

Effect of milled lupin products and transglutaminase on some properties of noodle

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RESEARCH ARTICLE

Abstract

In this study, wheat flour used in Turkish noodle (erişte) production was replaced with lupin flour (10, 20 and 30%) and lupin bran (10, 15 and 20%). Transglutaminase (TG) enzyme was used to improve technological properties of noodle. Some physical, chemical and sensory properties of the noodles were determined. As the lupin flour (LF) or lupin bran (LB) increased in the noodle formulation, water uptake values decreased, and cooking loss increased significantly ($P<0.05$). TG addition decreased the cooking loss values of noodles containing LF/LB. LF improved the nutritional status of noodle in terms of ash, protein and fat content, while significant ($P<0.05$) increase was observed in ash content of noodles prepared using LB. Calcium, copper, iron, magnesium, manganese and zinc content of noodle samples increased between 0.9 and 134 times with LF/LB substitution. Raw and cooked noodle samples with LF incorporated had the highest sensory scores particularly at 10% level.

Keywords: erişte, lupin flour, lupin bran, noodle, transglutaminase

1. Introduction

Lupines (*Lupinus albus* spp.) are members of the family *Leguminosae*. Lupin seeds are a rich source of protein, essential amino acids, fat, dietary fibre and minerals (Erbaş *et al.*, 2005; Faluyi *et al.*, 2000; Huyghe, 1997; Petterson and Mackintosh, 1994). Lupin and its milling products such as lupin flour (LF), and lupin bran (LB) obtained from hull have nutritive and functional components. Composition of LF has been given as 6.99% moisture, 1.85% ash, 38.65% protein, 1.90% cellulose and 12.23% fat by Yarpuz (2011). Lupin proteins have a good solubility, emulsion formation capacity and gel-formation abilities (Kiosseoglou *et al.*, 1999; Pozani *et al.*, 2002). The higher lysine and lower methionine contents in lupins complement well wheat proteins, which are poor in lysine and relatively rich in the sulphur-containing amino acids (Mubarak, 2001). Lupin and its milling products can be used as potential source for the preparation of enriched food stuff and dietetic food (Erickson, 1985; Sujak *et al.*, 2006). LF can be successfully incorporated into products such as fermented foods, pasta, crisps, bread, biscuits and cakes (Dervas *et*

al., 1999; Erbaş *et al.*, 2005). It has been reported that incorporation of LF to semolina improved considerably the protein quality of pasta (Martinez-Villaluenga *et al.*, 2010). Also, it has been reported that as the substitution level of LF in pasta formulation increased, the lysine content of pasta increased, but changes in texture and flavour of the pasta were detected at 15% LF level (Rayas-Duarte *et al.*, 1996). Jayasena *et al.* (2008) found that addition of 20% LF improved the nutritional value of the instant noodle by increasing protein by 42% and dietary fibre by 200%, and LF can be incorporated up to 20% in instant noodles without affecting the sensory properties.

The hull constitutes a considerable part of the lupin seeds (20%) with a high content of dietary fibre and other valuable sources of health promoting ingredients especially antioxidants (Gorecka *et al.*, 2000). Lupin hulls ground into coarse bran which is suitable for use as fibre enrichment of bread, currently used in Australia and in Europe (Sipsas, 2008). The proximate composition of LB has been given as 9% moisture, 10-12% protein, <1% fat, 3-4% ash and 75% dietary fibre in literature (Lupin Foods Australia, 2012). LB

is also a rich source of minerals. Phosphorous, potassium, calcium, magnesium, sodium, copper, iron, manganese and zinc content of LB were 153 mg/100 g, 32.3 mg/100 g, 1,239 mg/100 g, 141 mg/100 g, 79 mg/100 g, 0.3 mg/100 g, 1.63 mg/100 g, 109 mg/100 g and 2.4 mg/100 g, respectively (Yorgancılar *et al.*, 2009).

Transglutaminase (TG) enzyme (protein glutamine γ -glutamyl transferase, EC 2.3.2.13) is known to catalyse the transfer reaction between an amide group in a protein-bound glutamine and ϵ -amino group in a protein-bound lysine side chain, resulting in cross-link between protein molecules (Babiker, 2000; Nonaka *et al.*, 1989). TG has been found to be effective in improving the functional properties of gluten, soy protein and buckwheat protein (Babiker, 2000). The suitability of protein isolates from lupin for enzymatic cross-linking has been reported by Schafer *et al.* (2005). Ionescu *et al.* (2009) also reported that the TG treatment of lupin proteins led to the modification of their gelling and emulsifying properties. TG prevents deterioration in texture after cooking, even when low-grade flours are used in noodle products (Sakamoto *et al.*, 1996). Aalami and Leelavathi (2008) reported that the protein cross-linking reaction catalysed by TG resulted in changes in dry spaghetti quality and cooking quality characteristics of spaghetti. Basman *et al.* (2006) found that TG addition had a significant improving effect on spaghetti quality in terms of lower total organic matter in cooking water and higher sensory scores for firmness, stickiness, and bulkiness when compared with control samples.

The purpose of the present study was to investigate the effect of milled lupin products and TG enzyme on noodle quality.

2. Materials and methods

Materials

Noodle ingredients (wheat flour, egg and salt) were obtained from local markets in Konya, Turkey. Lupin seed were purchased as traditionally debittered from Doğanhisar, Konya, Turkey. Traditional debittering process contains heat treatments at 60-70 °C for 90 min in water and subsequent soaking for 4 days for removing alkaloids. The hulls of the debittered seeds were removed manually and dried below 14% moisture content in an oven, and then milled (<500 μ m) on a hammer mill (Perten-3100; Perten Instruments AB, Huddinge, Sweden). TG enzyme was obtained from AB Enzymes GMBH (Darmstadt, Germany).

Noodle preparation

For Turkish noodle preparation, a modification of the method given by Özkaya *et al.* (2001) was used. Control samples were made with wheat flour (200.0 g), whole egg (40.0 g), salt (1.0 g) and water. While LF was replaced at

levels of 0, 10, 20 and 30% of wheat flours, LB was used at 0, 10, 15 and 20% levels. TG level was 0% and 0.5% in noodle formulations containing LF/LB. Noodle ingredients were mixed in a Hobart mixer (Hobart-N 50; Canada Inc., North York, ON, Canada) for optimum dough development. The dough was rested for 20 min and dough pieces were thinned and then cut into long strips by a noodle machine (Shule Pasta Machine, China). Noodle samples were dried below 10% moisture content at 55 °C.

Cooking quality tests

The water uptake analysis of noodle samples was made according to Oh *et al.* (1985) and Özkaya *et al.* (2001). Water uptake value was calculated by differences of dry and cooked noodle weights. Cooking loss, the weight of total solids expressed as a percentage, was measured by evaporating the noodle cooking water to dryness in an oven, as described by the AACC method (AACC, 1990).

Colour values

Colour of the samples was evaluated by measuring the L* (white/black), a* (red/green) and b* (yellow/blue) values using a Minolta CR-400 (Minolta Camera Co. Ltd., Osaka, Japan) with illuminate D65 as reference. Values are the mean of three determinations.

Chemical analysis

AACC methods were used for determinations of moisture (method 44-19), ash (method 08-01), protein (method 46-12) and fat (method 30-25) contents of the samples (AACC, 1990). For analysing the mineral contents of the raw materials and noodles, the samples were preliminarily digested by means of a closed pressurised system microwave oven (MARS-5™ Cem Corp., Matthews, NC, USA). About 0.3 g of ground sample was put into a burning cup and 10 ml pure HNO₃ and H₂SO₄ were added. The sample was incinerated in a microwave oven and dissolved ash was diluted to a fixed volume with water. Concentrations were determined with an inductively coupled plasma atomic-emission spectrometer (Varian Vista Model, Melbourne, Australia) (Bubert and Hagenah, 1987).

Sensory properties

Raw and cooked noodle samples were subjected to sensory analysis. The sensory analyses were undertaken by 12 panellists. For noodle cooking, 100 g (wet basis) noodle samples were simmered in 500 ml unsalted water for 18 min and drained for remove excess water. Cooked noodles were evaluated on the basis of taste, odour, mouthfeel, texture and overall acceptability. Raw noodles were evaluated in terms of colour, appearance, specks, crackness and overall acceptability using a five-point scale by panellists.

Statistical analysis

The means, which were statistically different from each other, were compared using Duncan's multiple comparison tests at 5% confidence interval. TARIST (version 4.0; Izmir, Turkey) software was used to perform the statistical analyses.

3. Results and discussion

Cooking properties

Cooking properties of noodle samples as water uptake (WU) and cooking loss (CL) are given in Table 1 and 2. As the LF/LB replacement ratio increased in noodle formulation, WU values decreased significantly ($P < 0.05$). Doxastakis *et al.* (2007) reported that high amount of lupin protein incorporation into spaghetti formulation produces a significant decrease in the WU, which becomes dramatic when the incorporation reaches 15 and 20%. But, Jayasena *et al.* (2008) reported that the substitution of wheat flour

Table 1. Cooking properties and colour values of noodle samples prepared with lupin flour (LF)¹.

Properties	TG (%)	Control	10% LF	20% LF	30% LF
Water uptake (%)	0	219±0.71 ^{Aa}	206±0.84 ^{Ba}	203±0.31 ^{Ca}	202±0.42 ^{Ca}
	0.5	212±0.42 ^{Ab}	202±0.71 ^{Bb}	198±0.22 ^{Cb}	197±1.13 ^{Cb}
Cooking loss (%)	0	6.1±0.04 ^{Da}	6.5±0.06 ^{Ca}	6.8±0.04 ^{Ba}	7.2±0.04 ^{Aa}
	0.5	5.8±0.04 ^{Db}	6.2±0.03 ^{Cb}	6.4±0.04 ^{Bb}	7.0±0.06 ^{Ab}
L*	0	89.35±0.49 ^{Aa}	88.41±0.30 ^{Aa}	87.05±0.49 ^{Ba}	86.43±0.31 ^{Ba}
	0.5	90.29±0.41 ^{Aa}	88.83±0.47 ^{ABa}	87.44±0.41 ^{Ba}	86.61±0.28 ^{Ba}
a*	0	0.49±0.13 ^{Aa}	-0.51±0.11 ^{Ba}	-0.86±0.16 ^{BCa}	-1.24±0.20 ^{Ca}
	0.5	0.32±0.17 ^{Aa}	-0.44±0.14 ^{Ba}	-0.79±0.11 ^{BCa}	-0.94±0.16 ^{Ca}
b*	0	14.49±0.40 ^{Da}	21.55±0.37 ^{Ca}	25.25±0.27 ^{Ba}	27.92±0.27 ^{Aa}
	0.5	14.48±0.38 ^{Da}	20.32±0.28 ^{Ca}	23.86±0.23 ^{Ba}	27.40±0.28 ^{Aa}

¹ Duncan's multiple range test. Values in the same row sharing a capital common letter are not significantly different ($P > 0.05$). Values in the same column sharing a common letter are not significantly different ($P > 0.05$).

a* = red/green; b* = yellow/blue; L* = white/black; TG = transglutaminase.

Table 2. Cooking properties and colour values of noodle samples prepared with lupin bran (LB)¹.

Properties	TG (%)	Control	10% LB	15% LB	20% LB
Water uptake (%)	0	220±0.71 ^{Aa}	210±0.57 ^{Ba}	208±0.71 ^{Ba}	204±0.99 ^{Ca}
	0.5	214±0.84 ^{Ab}	207±0.42 ^{Bb}	203±0.71 ^{Cb}	199±0.57 ^{Db}
Cooking loss (%)	0	6.0±0.07 ^{Da}	7.2±0.04 ^{Ca}	7.5±0.06 ^{Ba}	8.3±0.04 ^{Aa}
	0.5	5.7±0.04 ^{Db}	6.8±0.03 ^{Cb}	7.1±0.04 ^{Bb}	8.0±0.04 ^{Ab}
L*	0	89.55±0.32 ^{Aa}	87.02±0.38 ^{Ba}	86.64±0.32 ^{Ba}	86.39±0.28 ^{Ba}
	0.5	90.35±0.19 ^{Aa}	87.30±0.24 ^{Ba}	86.99±0.31 ^{Ba}	87.30±0.25 ^{Ba}
a*	0	0.45±0.08 ^{Ba}	1.35±0.09 ^{ABa}	1.56±0.08 ^{ABa}	1.86±0.08 ^{Aa}
	0.5	0.33±0.07 ^{Ba}	1.26±0.07 ^{ABa}	1.45±0.05 ^{ABa}	1.62±0.09 ^{Aa}
b*	0	14.50±0.28 ^{Ba}	16.34±0.28 ^{Aa}	16.56±0.23 ^{Aa}	16.83±0.25 ^{Aa}
	0.5	14.48±0.21 ^{Ba}	15.60±0.28 ^{Aa}	16.29±0.25 ^{Aa}	16.35±0.33 ^{Aa}

¹ Duncan's multiple range test. Values in the same row sharing a capital common letter are not significantly different ($P > 0.05$). Values in the same column sharing a common letter are not significantly different ($P > 0.05$).

a* = red/green; b* = yellow/blue; L* = white/black; TG = transglutaminase.

with LF in instant noodle formulation had no effect on WU ($P>0.05$).

CL values changed between 6.1 and 7.2% in the samples containing LF (without TG) and between 6.0 and 8.3% in the samples prepared with LB (without TG). Increasing amount of LF/LB in noodle formulation increased CL values significantly ($P<0.05$). Rayas-Duarte *et al.* (1996) reported that CL of spaghetti changed between 7.0 and 8.6% with substitution of wheat flour with 5-30% LF. In another study, CL values were reported as 6.4-7.2% in semolina spaghetti containing 10% LF (Torres *et al.*, 2007). They also reported that the increase in CL in the supplemented pasta compared to control pasta could be a consequence of a weakened gluten network by fortification of LF.

Utilisation of TG enzymes in noodle formulation with and without LF/LB decreased CL significantly ($P<0.05$). Basman *et al.* (2006) reported that TG addition at 0.2 and 0.4% levels caused decreases in total organic matter in cooking water for 30% durum wheat bran supplemented spaghetti. They explained that this decrement by formation of covalent crosslinks catalysed by TG cause reduced amounts of solids released during cooking. Aalami and Leelavathi (2008) reported that CL of spaghetti from low-protein poor variety durum wheat treated with 0.5 and 1.0% TG was slightly lower than that of the control. The enzymatic cross-linking of protein using TG is suitable for improving the techno-functional properties of proteins (Motoki *et al.*, 1984) and rheological properties of gluten (Basman *et al.*, 2002; Köksel *et al.*, 2001). In our study modification of gluten/lupin protein with TG enzyme may cause lower CL values during cooking of noodle samples.

Colour values

Colour values of the samples are summarised in Table 1 and 2. In LF containing noodle, 20-30% LF with and without TG decreased the L^* and a^* values of the noodles significantly compared to the control samples ($P<0.05$). As the LF replacement ratio increased in noodle formulation, b^* values increased significantly ($P<0.05$) due to dominant yellowish colour of LF. Morad *et al.* (1980) reported that the natural colour of the lupin imparted a desirable colour to macaroni.

Yellowness and brightness are correlated both to the pigment concentration and to enzymatic reactions, whereas redness is generally related with the development of non-enzymatic browning reactions (Oliver *et al.*, 1993). The addition of TG did not change colour values of the noodles containing LF. Aalami and Leelavathi (2008) reported that TG treatment decreased the redness of the surface of spaghetti prepared semolina. The decrease in surface redness of spaghetti treated with TG was explained that the result of a limited amount of Maillard reaction due to a decrease in the amount of available lysine because of TG reactions.

In LB supplemented samples, a significant ($P<0.05$) decrease in L^* values were observed compared to control samples without LB (Table 2). Like LF containing samples, b^* values of the noodle samples containing LB showed higher values than control samples. TG enzyme addition into noodle formulation containing LB did not change the L^* , a^* and b^* values of the samples compared to samples without TG (Table 2).

Table 3. Some chemical properties of raw material and noodle samples prepared with lupin flour (LF) or lupin bran (LB) ^{1,2}.

	Moisture (%)	Ash (%)	Protein (%)	Fat (%)
Raw materials				
LF	8.5±0.14 ^b	1.51±0.03 ^b	40.3±0.85 ^a	9.3±0.14 ^a
LB	7.7±0.14 ^c	2.15±0.06 ^a	5.5±0.28 ^c	1.1±0.28 ^b
Wheat flour	10.1±0.14 ^a	0.51±0.03 ^c	12.3±0.28 ^b	0.6±0.07 ^b
Noodle samples				
Control	9.2±0.14 ^b	1.10±0.04 ^f	13.0±0.28 ^d	2.1±0.14 ^d
10% LF	9.0±0.17 ^{bc}	1.17±0.03 ^{ef}	16.5±0.14 ^c	2.9±0.21 ^c
20% LF	8.8±0.08 ^c	1.24±0.03 ^{de}	19.6±0.11 ^b	3.7±0.11 ^b
30% LF	9.2±0.14 ^b	1.32±0.03 ^{bc}	23.3±0.14 ^a	4.5±0.14 ^a
10% LB	9.7±0.11 ^a	1.28±0.01 ^{cd}	11.8±0.17 ^e	2.2±0.07 ^d
15% LB	10.1±0.11 ^a	1.37±0.03 ^{ab}	11.4±0.18 ^e	2.3±0.14 ^d
20% LB	9.9±0.10 ^a	1.49±0.03 ^a	10.9±0.17 ^f	2.3±0.07 ^d

¹ Duncan's multiple range test. Values in the same column sharing a common letter are not significantly different ($P>0.05$).

² Chemical compositions on dry-weight basis.

Chemical properties

Chemical properties of raw materials (LF, LB and wheat flour) and noodle samples prepared with LF/LB addition at different ratios are given in Table 3. Noodle containing LB had higher moisture content than the control samples and samples with LF. Compared to LF and wheat flour, higher ash content of the LB affected the ash content of the final product directly, and the highest ash values obtained with 15-20% LB addition. A significant ($P<0.05$) decrease was observed in protein content of LB added noodles compared to control. LF with 30% addition level increased the protein and fat content of the noodles from 13.0 to 23.3% and from 2.1 to 4.5%, respectively. Higher protein (40.3%) and fat (9.3%) content of LF compared to LB and wheat flour caused these considerable increments in noodle samples. Rayas-Duarte *et al.* (1996) reported that protein and fat content increased from 13.87 to 19.84% and from 0.48 to 2.0% with 30% LF substitution in spaghetti formulation.

Mineral values of the raw materials and noodles are given in Table 4. Similar mineral content for LF and LB have also been reported by Yorgancilar *et al.* (2009). In the majority of cases the addition of LF and LB to the noodles increased significantly ($P<0.05$) the levels of minerals in the samples. This is as expected result due to the levels of these minerals in LF and LB are higher ratio compared to wheat flour. The only decreasing mineral was potassium in all noodle samples containing LF/LB. Low levels of potassium content in LF/LB may be cause this decrement in noodle.

Sensory properties

Sensory properties of raw and cooked noodles are shown in Figure 1. Compared to control samples, all sensory scores of raw noodle decreased over 20% LF level or all addition level of LB. The lowest overall acceptability scores obtained for raw noodle with 20% LB usage (Figure 1A). In cooked noodle samples, 10-20% LF usage gave similar or higher sensory scores compared to control samples (Figure 1B). Jayasena *et al.* (2008) reported that LF can be substituted in instant noodles up to 20% level without any deteriorating effect on its sensory quality. The addition of LB into noodle formulation reduced the all sensory scores in cooked noodles. Basman *et al.* (2006) reported that bran supplementation caused disruption of the protein network by dilution of gluten and had inverse effects on the quality of cereal products.

4. Conclusions

This research has shown that the incorporation of LF up to 20% level in noodle formulation improves the sensory attributes in addition to the nutritional content. Although greater cooking losses occur with LF/LB addition in noodles, these can be reduced by the addition of TG. The use of LB in the noodles also increased the ash and mineral content but with decreased acceptability compared to wheat flour noodles. Thus the addition of milled lupin products, particularly LF up to 20% can successfully be used in the manufacture of noodles with enhanced properties being noted on TG addition.

Table 4. Mineral contents of raw material and noodle samples prepared with lupin flour (LF) or lupin bran (LB) (mg/100 g)^{1,2}.

	Calcium	Copper	Iron	Potassium	Magnesium	Manganese	Zinc
Raw materials							
LF	366.2±1.70 ^b	1.39±0.06 ^a	4.62±0.04 ^a	40.7±0.57 ^c	92.7±0.07 ^b	140.5±0.11 ^a	4.57±0.17 ^a
LB	742.3±1.84 ^a	0.81±0.06 ^b	3.88±0.04 ^b	112.4±0.44 ^b	135.9±0.14 ^a	90.4±0.14 ^b	1.39±0.06 ^b
Wheat flour	22.1±1.56 ^c	0.37±0.03 ^c	1.35±0.03 ^c	185.3±0.33 ^a	30.7±0.10 ^c	0.4±0.03 ^c	1.19±0.06 ^b
Noodle samples							
Control	41.1±0.99 ^g	0.51±0.06 ^c	1.33±0.04 ^f	256.4±0.57 ^a	39.1±0.14 ^g	0.3±0.07 ^g	1.85±0.07 ^c
10% LF	63.2±0.85 ^f	0.58±0.04 ^{bc}	1.64±0.03 ^d	243.7±0.57 ^d	43.1±0.14 ^f	13.3±0.10 ^d	2.12±0.07 ^b
20% LF	85.2±1.13 ^e	0.69±0.06 ^{ab}	1.94±0.04 ^b	231.5±0.42 ^f	47.2±0.28 ^c	27.3±0.06 ^b	2.41±0.08 ^a
30% LF	106.3±0.99 ^c	0.77±0.06 ^a	2.23±0.03 ^a	218.9±0.99 ^g	51.1±0.18 ^a	40.2±0.07 ^a	2.69±0.08 ^a
10% LB	92.3±1.13 ^d	0.53±0.04 ^c	1.51±0.03 ^e	248.7±0.57 ^b	43.6±0.03 ^e	8.5±0.11 ^f	1.88±0.04 ^c
15% LB	121.7±0.85 ^b	0.55±0.04 ^c	1.63±0.03 ^d	245.5±0.42 ^c	45.8±0.14 ^d	11.5±0.07 ^e	1.91±0.06 ^c
20% LB	152.3±0.99 ^a	0.58±0.03 ^{bc}	1.79±0.02 ^c	242.6±0.57 ^e	48.2±0.16 ^b	14.7±0.08 ^c	1.93±0.04 ^c

1 Duncan's multiple range test. Values in the same column sharing a common letter are not significantly different ($P>0.05$).

2 Mineral values on dry-weight basis.

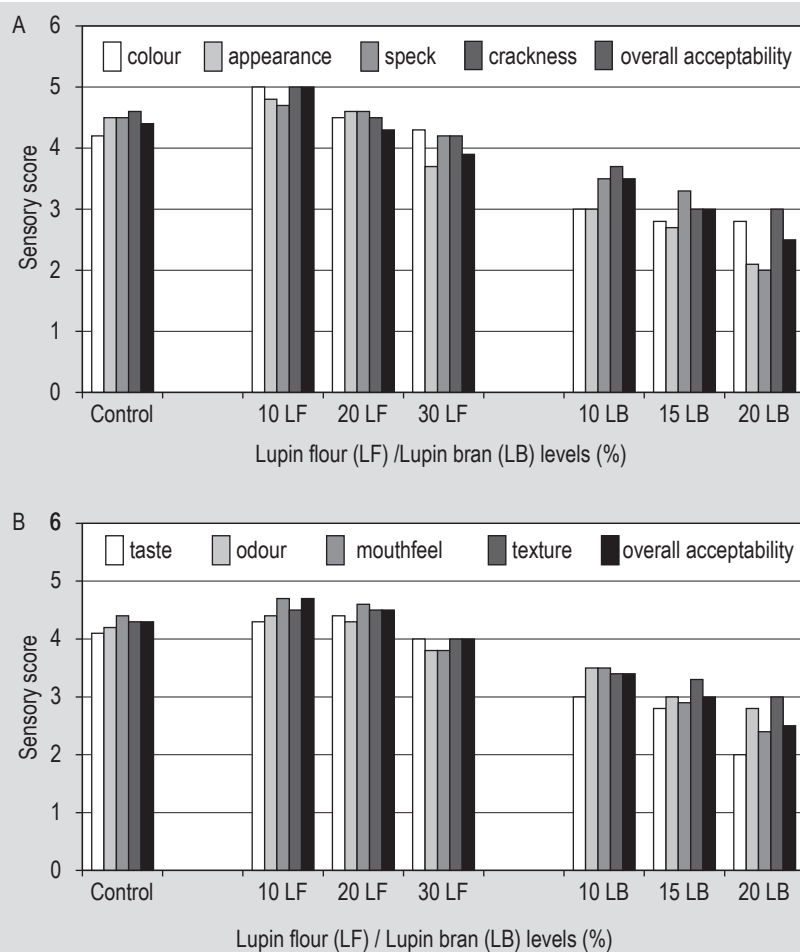


Figure 1. Sensory properties of (A) raw and (B) cooked noodles in which wheat flour was replaced with lupin flour (LF; 10, 20 or 30%) or lupin bran (LB; 10, 15 or 20%).

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