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Original Article

Production of high protein quality noodles using wheat flour fortified with different protein products from lupine

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Abstract Physicochemical, cooking quality and sensory characteristics of noodles fortified by whole lupine meal (WLM) and defatted lupine meal (DLM) as different protein products were evaluated. Optimum cooking time significantly decreased with increasing the replacement levels. The prepared noodles contained 10% WLM or DLM had swelling indices similar to that in the control sample. The higher cooking yield was observed in prepared noodles using 20% WLM or DLM. The cooking loss was improved when using DLM with significant ($p < 0.05$) lower values at all replacement levels than that in control sample. Used the WLM and DLM at levels 5% and 10%, respectively gave low nitrogen loss values. Calculated protein efficiency ratio, proportion of essential amino acid to the total amino acids, essential amino acid index, biological value, chemical score and limiting amino acid were improved. The received scores from sensory evaluation showed that WLM or DLM noodles at levels 5–10% or 5–20%, respectively had higher flavor and overall acceptability values with non-significant ($p > 0.05$) differences compared to the control sample.

Introduction

Noodles are very popular wheat foods made from common wheat flour, water and some additives (Sui et al., 2006). During the last 20 years, the annual consumption of pasta products has increased because of consumers changing perception of pasta. Noodles contain 11–15% protein (dry basis) but is deficient in lysine and therionine (the first and second limiting amino acid), common to most cereal products. A growing demand for functional plant proteins could be identified, which properties are customized for specific applications and formulations as food ingredients (Wäsche et al., 2001). Consequently, legumes and cereals are nutritionally complementary (Duranti, 2006).

Lupine is one of the most important crops in the world because of its nutritional quality. Seeds of various species of lupines have been used as food for over 3000 years around the Mediterranean (Longnecker et al., 1998). It is rich source of protein, complex carbohydrates, vitamins and minerals (Molina et al., 2002; Wang et al., 2010). Legumes have shown numerous health benefits (Chillo et al., 2008). Lupine (*Lupines albus*), a member of the legume family, is a pea like plant cultivated all over the world (Postglione, 1983). Lupines are highly

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valued as animal feed but have been underutilized as human food yet. The seeds are a source of protein (33–47%) and oil (6–13%). There are also claims that the seeds are rich in dietary fiber and beneficial phytochemicals. Lupines are now receiving national and international interest as a future source of food ingredients that could be used to enhance the nutritional profile of existing food product. Years of selective breeding have resulted in a lupine strain (sweet lupine) that is pleasing to the palate and contains fewer alkaloids than previous strains. Sweet lupine protein or flour has been suggested for use in bread, cookies and milk substitutes (Ivanovic et al., 1983).

The aim of this study was to produce protein-fortified noodles by using WLM and DLM as a different nontraditional protein products. The wheat flour incorporated with different levels of protein products. The effect of replacement levels on noodle nutritional parameters, cooking quality and sensory characteristics were determined.

Materials and methods

Materials

Wheat flour, sweet lupine seeds were purchased from the local market.

Methods

Preparation of whole meal

Whole milled lupine seeds were prepared by grinding in Kenwood (BL 335) grinder until the milled grains could pass through a 300 μm sieve (Laboratory Test Sieve, ENDECOTTS Ltd., London, ENGLAND).

Preparation of defatted meal

The whole milled lupine was defatted according to the procedure reported by Dervas et al. (1999) using hexane (1:4 w/v). The slurry was kept with periodical stirring for 45 min, at ambient temperature and the hexane with fat was decanted. The fat extraction was repeated twice and the defatted lupine product was desolventized in an air stream.

Noodles preparation

Noodle control sample was prepared using 100% wheat flour. Experimental samples were prepared by replacement a portion of the wheat flour with equivalent portions of lupine product (whole meal or defatted meal). The replacement levels were 5%, 10%, 15%, 20% and 25% based on solid contents. Noodles dough's were prepared according to the procedure reported by Collins and Pangloli (1997) using 600 g flour. All dry ingredients (wheat flour and lupine whole meal or defatted meal) were combined and mixed to produce homogenize mixture. The mixture was placed in a mixing bowl and mixed with tap water until the dough formed. The total moisture content in the dough was 31%. The dough was rounded (shaped into a ball), covered with plastic wrap, allowed to rest 30 min, hand-kneaded for 1 min, divided into approximately 100-g portions and sheeted using pasta machine (ATLAS 150 WELL.AS.P, Italy) by rolling at position one and repeated at position three. Thereafter, the sheet of dough was passed through a hand-operated pasta machine. The dough was cut into strips 5 mm wide, hung on rods and air dried at 23–25 °C for 4 h. The air-dried noodles were transferred to a cabinet dehydrator and dried to moisture content about 7% at 70 °C. Cooled to room temperature, packaged in plastic bags, sealed the plastic bags and stored at 12–14 °C until tested.

Analysis of wheat flour, lupine products and noodle

Moisture, ash and protein (N × 5.7) were carried out according to the (American Association of Cereal Chemists (AACC), 2000).

Noodle cooking quality

Noodle cooking quality was determined according to the approved method in American Association of Cereal Chemists (AACC), (2000). Optimum cooking time was the time required for the opaque central core of the noodle to disappear when squeezed gently between two glass plates after cooking. Twenty-five grams of noodle was cooked to optimum time in 300 ml tap water in a beaker, rinsed in cold water, and drained for 15 min before weighed. Percentage of increased weight was calculated as a cooking yield. Solids content in the cooking water was determined by drying at 105 °C overnight. The cooking loss was expressed as percentage between the solid weight and initial dry matter. To calculate the swelling index the water displacement of cooked noodle was divided on the water displacement of an equivalent amount of uncooked noodle. The nitrogen loss was determined according to the approved Kjeldahl method in American Association of Cereal Chemists (AACC), (2000).

Amino acids composition

Amino acids of the samples were determined in central laboratory, College of Agriculture and Food Sciences, King Faisal University according to the method reported in the Amino Acid Analyzer (LC 3000, USA) catalog.

Nutritional parameters

The proportion of essential amino acids (E) to the total amino acids (T) of the protein sample was calculated using (Chavan et al., 2001) equation as below:

$$\frac{E}{T}(\%) = \frac{\mathrm{Ilu + Leu + Lys + Met + Cys + Phe + Tyr + Thr + Val + His}}{\mathrm{Ala + Asp + Arg + Gly + Glu + Ile + Leu + Lys + Met + Cys + Phe + Tyr + Pro + Ser + Thr + Val + His}} \times 100$$

The predicted of calculated protein efficiency ratio (C-PER) values were calculated from their amino acid composition based on the equation developed by Alsmeyer et al. (1974), as given below:

$$\text{C-PER} = -1.816 + 0.435(\mathrm{Met}) + 0.780(\mathrm{Leu}) + 0.211(\mathrm{His}) - 0.944(\mathrm{Tyr})$$

Essential amino acid index (EAAI) in relation to amino acid requirements of whole egg protein (Valine, 6.6; Methionine + Cystine, 5.7; Isoleucine, 5.4; leucine, 8.6; Phenylalanine +

Tyrosine, 9.3; Lysine, 7.0; Threonine, 4.7) (Shils et al., 1998) was determined as described by Oser (1959) as follows:

$$EAAI = \sqrt[n]{(Ilu.P/Ilu.S) \times (Leu.P/Leu.S) \times \cdots \times (Phe. + Tyr.P/Phe. + Tyr.S)} \times 100$$

where P, refers to the sample protein and S, refers to the standard protein.

Biological value (BV) was calculated according to the following equation as described by Oser (1959):

$$BV = (1.09 \times EAAI) - 11.73$$

Chemical score (CS) was calculated using the standard of amino acid requirement for an adult human (FAO/WHO/UNU, 1985) according to the follows equation:

$$CS = \left(\frac{Ai}{As}\right) \times 100$$

where Ai, the amino acid in sample and As, the amino acid in standard.

Sensory evaluation

Quality attributes of prepared noodles were evaluated by ten members reference taste panel from staff of Department of Food and Nutrition Sciences, College of Agriculture and Food Sciences, King Faisal University according to the method reported by Inglett et al. (2005). Color, texture, flavor and overall acceptability were evaluating according the 1–9 hedonic scale. The scale had verbally anchored with nine categories, as follows: like extremely, like very much, like moderately, like slightly, neither like or dislike, dislike slightly, dislike moderately, dislike very much, and dislike extremely. Quality attributes of noodles prepared using lupine protein products were evaluated in comparison with the control sample, which prepared from 100% wheat flour.

Statistical analysis

Analysis of variance was used to compare between means by Duncan multiple range at significance 5%. Means with different letters are significantly different. ANOVA was carried out by Statistical Analysis System (SAS Program, 1996).

Results and discussion

Physicochemical characteristics

Proximate analysis of major constituents i.e., moisture, crude protein, fat and ash in wheat flour, WLM and defatted lupine meal are presented in Table 1. The moisture content in wheat flour was 13.52% while, it is percent was significantly ($p < 0.05$) lower in WLM and defatted lupine meal being 6.87% and 6.90%, respectively. The data referred to a high lipid content in WLM (8.56%) while, the wheat flour and DLM significantly ($p < 0.05$) had the lowest lipid content being 0.49% and 0.56%, respectively. The decrease of lipid content in defatted lupine meal was due to the lipid extraction from WLM. The protein content in WLM 35.20% was significantly ($p < 0.05$) higher than that in wheat flour (11.36%). The protein content in defatted lupine meal increased versus extraction of fat from the whole meal, reaching 38.40% with non-significant difference ($p > 0.05$) with that of the WLM. Wheat flour had significantly ($p < 0.05$) the lowest ash content compared to that in WLM and DLM. On the other hand, the DLM had the highest ash content. These obtained results are agreed with (Doxastakis et al., 2002).

Table 1 Physicochemical characteristics of wheat flour, WLM and DLM.

Character (%)	Wheat flour	WLM	DLM
Moisture	13.52^{A}	6.87^{B}	6.90^{B}
Lipid	0.49^{B}	8.56^{A}	0.56^{B}
Protein	11.36^{B}	35.20^{A}	38.40^{A}
Ash	0.57^{C}	3.55^{B}	3.88^{A}
WBC	113.01^{C}	256.63^{B}	261.81^{A}
OBC	128.34^{B}	110.85^{C}	151.35^{A}

Means in the same raw with different capital letters are significantly different ($p < 0.05$).
WBC, water binding capacity; OBC, oil binding capacity.

Both water and oil binding capacity increased with increasing the protein content. The highest water and oil binding capacity values were observed in DLM. Whereas, the WLM and wheat flour came in the second and third order with significant difference ($p < 0.05$).

Kinsella, 1979 reported that the carbohydrate and other components present in flours might impair the water binding. The presence of several non-polar side chains may bind the hydrocarbon chains of fats, thereby resulting in higher absorption of oil (Sathe et al., 1982). Proteins forming a three-dimensional network structure to produce a matrix capable of holding significant amounts of water (Cano and Ancos, 2005).

Optimum cooking time

The optimum cooking times for examined noodles are reported in Table 2. From this table it emerged that the optimum cooking time of noodles was longer for the control sample than for the prepared noodles using WLM or DLM. The optimum cooking time decreased significantly ($p < 0.05$) with increasing the WLM level reached to the minimum cooking time (10.05 min) at level 25%. The cooking time for WLM noodles ranged between 10.60 and 10.15 min. at level ranged between 5% and

Table 2 Optimum cooking time (min.) of noodles prepared using wheat flour supplemented with WLM or DLM at different levels.

Supplementation (%)		WLM	DLM
Wheat flour	Lupine sources		
100	0	$10.70^{a\ A}$	$10.70^{a\ A}$
95	5	$10.60^{ab\ A}$	$10.65_{ab\ A}$
90	10	$10.60^{ab\ A}$	$10.35^{bc\ A}$
85	15	$10.30^{ab\ A}$	$10.30_{c\ A}$
80	20	$10.15^{ab\ A}$	$10.15^{cd\ A}$
75	25	$10.05^{b\ A}$	$9.85^{d\ A}$

Means in the same column with different small letters are significantly different ($p < 0.05$).
Means in the same raw with different capital letters are significantly different ($p < 0.05$).

20% with non-significant difference ($p > 0.05$) compared to the control sample.

On the other hand, the same cooking time trend was observed for the DLM noodles with non-significant differences ($p > 0.05$) compared to the WLM noodles. Non-significant deference in cooking time was observed between the noodle prepared using 5% DLM and the control sample. After that, increasing the replacement level lead to decrease the cooking time till arrived the minimum cooking time being 9.85 min. for the prepared noodle using 25% DLM.

The obtained results were in accordance with (Chillo et al., 2008, 2008) whom found that the optimum cooking time of durum spaghetti was longer than for spaghetti in base quinoa, broad bean and chickpea flours.

Swelling index

The obtained results in Table 3 presents the swelling index for the different prepared noodle samples using WLM and DLM. Generally, the prepared noodles using DLM had swelling index significantly ($p < 0.05$) higher than those samples prepared using WLM. The prepared noodles using 5% and 10% WLM had higher swelling index values (271% and 256%) with non-significant difference ($p > 0.05$) compared to the control sample. The swelling index values for noodle prepared using the levels of 15% or 20% and 25% WLM came in the second and third order, respectively with significant differences ($p < 0.05$). On the other hand, used the DLM at the level of 5% in preparation of noodle gave the highest swelling index value (302%) with significant difference ($p < 0.05$) compared to all noodles and the control sample that had a swelling value 261%. The sample was prepared using 10% DLM gave a swelling index value 266% which came in the second order with non-significant difference ($p > 0.05$) with the control sample. Increased the DLM supplementation in prepared noodles more than 15% performed to decreased significantly ($p < 0.05$) the swelling index values. Several authors reported that the water absorption capacity depend on the behavior of the proteins denaturation and the function of the amylose/amylopectin ratio as well as the chain length distribution of amylopectin (Enwere et al., 1998; Granito et al., 2004; Köber et al., 2007).

Table 3 Swelling index (%) of noodles prepared using wheat flour supplemented with WLM or DLM at different levels.

Supplementation (%)		WLM	DLM
Wheat flour	Lupine sources		
100	0	$261^{a\ A}$	$261^{b\ A}$
95	5	$271^{a\ B}$	$302^{a\ A}$
90	10	$256^{a\ A}$	$266^{b\ A}$
85	15	$233^{b\ A}$	$248^{c\ A}$
80	20	$219^{b\ A}$	$238^{d\ A}$
75	25	$199^{c\ B}$	$226^{e\ A}$

Means in the same column with different small letters are significantly different ($p < 0.05$).
Means in the same raw with different capital letters are significantly different ($p < 0.05$).

Table 4 Cooking yield (%) of noodles prepared using wheat flour supplemented with WLM or DLM at different levels.

Supplementation (%)		WLM	DLM
Wheat flour	Lupine sources		
100	0	$207^{bc\ A}$	$207^{d\ A}$
95	5	$218^{a\ B}$	$252^{a\ A}$
90	10	$217^{a\ B}$	$238^{b\ A}$
85	15	$211^{b\ B}$	$231^{c\ A}$
80	20	$205^{c\ B}$	$229^{c\ A}$
75	25	$180^{d\ B}$	$199^{e\ A}$

Means in the same column with different small letters are significantly different ($p < 0.05$).
Means in the same raw with different capital letters are significantly different ($p < 0.05$).

Cooking yield

The obtained cooking yield values are presented in Table 4. Generally, WLM or DLM at the studied levels in prepared noodles lead to produce noodles with cooking yield values higher than that of sample prepared using 100% wheat flour. The prepared noodles using 5% or 10% WLM had significantly ($p < 0.05$) the highest cooking yield values compared to the control sample. Increased the replacement level to 20% gave noodle with cooking yield 205% with non-significant ($p > 0.05$) difference with that of the control sample (207%). Baiano et al., 2006 found that with increasing the bean flour more than 15% in prepared pasta the water absorption decreased. On the other hand, used the DLM in noodles preparation produced noodles with cooking yield values significantly ($p < 0.05$) higher than those prepared by WLM. On the other hand, prepared noodle using 5% DLM had the highest cooking yield value being 252%. The prepared noodle using 10% and those prepared using 15% or 20% DLM significantly ($p < 0.05$) became in the second and third orders with values 238%; 231% and 229%, respectively. While, the wheat flour noodle became in the fourth order with cooking yield value 207%. The obtained data agreed with the water binding capacity data presented in Table 1. However, the water binding capacity in WLM and DLM were significantly higher than that value for the wheat flour. These increases were due to the high protein content in the prepared lupine protein products.

Cooking loss

Cooking loss defined as a weight of the total solids lost in the cooking water. The obtained cooking loss data for prepared noodles using WLM or DLM are presented in Table 5. Replacement of wheat flour by 5% and 10% WLM significantly ($p < 0.05$) decreased the cooking loss to its minimum values being 5.30% and 5.45%, respectively compared to the control sample (5.85%). The noodle sample prepared using 15% WLM had the same cooking loss of the control sample. The highest cooking loss values were observed when the replacement levels with increased to 20% and 25%.

Concerning, the obtained cooking loss of the DLM noodles, its values were significantly ($p < 0.05$) lower than those obtained from the control sample and prepared noodles using WLM at all replacement levels ranging between 4.75% and

Table 5 Cooking loss (%) of noodles prepared using wheat flour supplemented with WLM or DLM at different levels.

Supplementation (%)		WLM	DLM
Wheat flour	Lupine sources		
100	0	5.85$^{c\ A}$	5.85$^{a\ A}$
95	5	5.30$^{d\ A}$	4.75$^{d\ B}$
90	10	5.45$^{d\ A}$	4.85$^{d\ B}$
85	15	5.85$^{c\ A}$	5.45$^{c\ B}$
80	20	6.25$^{b\ A}$	5.50b$^{c\ B}$
75	25	6.70$^{a\ A}$	5.65$^{b\ B}$

Means in the same column with different small letters are significantly different ($p < 0.05$).
Means in the same raw with different capital letters are significantly different ($p < 0.05$).

5.65%. The lowest cooking losses were observed at replacement levels of 5% and 10%. (Bergman et al., 1994) reported that the higher protein content in the noodles made from soft wheat flour and cowpea compared to soft wheat flour, might have provided a superior framework of denaturated protein that was better able to trap starch molecules, preventing their loss during cooking and thus ultimately decreasing cooking loss.

Nitrogen loss

The nitrogen loss values of prepared noodles using WLM or DLM are shown in Table 6. It could be noticed that the loss of nitrogen depends on the replacement level. Worth mentioning, the addition of WLM up to 5% to wheat flour during the preparation of noodles lead to keep the nitrogen loss at 3.30% with non-significant difference ($p > 0.05$) compared to that of the control sample, which was prepared using 100% wheat flour (3.33%). In addition, the higher replacement levels which used in prepared noodles were the main factor for raising the nitrogen loss. Nitrogen loss was gradually increased ranging between 3.65% and 5.20% for noodles prepared using WLM at levels ranged between 10% and 25%. The nitrogen losses for prepared noodles using DLM were lower than those in noodles prepared using WLM. Also, with increasing the DLM replacement in prepared noodles the nitrogen loss was gradually increased from 3.05% to 4.80% for prepared noodles using replacement levels from 5% to 25%, respectively. During cooking, a weak or discontinuous protein matrix results in a protein network that is too loose and permits a greater amount of exudate to escape during starch granule gelatinization (Skrabanja and Kreft, 1998; Resmini and Pagani, 1983).

Table 6 Nitrogen loss (%) of noodles prepared using wheat flour supplemented with WLM or DLM at different levels.

Supplementation (%)		WLM	DLM
Wheat flour	Lupine sources		
100	0	3.33$^{e\ A}$	3.33$^{d\ A}$
95	5	3.30$^{e\ A}$	3.05$^{e\ B}$
90	10	3.65$^{d\ A}$	3.45$^{d\ B}$
85	15	4.15$^{c\ A}$	4.05$^{c\ B}$
80	20	4.65$^{b\ A}$	4.40$^{b\ B}$
75	25	5.20$^{a\ A}$	4.80$^{a\ B}$

Means in the same column with different small letters are significantly different ($p < 0.05$).
Means in the same raw with different capital letters are significantly different ($p < 0.05$).

Nutritional quality

Nutritional quality of protein depends on its essential amino acid (EAA). The nutritive value of plant proteins is known to be lower than that of animal protein. It is possible to improve the protein nutritional quality parameters as protein efficiency ratio (PER), essential amino acids/total amino acids ratio (E/T%), essential amino acid index (EAAI), biological value (BV), chemical score and limiting amino acid (LAA) by protein preparations replacement.

Essential amino acid (gm/100 gm^{-1} protein), C-PER, E/T, EAAI, BV and LAA of wheat flour, lupine proteins and their mixtures are presented in Table 7. Mixing wheat flour with WLM or DLM improved the amino acid profile specially lysine and threonine, they increased from 2.01 and 2.96 gm/100 gm protein to 3.88 and 3.42 gm/100 gm protein, respectively at replacement level of 25%. Also, aspartic, alanine, arginine, glycine were increased. According to the previous presented data, it could be noticed that, the total essential amino acids increased with increasing the replacement level and decreasing the total non-essential amino acids percentage. Amino acids levels were in the range of those reported in the literatures (El-Dash and Sgarbieri, 1980; Martínez-Villaluenga et al., 2010)

C-PER was increased to arrive the maximum value of 2.4 in the mixture of 75% wheat and 25% lupine protein. Wheat protein had the lowest C-PER with value of 1.2. EAAI was enhanced with the different lupine replacement level. It ranged between, 65.5 in wheat flour protein to 69.3 in wheat flour lupine protein mixture at the maximum replacement level. In addition, the BV increased from 59.7 in wheat flour to values ranged between 61.4 and 63.8 in the final mixing formulas.

Moreover, higher lysine content was associated with increases in the biological value (Lampart-Szczapa et al., 1997). However, the CS of wheat flour protein increased gradually from 34.6% with increasing the lupine replacement level, it arrived to the maximum value of 66.9% at the maximum replacement level. Although, the lysine was identifying as a limiting amino acid in wheat flour protein and lupine proteins mixture nevertheless, the lysine percent in the mixtures was higher than that in wheat flour protein. These results are consistent with the vivo studies showing an improvement in the protein efficiency ratio in rats fed cooked semolina pasta supplemented with 10% processed lupine flour (Torres et al., 2007). Incorporation of these processed legume flours to semolina improved considerably the protein quality of pasta (Martínez–Villaluenga et al., 2010). The addition or substitution of raw materials rich in proteins resulted pasta products with higher protein contents and better nutritional values than that in conventional semola pasta (Marconi and Carcea, 2001).

Sensory evaluation

According to Fig. 1, the noodles color was affected by the WLM replacement. Noodles prepared using 100% wheat flour and 5% WLM had the highest color scores. The received color

Table 7 Amino acid composition (gm/100 gm protein) and predicted nutritional quality of wheat flour, lupine and their mixtures proteins.

Amino acids	100% WF	100% L	95% WF, 5% L	90% WF, 10% L	85% WF, 15% L	80% WF, 20% L	75% WF, 25% L	FAO[a]
Non essential amino acids								
Aspartic	3.83	10.48	4.76	5.54	6.18	6.73	7.21	
Glutamic	31.40	27.93	30.92	30.52	30.19	29.88	29.64	
Serine	5.57	5.30	5.54	5.50	5.48	5.45	5.43	
Alanine	3.17	3.40	3.20	3.23	3.25	3.27	3.28	
Arginine	3.94	9.33	4.70	5.32	5.85	6.29	6.68	
Glycine	3.67	3.81	3.69	3.70	3.72	3.73	3.74	
Proline	12.50	3.66	11.26	10.23	9.37	8.64	8.00	
Total	64.08	63.90	64.06	64.05	64.04	63.99	63.99	
Essential amino acids								
Histidine	1.99	2.40	2.05	2.09	2.13	2.17	2.20	1.9
Valine	4.82	3.31	4.61	4.44	4.29	4.16	4.05	3.5
Methionine	1.58	1.54	1.58	1.57	1.57	1.56	1.56	2.5
Cystine	1.83	1.69	1.81	1.79	1.78	1.77	1.76	
Isoleucine	4.16	3.84	4.12	4.08	4.05	4.02	4.00	2.8
Leucine	7.33	7.99	7.42	7.50	7.57	7.62	7.66	6.6
Phenylalanine	5.22	3.72	5.01	4.84	4.69	4.56	4.46	6.3
Tyrosine	4.00	2.08	3.73	3.51	3.32	3.16	3.02	
Lysine	2.01	5.69	2.52	2.95	3.31	3.61	3.88	5.8
Threonine	2.96	3.86	3.09	3.20	3.28	3.36	3.42	3.4
Total	35.9	36.10	35.94	35.97	35.99	35.99	36.01	
Nutritional parameters								
C-PER	1.2	3.6	1.6	1.8	2.1	2.3	2.4	
E/T%	35.91	56.50	35.94	35.96	35.98	36.00	36.01	
EAAI	65.5	69.5	67.1	68.0	68.6	68.9	69.3	
BV	59.7	64.0	61.4	62.3	63.1	63.4	63.8	
CS	34.6	122.1	43.4	51.0	57.2	62.4	66.9	
LAA	Lysine	Phe + Tyr	Lysine	Lysine	Lysine	Lysine	Lysine	

WF, wheat flour; L, Lupine; a, FAO/WHO/UNU (1985).

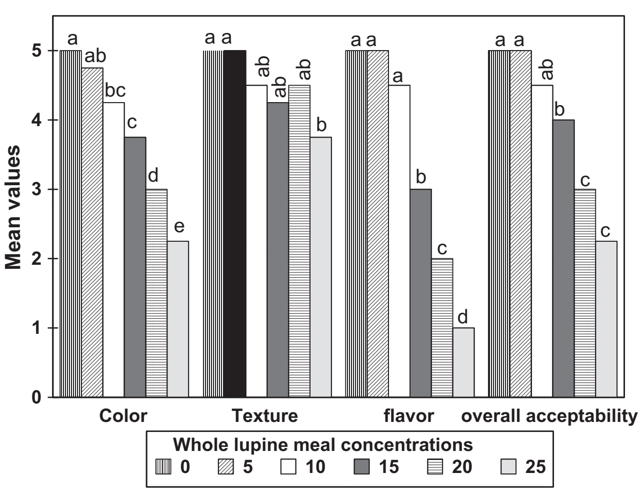

Fig. 1 Sensory evaluation of noodles prepared using different levels of WLM.

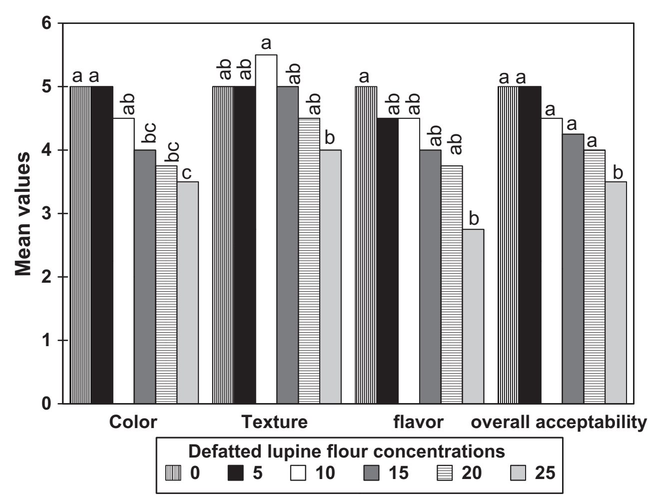

Fig. 2 Sensory evaluation of noodles prepared using different levels of DLM.

score values were declined with uprising the replacement level of WLM till reached its lowest value at the level of 25%. The texture of prepared noodles was not affected by adding the WLM except the prepared noodle using 25% WLM, it received the least value, yet it was significantly ($p < 0.05$) equal to those of noodles supplemented with 10%, 15% and 20% WLM. Texture scores ranged between 5 and 4.5 for noodles prepared using 100% wheat flour, or 5–20% WLM. These data are in accordance with those found by Shogren et al. (2006). No variation was noted in flavor between noodles, which prepared using WLM at levels 5%, 10% and the control sample. The overall acceptability reflected all the previously judged quality attributes and had the same trend.

The quality attributes score values of the prepared noodles using DLM are shown in Fig. 2. The obtained scores confirmed the improvement in the quality attributes of the DLM noodles compared to those prepared using WLM. The noodles color was non-significantly ($p > 0.05$) affected by the DLM replacement at levels of 5% and 10% compared to control sample. At 10% DLM replacement the texture was improved and arrived to the highest score value (5.5). At the same time, no significant difference ($p > 0.05$) was observed between this sample and all the other samples, except that prepared using 25% DLM which exhibited lowest mean score value. In addition, no significant difference was observed in the flavor between the samples prepared using DLM at levels ranged from 5% to 20% compared to control sample. The obtained overall acceptability established the possibility to use the replacement level until 20% of DLM to prepare the noodle with non-significant difference ($p > 0.05$) compared to control sample. Sensory evaluation studies indicate that various forms of lupine can be used satisfactorily as a food ingredient in a wide range of foods (Dervas et al., 1999). The results obtained are in accordance with (Sisson et al., 2005) and (Chillo et al., 2008).

Conclusion

WLM and DLM can be used as a protein sources to improve the nutritional quality of the prepared noodles. The optimum cooking time was decreased according to increase the level of lupine preparations. Prepared noodles enriched by 5% and 10% WLM and 5–20% DLM had cooking quality and sensory scores with non-significant differences compared to the control sample.

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