Influence of wheat germ and β -glucan on some chemical and sensory properties of Turkish noodle

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Abstract Wheat flour used in Turkish noodle (erişte) production was replaced with wheat germ (0, 10, 20 and 30 %) and β -glucan (0 and 4 %). Noodle samples were analyzed for their moisture, ash, protein, fat, mineral contents, color values and sensory properties. Cooking properties as volume increase (VI), weight increase (WI) and cooking loss (CL) were also determined. Wheat germ increased the ash, protein, fat and mineral contents of the noodles. β -glucan had an improving effect especially on Ca, Fe, Mg and P contents of noodle samples. While wheat germ raised VI values of the noodle, β -glucan had a negative effect on VI. The CL of noodle samples varied between 5.8 % and 7.3 %. Decreasing sensory scores obtained at high level of wheat germ with and without β -glucan. The present results showed that wheat germ and β -glucan have a good potential for increasing nutritional quality of noodle.

Research highlights

1. Wheat germ (0, 10, 20 and 30 %) and β -glucan (0 and 4 %) were used in noodle formulation.
2. Wheat germ increased the ash, protein, fat and mineral contents of the noodles.
3. β -glucan especially improved Ca, Fe, Mg and P contents.
4. High level of wheat germ with and without β -glucan decreased sensory scores.
5. Wheat germ and β -glucan have a good potential for increasing nutritional quality of noodle.

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Introduction

Traditional Turkish noodle, erişte, prepared with wheat flour, salt and water. Also egg, milk and other additives can be added into noodle formulation in some part of Turkey. Basically, production process of noodle includes dough mixing, sheeting, pre-drying, cutting and drying (under the sun, at room conditions, in an oven or on a hot pan) stages (Özkaya et al. 2001; Akıllıoğlu and Yalçın 2010). For increasing nutritional/functional value of Turkish noodle and other noodle type products, legume flours, buckwheat, amaranth, lupin, quinoa and apricot kernel flours, wheat germ, some cereal brans, β -glucan and banana flour (Rayas-Duarte et al. 1996; Yokoyama et al. 1997; Ge et al. 2001; Pınarlı et al. 2004; Eyidemiir 2006; Karadeniz 2007; Chillo et al. 2008, 2011; Bilgiçli 2009; Chong and Aziah 2010; Gallegos-Infante et al. 2010; Bilgiçli et al. 2011) have been used.

Wheat germ is a by-product of wheat milling process. It has high nutritive value protein due to high lysine content, and high level unsaturated fatty acids, minerals, free sugar, dietary fiber, α and β -tocopherols, B group vitamins and vitamin E (Shurpaleker and Haridas Rao 1977; Amado and Arrigoni 1992; Zhu et al. 2006; Sidhu et al. 2007). As compared to wheat flour, wheat germ contains approximately 2–3 times as much protein, 7 times as much fat and 15 times as much sugar. Due to its rich composition, wheat germ is immense importance in human nutrition.

β -glucan, cereal non-starch polysaccharides, is predominant cell wall component of barley and oat (Bacic and Stone 1981; Izydorczyk and Biliaderis 1995; Karppinen et al. 2000). The usage of β -glucan imparts valuable health benefits to the foods. It reduces of serum cholesterol and postprandial serum glucose levels, insulin response and also prevents from atherosclerosis

and colon cancer (Karppinen et al. 2000; Brennan and Clearly 2005).

Wheat germ and β -glucan have many important health benefits separately. However there is no information about the usage of wheat germ and β -glucan together in Turkish noodle or noodle type product. Therefore the objective of this study was to determine the suitability of wheat germ and β -glucan for improvement of nutritional quality of noodle.

Material and methods

Material Wheat flour, whole egg and salt were purchased from local markets. Wheat germ was obtained from commercial wheat flour company in Konya. Wheat germ was used after microwave stabilization process and grinding ($<500\ \mu\text{m}$). For this purpose, 2 % (v/w) distilled water was sprayed on wheat germ and the microwave heating was applied on the 3-mm-thick layer of samples in home-type rotating microwave oven (Arçelik-ARMID 2450 Hz, 700 W, Istanbul, Turkey) at 700 W for 5 min. Vital gluten Meelunie, B.V., Amsterdam, Holland) and β -glucan (Cargill, Minneapolis, United States) were used in noodle formulations.

Noodle production Noodle samples were prepared according to the formulation given in Table 1. Wheat flour was replaced with wheat germ (0 %, 10 %, 20 % and 30 %) and β -glucan (0 % and 4 %) for preparing enriched noodle samples. Varied ratios of vital gluten (Table 1) were also used due to reduced gluten content of wheat flour with replacement of wheat germ and β -glucan. The ingredients were mixed in a lab type mixer (Hobart-N 50, Canada) for 8 min. Noodle dough was divided into 50 g pieces and rested for 20 min at room conditions. Dough pieces were sheeted and cutted with using a home-type noodle machine (Shule Pasta Machine, China). Drying was performed at 55 °C in a drier (Nüve FN-500, Ankara, Turkey). The moisture content of dried noodle was maximum 10 %.

Chemical analysis Wheat flour, wheat germ, β -glucan and noodle samples were analyzed for moisture, ash, protein and fat using standard methods (AACC 1990). For determining of

Table 2 Chemical composition and color values of some ingredients used in noodle production¹

	Wheat flour	Wheat germ	β -glucan
Moisture (%)	9.56 $\pm$ 0.04 ^a	3.85 $\pm$ 0.06 ^c	5.03 $\pm$ 0.07 ^b
Ash ² (%)	0.50 $\pm$ 0.01 ^c	4.12 $\pm$ 0.03 ^a	3.02 $\pm$ 0.04 ^b
Protein ² (%)	12.06 $\pm$ 0.14 ^b	26.12 $\pm$ 0.17 ^a	2.23 $\pm$ 0.11 ^c
Fat ² (%)	0.58 $\pm$ 0.25 ^b	8.75 $\pm$ 0.37 ^a	0.25 $\pm$ 0.35 ^b
Minerals ² (mg/100 g)			
Ca	22.74 $\pm$ 0.33 ^c	41.71 $\pm$ 0.51 ^b	177.54 $\pm$ 0.76 ^a
Fe	2.10 $\pm$ 0.14 ^c	6.50 $\pm$ 0.07 ^b	12.75 $\pm$ 0.10 ^a
K	158.40 $\pm$ 0.78 ^b	750.11 $\pm$ 1.29 ^a	135.23 $\pm$ 1.03 ^c
Mg	47.16 $\pm$ 0.72 ^c	220.80 $\pm$ 0.61 ^b	244.06 $\pm$ 0.85 ^a
P	230.99 $\pm$ 1.54 ^c	769.75 $\pm$ 1.06 ^b	836.93 $\pm$ 1.32 ^a
Zn	0.92 $\pm$ 0.11 ^b	12.50 $\pm$ 0.28 ^a	1.19 $\pm$ 0.31 ^b
Color			
L*	99.42 $\pm$ 0.59 ^a	78.32 $\pm$ 0.81 ^c	83.10 $\pm$ 0.78 ^b
a*	-0.55 $\pm$ 0.07 ^c	1.38 $\pm$ 0.18 ^a	0.60 $\pm$ 0.10 ^b
b*	8.16 $\pm$ 0.24 ^c	28.25 $\pm$ 0.21 ^a	9.03 $\pm$ 0.11 ^b

¹ Means with same letter within row are not significantly different ($p<0.05$)

² Results are dry-weight basis.

mineral contents, 0.3 g dried sample was put into burning cup and 5 ml HNO₃+ 5 ml H₂SO₄ were added. The samples were incinerated in a microwave oven (MARS 5, CEM Corporation, USA). The solution was diluted with distilled water to 100 ml. Mineral analyses (Ca, Fe, K, Mg, P and Zn) were determined with an inductively coupled plasma atomic emission spectrometer (ICP-AES, Varian Vista Model, Australia) (Bubert and Hagenah 1987).

Color The color of wheat flour, wheat germ, β -glucan and noodle samples was evaluated by measuring the L*, a* and b* values using Minolta CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan). Values are the mean of five determinations.

Cooking quality of noodle samples Weight increase (WI), volume increase (VI) and cooking loss (CL) values were determined according to Oh et al. (1985) and Özkaya et al. (2001). Ten g noodle samples was cooked in 300 ml distilled

Table 1 The formulation of Turkish noodles

Wheat germ (%)	0	10	20	30
β -glucan (%)	0	4	0	4
Wheat flour	100	96	90	86
Whole egg	30	30	30	30
Salt	0.5	0.5	0.5	0.5
Wheat germ	0	0	10	20
β -glucan	0	4	0	4
Vital gluten	0	0.4	1.0	1.4

Table 3 Effect of wheat germ and β -glucan on chemical properties of noodle samples¹

	β -glucan ratio (%)	Wheat germ ratio (%)			
		0	10	20	30
Moisture (%)	0	8.66±0.50(a,A)	9.00±0.35(a,A)	9.13±0.18(a,A)	9.68±0.36(a,A)
	4	8.96±0.41(a,A)	9.41±0.57(a,A)	9.37±0.52(a,A)	9.63±0.22(a,A)
Ash (%)	0	1.26±0.05(d,A)	1.58±0.04(c,A)	1.89±0.03(b,A)	2.20±0.03(a,A)
	4	1.35±0.03(d,A)	1.70±0.02(c,A)	1.95±0.04(b,A)	2.23±0.04(a,A)
Protein (%)	0	15.84±0.13(d,A)	16.45±0.18(c,A)	18.37±0.17(b,A)	21.70±0.14(a,A)
	4	15.31±0.27(d,A)	16.14±0.08(c,A)	18.20±0.13(b,A)	21.00±0.20(a,A)
Fat (%)	0	3.70±0.14(d,A)	4.80±0.21(c,A)	6.04±0.19(b,A)	7.30±0.23(a,A)
	4	3.62±0.17(d,A)	4.73±0.15(c,A)	5.75±0.17(b,A)	7.60±0.14(a,A)

¹ Means in the same row sharing a common letter in parenthesis and means in the same column sharing a capital letter in parenthesis are not significantly different ($p<0.05$).

water for 18 min. For VI, raw and cooked noodle samples were put into a graduated cylinder with specific amount of distilled water, the increase in the water level was measured. The VI was calculated using the Equation 1. Before and after cooking, noodle samples were measured and the weight increase was calculated using the Equation 2. By drying of cooking water to constant weight at 100 °C, CL, weight of total solids %, was determined.

$$VI (\%) = 100 \times \frac{\text{volume of cooked noodle} - \text{volume of raw noodle}}{\text{volume of raw noodle}} \quad (1)$$

$$WI (\%) = 100 \times \frac{\text{weight of cooked noodle} - \text{weight of raw noodle}}{\text{weight of raw noodle}} \quad (2)$$

Sensory analysis Raw and cooked noodle samples were evaluated by 25 panelists from Food Engineering Department of Selçuk University, Turkey. Panelists scored the raw noodle characteristics (color, appearance, surface smoothness, crack

and overall acceptance) and cooked noodle characteristics (color, appearance, stickiness, taste-odor, mouthfeel and overall acceptance) by using 9 point scale where 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much, 9- like extremely. For sensory evaluation of cooked samples, noodle (100 g, wet basis) was cooked for 18 min in 500 ml boiling water and drained in a colander.

Statistical analyses Statistical analyses were performed using the Statistical software JMP 5.0.1 (SAS Institute, Cary, NC). Means were compared at 5 % confidence interval.

Results and discussion

Chemical compositions and color values of raw materials used in noodle production are presented in Table 2. Ash, protein and fat contents of wheat germ were significantly higher than

Table 4 Effect of wheat germ and β -glucan on mineral composition (mg/100 g) of noodle samples¹

	β -glucan ratio (%)	Wheat germ ratio (%)			
		0	10	20	30
Ca	0	36.75±0.52(c,B)	38.12±0.62(c,B)	41.58±0.33(b,B)	43.42±0.59(a,B)
	4	41.25±0.76(b,A)	42.85±0.48(b,A)	47.06±0.47(a,A)	48.65±0.72(a,A)
Fe	0	1.95±0.16(d,A)	2.35±0.10(c,B)	2.75±0.07(b,B)	3.23±0.03(a,B)
	4	2.31±0.03(d,A)	2.73±0.01(c,A)	3.25±0.13(b,A)	3.71±0.04(a,A)
K	0	207.45±1.42(d,A)	271.22±1.07(c,A)	312.40±1.24(b,A)	388.11±1.40(a,A)
	4	205.42±0.78(d,A)	267.50±0.89(c,A)	313.58±1.13(b,A)	385.49±1.19(a,A)
Mg	0	37.83±0.89(d,B)	55.31±0.65(c,B)	70.18±0.38(b,B)	86.35±0.75(a,B)
	4	43.86±0.48(d,A)	61.19±0.92(c,A)	75.82±0.86(b,A)	92.97±0.69(a,A)
P	0	152.93±1.31(d,B)	204.28±1.81(c,B)	252.18±1.03(b,B)	309.76±2.19(a,B)
	4	172.50±1.53(d,A)	223.50±2.12(c,A)	273.12±1.30(b,A)	330.41±1.78(a,A)
Zn	0	1.08±0.11(d,A)	2.18±0.13(c,A)	3.48±0.10(b,A)	4.56±0.06(a,A)
	4	1.10±0.16(d,A)	2.19±0.08(c,A)	3.50±0.07(b,A)	4.57±0.14(a,A)

¹ Means in the same row sharing a common letter in parenthesis and means in the same column sharing a capital letter in parenthesis are not significantly different ($p<0.05$).

Table 5 Effect of wheat germ and β -glucan on color values of noodle samples¹

	β -glucan ratio (%)	Wheat germ ratio (%)			
		0	10	20	30
L*	0	90.89 $\pm$ 0.52 (a,A)	89.81 $\pm$ 0.79(ab,A)	88.34 $\pm$ 0.31(bc,A)	87.37 $\pm$ 0.52(c,A)
	4	90.58 $\pm$ 0.82(a,A)	89.17 $\pm$ 0.24(b,A)	88.06 $\pm$ 0.37(bc,A)	86.92 $\pm$ 0.24(c,A)
a*	0	-1.19 $\pm$ 0.13(a,A)	-1.42 $\pm$ 0.10(a,A)	-1.42 $\pm$ 0.17(a,A)	-1.36 $\pm$ 0.11(a,A)
	4	-1.23 $\pm$ 0.15 (a,A)	-1.46 $\pm$ 0.18(a,A)	-1.50 $\pm$ 0.14(a,A)	-1.42 $\pm$ 0.16(a,A)
b*	0	15.13 $\pm$ 0.18(d,A)	18.00 $\pm$ 0.70(c,A)	19.47 $\pm$ 0.31(b,A)	21.02 $\pm$ 0.27(a,A)
	4	13.89 $\pm$ 0.24(d,B)	17.37 $\pm$ 0.52(c,A)	19.01 $\pm$ 0.37(b,A)	20.58 $\pm$ 0.28(a,A)

¹ Means in the same row sharing a common letter in parenthesis and means in the same column sharing a capital letter in parenthesis are not significantly different ($p < 0.05$).

those of wheat flour and β -glucan. Our results are in agreement with those reported by Pınarlı et al. (2004) and Bilgiçli et al. (2006). Mineral content of wheat germ were found higher than that of wheat flour. Also, β -glucan has high amounts of Ca, Fe, Mg and P. In the study conducted by Bilgiçli et al. (2006), the Ca, Cu, Fe, K, Mg, Mn, P and Zn contents of wheat germ were found significantly higher than wheat flour. Wheat germ gave lower L* (lightness), higher a* (redness) and higher b* (yellowness) values compared to wheat flour and β -glucan.

Some chemical properties of noodle samples are given in Table 3. Wheat germ and β -glucan addition did not significantly ($p > 0.05$) affect the moisture contents of noodle samples. As the wheat germ level increased in noodle formulation, ash, protein and fat content of noodle samples also increased ($p < 0.05$). Moisture, ash, protein and fat content of noodle samples at the highest level (30 %) of wheat germ (without β -glucan) were found as 9.68 %, 2.20 %, 21.70 and 7.30 %, respectively. β -glucan addition did not significantly ($p > 0.05$) affect the, ash, protein and fat contents of noodle samples. Ge et al. (2001) reported that nutritive noodle with high protein, fat, fiber and mineral content can be produced by using defatted wheat germ in noodle formulation at 15 % level.

Mineral contents of noodle samples are given in Table 4. Wheat germ at all addition levels increased mineral contents of noodle samples except Ca which increased above 10 % addition level of wheat germ. The highest level (30 %) of

wheat germ without β -glucan increased Ca, Fe, K, Mg, P and Zn contents of noodle samples from 36.75 mg/100 g, 1.95 mg/100 g, 207.45 mg/100 g, 37.83 mg/100 g, 152.93 mg/100 g and 1.08 mg/100 g (control without wheat germ and β -glucan) to 43.42 mg/100 g, 3.23 mg/100 g, 388.11 mg/100 g, 86.35 mg/100 g, 309.76 mg/100 g and 4.56 mg/100 g, respectively. Bilgiçli et al. (2006) reported that wheat germ was a good source of minerals as compared to wheat flour, and its usage in tarhana, fermented wheat flour-yoghurt product, increased the mineral contents of tarhana samples. Arshad et al. (2007) found that supplementation of cookies with defatted wheat germ (at 25 % level) significantly increased ($p < 0.05$) the levels of Ca, Fe and K contents. In the present study, β -glucan also increased the Ca, Fe, Mg and P content of noodle samples significantly ($p < 0.05$) compared to sample without β -glucan. As comparing with wheat flour, rich Ca, Fe, Mg and P content of β -glucan may be effective in achieving this result.

The color values of noodle samples are presented in Table 5. Increasing level of wheat germ also increased the darkness and yellowness values of noodle samples. Natural pigmentation of wheat germ affected the color values of end product, noodle. While β -glucan decreased the yellowness values of control samples, this effect of β -glucan on noodle color did not observed in samples prepared with wheat germ due to the intense yellow color of wheat germ. In the study conducted by Knuckles et al. (1997), pasta produced with barley fraction enriched with β -glucan was found to be more

Table 6 Effect of wheat germ and β -glucan on the cooking properties of noodle samples¹

	β -glucan ratio (%)	Wheat germ ratio (%)			
		0	10	20	30
Weight increase (%)	0	127.6 $\pm$ 0.9(a,A)	129.1 $\pm$ 1.5(a,A)	128.4 $\pm$ 1.3(a,A)	126.8 $\pm$ 1.2(a,A)
	4	127.9 $\pm$ 1.9(a,A)	128.3 $\pm$ 1.8(a,A)	127.6 $\pm$ 0.9(a,A)	126.6 $\pm$ 1.2(a,A)
Volume increase (%)	0	144.2 $\pm$ 0.2(d,A)	150.0 $\pm$ 0.6(c,A)	153.4 $\pm$ 0.2(b,A)	154.7 $\pm$ 0.6(a,A)
	4	138.5 $\pm$ 0.7(d,B)	145.0 $\pm$ 0.4(c,B)	148.0 $\pm$ 0.3(b,B)	149.9 $\pm$ 0.5(a,B)
Cooking loss (%)	0	5.9 $\pm$ 0.2(b,A)	6.3 $\pm$ 0.2(b,A)	6.6 $\pm$ 0.5(ab,A)	7.3 $\pm$ 0.4(a,A)
	4	5.8 $\pm$ 0.1(b,A)	6.1 $\pm$ 0.4(b,A)	6.5 $\pm$ 0.3(ab,A)	6.9 $\pm$ 0.3(a,A)

¹ Means in the same row sharing a common letter in parenthesis and means in the same column sharing a capital letter in parenthesis are not significantly different ($p < 0.05$).

Fig. 1 Sensory scores of raw noodle samples

dark (lower L^* values) and less yellow (lower b^* values) than the wheat pasta. Pınarlı et al. (2004) reported that raw and microwaved wheat germ usage at 15 % (w/w) level in macaroni production caused more red and less yellow in color compared to the control sample.

WI, VI and CL of the samples are presented in Table 6. Wheat germ and β -glucan addition did not significantly affected ($p>0.05$) the WI of noodle samples. VI was significantly ($p<0.05$) affected by wheat germ and β -glucan addition, and the highest level of wheat germ in the noodle formulation without β -glucan gave the highest VI value. β -glucan decreased the VI of samples significantly ($p<0.05$) at all addition level of wheat germ. The CL of noodle samples changed between 5.8 % and 7.3 % and the highest value was obtained with 30 % wheat germ addition level. In the study conducted by Pınarlı et al. (2004), wheat germ substituted with semolina for macaroni preparation and the CL was found between 7.8 and 11.6 %. In another study, CL was increased from 6.2 g/100 g to 11.8 g/100 g in spaghetti containing 10 g/100 g barley β -glucan concentrate (Chillo et al. 2011). In the present study, CL value was not found higher level due to the

usage of vital gluten against to gluten diluting effect of wheat germ and β -glucan. Weak or discontinuous protein network causes leaching during cooking (Resmini and Pagani 1983; Rayas-Duarte et al. 1996). Pagani et al. (1986) reported that the protein content and quality are very important for good quality pasta.

Sensory analysis results of raw and cooked noodle samples are presented in Figs 1 and 2. In general, panelists gave higher overall acceptance score to raw control noodle without wheat germ and β -glucan. The incorporation of wheat germ caused to slight decrease in sensory scores of raw noodles. Wheat germ above 20 % addition level with/without β -glucan decreased the all sensory score of cooked noodle compared to control whereas cooked noodle samples at 10 % wheat germ ratio gained highest mouthfeel scores from the panelists. It can be concluded that wheat germ can be used in noodle manufacture up to 20 % levels. Ge et al. (2001) reported that the usage of defatted wheat germ in noodle formulation at 15 % level improves the chewing properties of noodle samples which have also smooth appearance. In the study conducted by Pınarlı et al. (2004) 15 % raw and microwaved wheat germ

Fig. 2 Sensory score of cooked noodle samples

substituted with wheat semolina for macaroni production and also, both types of macaroni gained similar texture and overall score in sensory evaluation.

Conclusion

The effects of wheat germ and β -glucan addition on noodle quality were investigated. The rich composition of wheat germ improved the nutritional value of noodle samples in terms of ash, protein, fat and mineral content. In addition, β -glucan usage especially increased the Ca, Fe, Mg and P contents of noodle samples. Compared to wheat flour, the dark and yellow color of wheat germ directly affected the color of end product. The highest VI and CL were obtained at the highest addition level of wheat germ. The results of this study showed that wheat germ and β -glucan improved nutritional status of noodle, but high addition level of wheat germ with β -glucan had an adverse effect on sensory quality of noodle.

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