turkey). β G (Barliv™, barley β G>70%) was purchased from Cargill Foods (Istanbul, Turkey).

Experimental design

Three different DBP (WP, WPC and BP) with four ratios (0, 5, 7.5 and 10%) and β G at 0, 3, 5 and 7% ratios were used as factors in the experiments with two replications according to the completely randomised design of (3 $\times$ 4 $\times$ 4) $\times$ 2 factorial plan.

Erişte preparation

Erişte samples were produced according to Yalçın (2005) with some modifications. Control erişte was prepared with 100% wheat flour, 0.5% salt, 30% egg and 16% water. In other erişte samples, WPC, WP, BP (0, 5, 7.5 and 10%) and β G (0, 3, 5 and 7%) were replaced with wheat flour. The amounts of salt (0.5%) and egg (30%) were the same as used in control formulations, but the amount of water was variable (7-21%). The ingredients were mixed with a laboratory type

mixer (Kitchen Aid Artisan Series Mixer; Kitchen Aid, St. Joseph, MI, USA) for 5 min. Erişte dough was divided into three pieces and rested at room temperature for 15 min in polyethylene bags. The dough pieces were sheeted (2 mm thick) and cut with using an erişte machine (Shule Pasta Machine, Xixiashu, China P.R.) as long stripes (5 mm wide). Then the stripes were cut into 4 cm long pieces. Drying took place at ambient conditions for approximately 7 days. The moisture content of end product was not more than 10%.

Chemical analysis

Raw materials and erişte samples were analysed for their moisture (method 44-19), ash (method 08-01), protein (according to Kjeldahl method) (method 46-12) and cellulose (method 32-10) contents by using standard methods (AACC, 2002). While the crude fat contents of the samples and β G were determined by method 30-25 of AACC (2002), for DBP, the Gerber method was used. Phytic acid was measured by a colorimetric method according to Haug and Lantzsch (1983).

For determination of mineral contents, dry samples (1 g) were incinerated with wet digestion method. Concentrated sulphuric acid and hydrogen peroxide were used for this purpose. The solution was diluted to 100 ml with water. The concentrations were determined by inductively-coupled plasma atomic emission spectrometer (Vista series; Varian International AG, Zug, Switzerland).

Colour

The colour of wheat flour, WPC, WP, BP, β G and erişte samples was evaluated by measuring the L* (100 = white; 0 = black), a* (+ = red; - = green) and b* (+ = yellow; - = blue) values using Minolta CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan). For colour measurement, the samples were ground in a blender (Sinbo SCM-2934; Sinbo, Istanbul, Turkey), sieved from 500 μ m opening screen and colour measurement was made on the granulated material in a glass container. The results were reported as average of three readings.

Breaking strength

The breaking strength of uncooked erişte samples was measured by using a texture analyser model TA-XT (Stable Microsystems, Surrey, UK). The samples were sheared with HDP/3PB attachment (Stable Microsystems). The measurement was performed at a crosshead speed of 60 mm/min and load cell of 5 kg. The tests were carried out in duplicate and the average values were reported.

Cooking quality of erişte samples

The weight increase (WI) and volume increase (VI) were determined according to Oh *et al.* (1985) and Özkaya and Kahveci (1990). 10 g erişte sample was boiled in 250 ml distilled water for 18 min and WI was determined by weighing the samples before cooking and after draining and calculated as shown in Equation 1. For VI, dry and cooked erişte samples were placed into a graduated cylinder filled with distilled water and water overflow was measured and calculated as shown in Equation 2. For cooking loss (CL), the cooking water was evaporated to constant weight and total solids were expressed as percentage according to Kahveci and Özkaya (1989).

$$\text{Weight increase (\%)} = \left(\frac{\text{weight (cooked erişte)} - 1}{\text{weight (raw erişte)}} \right) \times 100 \quad (1)$$

$$\text{Volume increase (\%)} = \left(\frac{\text{volume (cooked erişte)} - 1}{\text{volume (raw erişte)}} \right) \times 100 \quad (2)$$

Sensory analysis

The sensory analyses were conducted on the highest addition levels (10%) of all DBP and all levels of β G except 7% that had a negative effect on physical properties of erişte. Sensory analyses were undertaken by 7 panellists. Cooked erişte samples were evaluated in terms of colour, firmness, stickiness, chewiness, taste and odour by using a 7-point hedonic scale with 1 = dislike extremely, 4 = acceptable and 7 = like extremely. For sample preparation, erişte (100 g,

wet basis) was cooked for 18 min in 500 ml boiling water with 2.5 g salt and drained in a colander. The samples on a plate identified by code numbers and served to the panellists under daylight room conditions.

Statistical analyses

JMP 10.0 (SAS Institute Inc., Cary, NC, USA) software was used to perform the statistical analyses. Means that were statistically different from each other were compared by using Student's *t* comparison tests at 5% confidence interval.

3. Results and discussion

Raw material properties

Colour values and chemical properties of wheat flour, WPC, WP, BP and β G are given in Table 1. Ash, protein, fat, cellulose and phytic acid contents of wheat flour were found to be 0.50%, 10.50%, 0.62%, 0.20% and 240 mg/100 g, respectively. In the literature, ash, protein, crude fat, cellulose and phytic acid contents of wheat flour used in erişte production were reported as 0.52%, 10.8%, 0.76%, 0.50% and 130 mg/100 g, respectively (Bilgiçli, 2009). β G had higher *a** value and lower *L** value than the other raw materials probably due to the natural colour of barley (Baik and Ullrich, 2008). Higher ash, protein and fat contents were obtained in WP, WPC and BP respectively. Madenci and Bilgiçli (2014) observed similar values for chemical properties of WPC and BP. Yılmaz *et al.* (2010) reported

Table 1. Colour values and chemical properties of raw materials.¹

Properties	Wheat flour	WPC	WP	BP	β G
Chemical properties					
Moisture (%)	9.36±0.32 ^a	5.97±0.25 ^b	6.17±0.12 ^b	5.45±0.25 ^c	4.42±0.27 ^d
Ash (%)	0.50±0.11 ^d	5.90±0.57 ^b	7.02±0.15 ^a	6.81±0.17 ^a	3.13±0.33 ^c
Protein (%) ²	10.50±1.07 ^c	32.70±0.53 ^a	8.35±0.32 ^d	26.30±0.52 ^b	2.11±0.18 ^e
Fat (%)	0.62±0.18 ^d	1.45±0.16 ^b	1.00±0.33 ^c	8.36±0.20 ^a	0.19±0.08 ^e
Cellulose (%)	0.20±0.03	–	–	–	22.01±2.07
Phytic acid (mg/100 g)	240±6.01	–	–	–	2,683±43.21
Mineral matter					
Ca (mg/100 g)	22.7±4.53 ^e	467.4±3.88 ^b	445.8±5.47 ^c	686.4±5.70 ^a	177.3±0.83 ^d
Mg (mg/100 g)	49.3±1.68 ^e	92.1±0.87 ^d	140.3±2.26 ^b	127.6±1.25 ^c	244.1±4.26 ^a
P (mg/100 g)	230.6±4.13 ^e	660.3±5.35 ^c	562.6±2.30 ^d	871.0±6.75 ^a	836.8±6.05 ^b
K (mg/100 g)	158.3±5.02 ^d	1,158.8±9.29 ^c	1,356.1±9.31 ^b	1,592.6±7.21 ^a	135.7±3.04 ^e
Colour					
<i>L</i> *	96.1±0.11 ^c	98.3±0.06 ^b	99.4±0.01 ^a	96.0±0.23 ^c	83.3±0.91 ^d
<i>a</i> *	-0.57±0.03 ^b	-1.08±0.02 ^c	-3.90±0.06 ^d	-5.27±0.03 ^e	0.69±0.04 ^a
<i>b</i> *	8.27±0.08 ^c	8.25±0.08 ^c	12.93±0.16 ^b	19.80±0.13 ^a	8.41±0.06 ^c

¹ WPC = whey protein concentrate powder, WP = whey powder, BP = buttermilk powder, β G = β -glucan.

² Protein = N × 5.75 for wheat flour and N × 6.25 for other materials.

that the protein, fat and ash contents of BP were 24, 8 and 8.5%, respectively. Cellulose and phytic acid contents of β G were considerably higher than those of wheat flour. With increasing the fibre content in the cereal products, a growing proportion of phytic acid is observed (Havrlentová *et al.*, 2011). Mineral contents of raw materials are also given in Table 1. The mineral contents of WPC, WP, BP and β G were generally higher than those of wheat flour. Among the raw materials, BP was found to be the richest in terms of mineral contents except for Mg. While Ca, P and K contents of BP were found as 686.4, 871 and 1,592.6 mg/100 g, respectively, the highest Mg content (244.1 mg/100 g) was found in β G. In the study conducted by Madenci *et al.* (2012), the Ca, K and P contents of BP were found to be significantly higher than those of wheat flour.

Chemical analyses of erişte samples

Chemical properties of erişte samples are presented in Table 2. Effects of DBP types and DBP ratios on the moisture, ash, protein and fat contents were statistically significant (Table 3). The addition of WPC to erişte samples increased the moisture content as compared to the addition of WP and BP. The highest protein and fat contents were obtained with WPC and BP additions, respectively. Since, the protein and fat contents of WPC and BP were relatively high; increase in protein and fat content with WPC and BP supplementation is an expected result (Table 1). The results presented in this study are in agreement with those reported by Bilgiçli and Temel (2012). As the

DBP addition level increased in erişte formulation, ash, protein and fat contents of erişte samples increased. As compared to control erişte (without DBP), at 10% DBP supplementation level, the ash content increased from 1.17 to 1.83%, the protein content increased from 13.4 to 14.6% and the fat content increased from 3.24 to 3.57%. Baskaran *et al.* (2011a) reported that protein and ash contents of the noodles increased as the supplementation levels of protein source (skim milk powder) increased. From the variance sources, DBP types and DBP ratios did not have a significant effect on the cellulose content but β G ratios significantly ($P<0.01$) affected the cellulose and phytic acid contents of the samples (Table 3). Increasing level of β G supplementation increased the cellulose and phytic acid contents of erişte samples. There is a slight phytic acid loss in erişte samples as compared to the raw materials. Bilgiçli (2014) observed that phytic acid loss in unfermented cereal products (noodle) was found to be lower than in fermented products.

Mineral contents of erişte samples are also given in Table 4. Ca, Mg and P contents of the samples were affected by all variance sources ($P<0.01$) (Table 3). The mineral contents of the samples increased at all DBP addition levels compared to the control samples (without DBP). This increase was 2.46 times in Ca, 1.12 times in Mg, 1.66 times in K and 1.17 times in P for 10% DBP addition level. Ertaş *et al.* (2009) reported that whey concentrate was a good source of minerals and its usage in tarhana increased the mineral contents of tarhana samples. In general, β G also increased

Table 2. Effects of dairy by-products, their addition ratios and β -glucan on chemical properties of erişte samples.^{1,2}

Factors	n	Moisture (%)	Ash (%)	Protein (%) ³	Fat (%)	Cellulose (%)	Phytic acid (mg/100 g)
Dairy by-products types ⁴							
WPC	32	8.80±0.38 ^a	1.49±0.23 ^b	14.8±0.88 ^a	3.26±0.04 ^b	1.07±0.58 ^a	313.4±82.12 ^a
WP	32	8.18±0.57 ^b	1.56±0.29 ^a	13.3±0.25 ^c	3.27±0.06 ^b	1.13±0.51 ^a	314.3±80.04 ^a
BP	32	8.08±0.59 ^b	1.56±0.25 ^a	14.2±0.63 ^b	3.75±0.36 ^a	1.08±0.53 ^a	308.3±79.44 ^a
Dairy by-products ratios (%)							
0	24	9.05±0.32 ^a	1.17±0.06 ^d	13.4±0.25 ^d	3.24±0.05 ^d	1.13±0.50 ^a	334.5±78.12 ^a
5	24	8.38±0.48 ^b	1.49±0.08 ^c	14.1±0.67 ^c	3.39±0.22 ^c	1.04±0.53 ^a	319.4±83.67 ^b
7.5	24	8.03±0.40 ^c	1.66±0.10 ^b	14.3±0.89 ^b	3.51±0.34 ^b	1.11±0.56 ^a	300.9±80.25 ^c
10	24	7.94±0.50 ^c	1.83±0.11 ^a	14.6±1.07 ^a	3.57±0.41 ^a	1.10±0.59 ^a	293.2±75.03 ^d
β -glucan ratios (%)							
0	24	8.23±0.60 ^b	1.44±0.26 ^d	14.4±0.90 ^a	3.42±0.31 ^a	0.38±0.14 ^d	198.5±18.90 ^d
3	24	8.38±0.53 ^a	1.52±0.25 ^c	14.2±0.85 ^b	3.44±0.31 ^a	0.90±0.21 ^c	297.7±13.68 ^c
5	24	8.44±0.59 ^a	1.57±0.25 ^b	14.0±0.88 ^c	3.45±0.33 ^a	1.34±0.14 ^b	341.7±23.50 ^b
7	24	8.35±0.71 ^a	1.62±0.25 ^a	13.8±0.84 ^d	3.40±0.31 ^a	1.76±0.14 ^a	410.1±23.26 ^a

¹ Figures in the same column sharing a common letter are not significantly different at 0.05 level.

² Ash, protein, fat, cellulose and phytic acid contents are on dry matter basis.

³ Protein = N $\times$ 6.25 for noodle samples.

⁴ WPC = whey protein concentrate powder; WP = whey powder; BP = buttermilk powder.

Table 3. Summary of ANOVA results of some properties of erişte samples.¹

Variance source	df	Chemical properties, F-values ²									
		Moisture	Ash	Protein	Fat	Cellulose	Phytic acid	Ca	Mg	K	P
DBP types (A)	2	101.18**	13.225**	652.27**	350.07**	1.464ns	2.239ns	981.12**	5.712**	1,096.61**	436.04**
DBP ratios (B)	3	124.91**	470.16**	222.16**	68.86**	1.416ns	56.605**	8,021.11**	44.505**	8,165.72**	649.12**
(A×B)	6	6.32**	3.01*	84.74**	53.54**	2.459*	0.502ns	160.28**	1.507ns	190.461**	20.243**
β G ratios (C)	3	3.97*	33.51**	60.93**	1.45ns	361.44**	1,282.47**	376.069**	201.13**	0.913ns	486.22**
(A×C)	6	0.42ns	0.165ns	0.29ns	0.58ns	1.140ns	0.809ns	0.673ns	0.344ns	0.035ns	1.543ns
(B×C)	9	1.68ns	0.010ns	0.27ns	0.58ns	0.60ns	1.961ns	1.530ns	0.126ns	0.035ns	0.377ns
(A×B×C)	18	2.47**	0.046ns	0.09ns	0.89ns	1.427ns	0.454ns	1.026ns	0.055ns	0.045ns	0.325ns
Error	48	2.329	0.195	1.326	0.346	1.120	7,066	63.853	266.216	410.44	725.598

Variance Source	df	Cooking quality, F values				Physical properties, F-values		
		WI	VI	CL	Breaking strength	L*	a*	b*
DBP types (A)	2	85.066**	253.572**	692.646**	43.52**	22.76**	651.43**	1,007.72**
DBP ratios (B)	3	46.550**	216.122**	2,054.03**	107.01**	11.33**	1,737.89**	238.36**
(A×B)	6	2.101ns	21.755**	109.465**	11.09**	5.56**	87.78**	157.75**
β G ratios (C)	3	21.086**	189.624**	113.648**	123.64**	9.47**	34.52**	128.60**
(A×C)	6	1.327ns	3.547**	0.371ns	3.23**	0.08ns	0.18ns	0.39ns
(B×C)	9	0.252ns	3.052**	3.799**	2.51*	0.22ns	1.16ns	2.58*
(A×B×C)	18	0.290ns	0.821ns	0.782ns	0.91ns	0.05ns	0.53ns	0.91ns
Error	48	633.35	94.271	0.761	14.797	19.35	0.019	2.813

¹ DBP = dairy by-products; β G = β -glucan; WI = weight increase; VI = volume increase; CL = cooking loss; df = degrees of freedom; L* = lightness; a* = red/greenness; b* = yellow/blueness.
² ** $P < 0.01$; * $P < 0.05$; ns = not significant.

the mineral content of erişte samples except K content. Similar trend was obtained by Choo and Aziz (2010) who reported that incorporation of oat β G into noodles (at 10% level) increased the levels of Ca, Mg, P and K contents. Moreover, this study indicated that oat β G supplementation contributed to the protein, ash and cellulose contents. Enrichment of erişte samples with DBP and β G was found to be suitable in terms of ash, protein and mineral contents.

Colour

The colour values of erişte samples are presented in Table 5. All variance sources had a significant effect on L*, a* and b* values. Compared with WPC and WP supplementation, BP decreased L* and a* values but also the highest b* values were obtained from BP supplemented samples. Increasing level of DBP decreased the a* values but the b* values of erişte samples increased. Kadharmestan *et al.* (1998), reported that the incorporation of both untreated and treated commercial WPC with heat or with high hydrostatic pressure, improved the yellowness (b*) of Cantonese noodle dough. In addition to our findings, β G addition

significantly affected ($P < 0.05$) the a* value of the samples and they became darker (lower L* value) as the amount of β G supplementation was increased. Izydorczyk *et al.* (2005) reported that the addition of fibre-rich fractions derived from roller milling of waxy and high amylose starch hull-less barley genotypes significantly decreased brightness (L*) and increased redness (a*) values of yellow alkaline noodles. In another study, pasta produced with barley flour fraction enriched with β G was found to be darker (lower L score) and less yellowish (lower b score) than the wheat pastas (Knuckles *et al.*, 1997).

Breaking strength

The breaking strength value was used as a measure of firmness for erişte samples. The breaking strength values were affected by all variance sources ($P < 0.01$). The incorporation of BP caused an increase in breaking strength values compared with WPC and WP. DBP supplementation decreased the breaking strength values of the samples at all supplementation levels. Also, the samples prepared with β G were weaker than the control erişte (without β G).

Table 4. Mineral composition (mg/100 g) and cooking properties of erişte samples.^{1,2}

Factors	n	Ca	Mg	K	P	WI (%) ³	VI (%) ³	CL (%) ³
Dairy by-products types ⁴								
WPC	32	58.2±16.65 ^b	65.4±6.83 ^b	243.1±35.19 ^c	295.7±23.34 ^b	92.8±6.56 ^c	125.6±5.91 ^b	5.54±0.94 ^b
WP	32	57.4±16.32 ^c	67.2±6.96 ^a	259.8±47.40 ^b	280.1±18.92 ^c	104.2±6.85 ^a	130.4±6.22 ^a	6.54±1.49 ^a
BP	32	68.8±24.12 ^a	67.0±6.90 ^a	277.3±60.00 ^a	308.8±28.68 ^a	95.6±5.34 ^b	122.6±4.30 ^c	5.51±0.77 ^b
Dairy by-products ratios (%)								
0	24	33.6±3.94 ^d	62.3±3.57 ^d	189.0±2.36 ^d	268.2±16.62 ^d	92.3±5.58 ^d	122.1±5.65 ^d	4.41±0.19 ^d
5	24	58.5±6.06 ^c	66.1±6.44 ^c	251.7±10.80 ^c	291.8±18.84 ^c	95.5±6.51 ^c	124.1±4.27 ^c	5.58±0.41 ^c
7.5	24	70.6±8.04 ^b	67.9±6.31 ^b	284.8±18.93 ^b	304.1±21.05 ^b	98.1±6.23 ^b	126.7±3.59 ^b	6.31±0.68 ^b
10	24	83.1±11.05 ^a	69.8±6.19 ^a	314.8±27.90 ^a	315.4±23.34 ^a	104.3±8.06 ^a	131.8±7.01 ^a	7.16±1.00 ^a
β-glucan ratios (%)								
0	24	55.7±19.50 ^d	57.8±3.41 ^d	260.7±50.80 ^a	273.4±21.41 ^d	93.7±8.34 ^d	121.3±4.21 ^d	5.54±1.12 ^d
3	24	60.2±20.03 ^c	65.0±3.60 ^c	260.3±50.87 ^a	290.5±21.31 ^c	96.1±7.88 ^c	125.0±5.04 ^c	5.75±1.16 ^c
5	24	63.6±19.56 ^b	69.5±3.67 ^b	259.8±51.10 ^a	301.7±23.44 ^b	98.9±6.85 ^b	128.0±6.01 ^b	6.00±1.24 ^b
7	24	66.3±20.02 ^a	73.8±3.40 ^a	259.4±50.84 ^a	313.8±22.67 ^a	101.5±6.53 ^a	130.4±6.32 ^a	6.16±1.25 ^a

¹ Figures in the same column sharing a common letter are not significantly different at 0.05 level.

² Mineral contents are on dry matter basis.

³ WI = weight increase; VI = volume increase; CL = cooking loss.

⁴ WPC = whey protein concentrate powder; WP = whey powder; BP = buttermilk powder.

Table 5. Breaking strength and colour values of erişte samples.¹

Factors	n	Breaking strength (F, kg)	L *	a*	b*
Dairy by-products types ²					
WPC	32	6.14±1.84 ^b	91.3±0.79 ^a	-0.46±0.08 ^a	13.6±0.78 ^b
WP	32	6.27±1.65 ^b	91.3±0.79 ^a	-0.61±0.17 ^b	12.6±0.56 ^c
BP	32	7.32±1.56 ^a	90.3±0.80 ^b	-0.63±0.19 ^c	15.3±1.76 ^a
Dairy by-products ratios (%)					
0	24	8.04±1.61 ^a	90.4±0.38 ^c	-0.33±0.02 ^a	12.8±0.70 ^c
5	24	6.93±1.47 ^b	91.4±0.68 ^a	-0.58±0.07 ^b	13.6±1.23 ^b
7.5	24	6.00±1.26 ^c	91.0±0.98 ^b	-0.65±0.10 ^c	14.5±1.73 ^a
10	24	5.35±1.44 ^d	91.2±1.09 ^{ab}	-0.72±0.13 ^d	14.4±1.93 ^a
β-glucan ratios (%)					
0	24	8.14±1.64 ^a	91.4±0.91 ^a	-0.59±0.17 ^d	14.5±1.44 ^a
3	24	6.93±1.53 ^b	91.1±0.87 ^{ab}	-0.58±0.17 ^c	14.0±1.53 ^b
5	24	6.07±1.32 ^c	90.8±0.80 ^{bc}	-0.56±0.17 ^b	13.5±1.60 ^c
7	24	5.18±0.97 ^d	90.5±0.80 ^c	-0.54±0.17 ^a	13.2±1.60 ^d

¹ Figures in the same column sharing a common letter are not significantly different at 0.05 level.

² WPC = whey protein concentrate powder; WP = whey powder; BP = buttermilk powder.

The effect of 'DBP×βG' interaction on breaking strength value is presented in Figure 1. According to findings of Prabhasankar *et al.* (2007), with increase in WPC from 0 to 10% for enrichment of vermicelli, the sheer force of

vermicelli was decreased (66-45 g). Cleary and Brennan (2006) reported that the addition of a βG fibre fraction from barley to durum wheat pasta increased loss of hardness compared with the control pasta. This effect was due to decreasing amount of gluten with the βG fibre fraction additions. The dilution of gluten resulted in weaker structure of erişte samples.

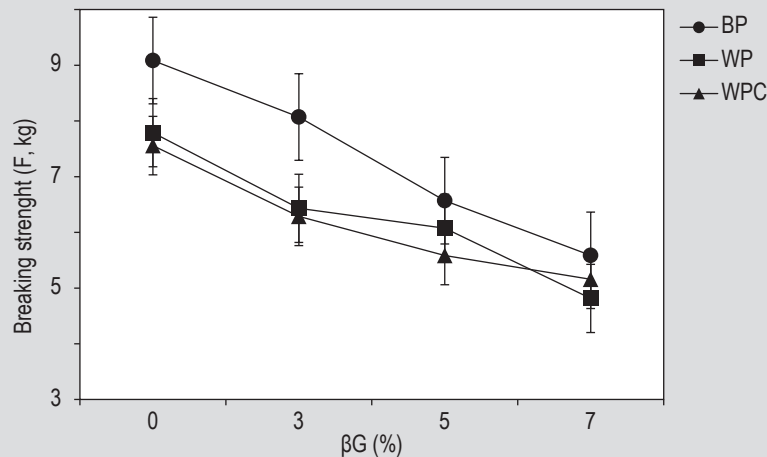


Figure 1. Effect of 'DBP $\times$ β G' interaction on breaking strength value of uncooked erişte samples (BP = buttermilk powder; WP = whey powder; WPC = whey protein concentrate powder; β G = β -glucan; DBP = dairy by-products).

Cooking properties

The cooking properties, WI, VI and CL values of the samples are presented in Table 4. All variance sources had a significant ($P < 0.01$) effect on the WI, VI and CL of the samples. In terms of DBP, the WI varied from 92.8 to 104.2% between samples. The highest level of DBP in the erişte formulation, gave the highest VI, 131.8%. The substitution of β G in erişte formulation increased both WI and VI values from 93.7 and 121.3% to 101.5 and 130.4%, respectively.

CL is an important indicator for predicting spaghetti cooking performance by both consumers and the industry (Tudorică *et al.*, 2002). The difference between CL values of WPC and BP added samples was insignificant ($P > 0.05$) (Table 4) and CL of erişte samples increased with the increasing level of DBP and β G. In the study conducted by Baskaran *et al.* (2011b), using of WPC for enrichment of noodle increased VI, WI values and total solid loss found between 8.14 and 9.86%. In another study, CL increased from 6.15 to 11.84 g/100 g in spaghetti containing 10 g/100 g barley β G concentrate (Chillo *et al.*, 2011). Leaching of more solids into the cooking water might be due to the diluted gluten content and weak or discontinuous protein network (Rayas-Duarte *et al.*, 1996; Resmini and Pagani, 1983).

Sensory analysis

Sensory properties of the cooked erişte samples are presented in Figure 2. The results indicated that significantly higher colour scores were observed at the 5% β G and 10% WPC supplementation level. In literature, it has been reported that whey proteins can be used at optimal levels in foods to improve their colour (Kilara 1994; Yılmaz *et al.*, 2011). Firmness scores of the erişte made with BP were found to be higher than the others at all supplementation

levels of β G. WPC, WP, BP and β G had no statistically significant effect on stickiness rating. Erişte samples containing BP with 3 and 5% β G gave the highest score in terms of chewiness. Compared to the control sample, the taste scores of the erişte samples were found higher for BP at 0 and 5% β G addition levels. Erişte containing BP at all β G substitution levels was the most preferred sample in terms of odour. As a result, the sensory characteristics can be improved with BP, because buttermilk contains more fat and phospholipids content than milk (Sodini *et al.*, 2006).

4. Conclusions

In the present study, the effect of some DBP and their combinations with β G were investigated. DBP addition into erişte formula improved the nutritional value of the samples in terms of ash, protein, fat and mineral (Ca, Mg, K and P) contents. Furthermore, β G supplementation increased ash and mineral contents of the erişte samples except K. The dark colour of β G and yellow colour of BP directly affected the colour of the end products. All additives affected the breaking strength of erişte samples negatively. WI, VI and CL values of the erişte samples increased with the increasing level of both DBP and β G. BP added samples had higher sensory scores than the control samples. As a result, the combination of 10% BP and 3% β G can be used successfully in erişte formulation.

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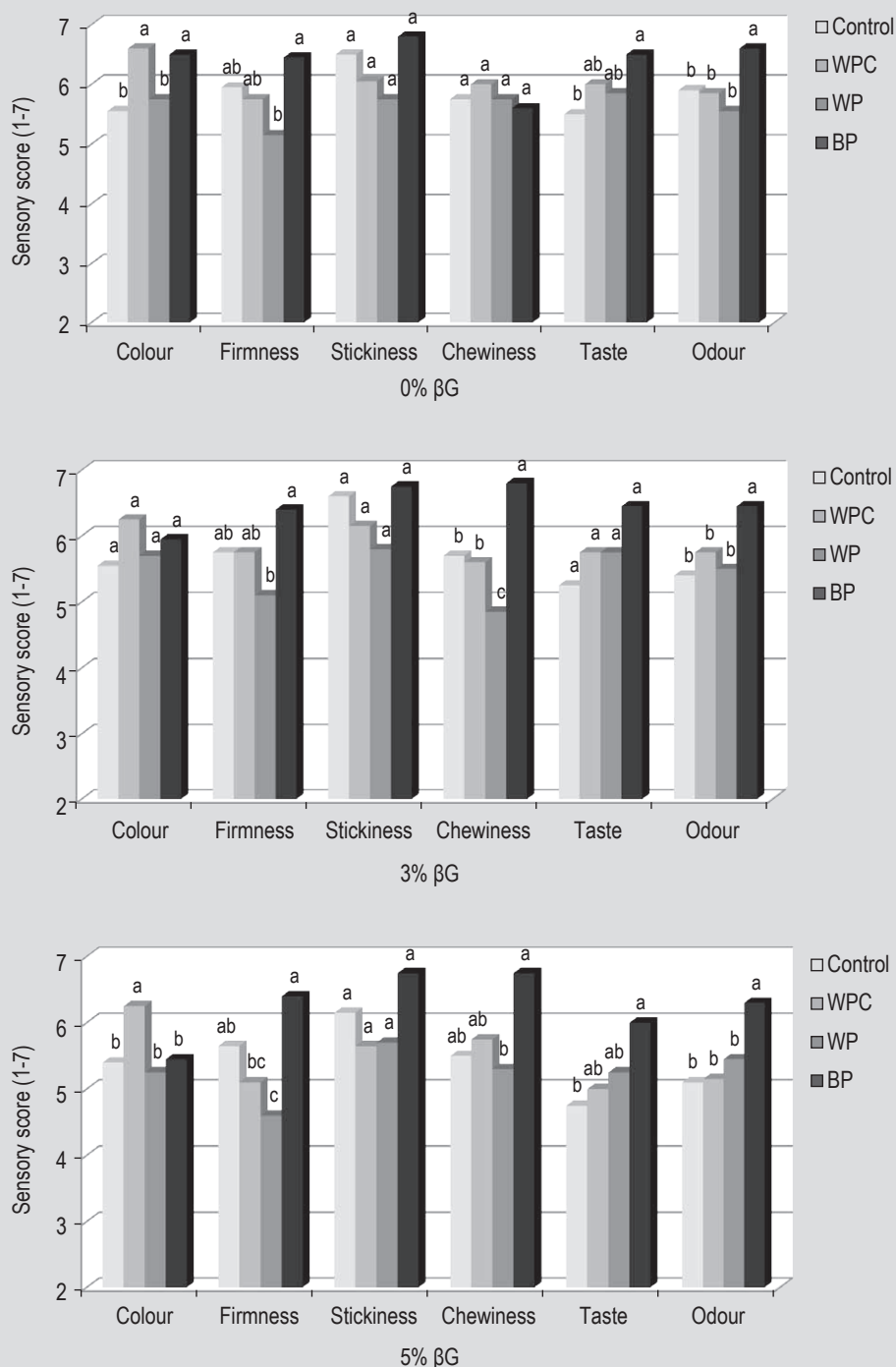


Figure 2. Sensory properties of cooked control (without WPC, WP, BP and β G) and erişte samples containing 10% WPC, 10% WP or 10% BP with 0, 3 or 5% β G (WPC = whey protein concentrate powder; WP = whey powder; BP = buttermilk powder; β G = β -glucan). Columns with different letters are significantly different ($P<0.05$).

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