DEVELOPMENT AND QUALITY EVALUATION OF LUPIN-FORTIFIED INSTANT NOODLES

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ABSTRACT

Noodles are widely consumed throughout the world and their global consumption is second only to bread. The instant noodle market is growing fast in Asian countries, and is gaining popularity in the Western market. Wheat flour which is usually used to make instant noodles is not only low in fibre and protein contents but also poor in essential amino acid lysine. Australian sweet lupin, a low cost grain legume, is becoming popular in various food applications as it is rich in fibre and protein with high lysine content. In addition, lupin contains a wide range of phytochemicals with beneficial health effects.

The wheat flour in the traditional noodle formulation was replaced with 10, 20, 30, 40 and 50% lupin flour. The flours were mixed with other ingredients and instant noodle samples were prepared by extruding through 1.2 mm die (La Monferrina P3, Italy) using a standard method. The samples were evaluated for changes in colour and protein, fat and ash contents. The samples were cooked and analysed for colour, texture and sensory properties in comparison with the control sample.

The results revealed that the extrusion rate decreased with the increase in lupin concentration. The colour of the uncooked and cooked noodles became more yellowish with the increase in lupin concentration. Addition of lupin up to 20% had no significant effect on the sensory properties of instant noodles. Addition of 20% lupin flour improved the nutritional value of the product by increasing protein by 42% and dietary fibre by 200%. The results showed that lupin flour can be incorporated up to 20% in instant noodles to improve the nutrient value without affecting the sensory properties.

KEYWORDS

lupin, pasta, noodles, cooking quality, nutrition, sensory evaluation

INTRODUCTION

Instant noodles are widely consumed throughout the world and it is a fast growing sector of the noodle industry (Owen, 2001). The world instant noodle market is projected to reach 158.7 billion packs by the year 2010 (Anonymous, 2008). This is because instant noodles are convenient, easy to cook, low cost and have a relatively long shelf-life. Flour of hard wheat (*Triticum aestivum* L.) is the main primary ingredient (Crosbie, Huang and Barclay, 1998) and the addition of alkaline salts can help strengthen the structure and hence improve the firmness of the final product (Hou and Kruk, 1998). As there is an increasing awareness that health may be modified through diet, it has been a challenge for food scientists in finding more nutritious and healthy substitutes or alternatives to wheat flour for noodle products. Australian sweet lupin (*Lupinus angustifolius*) has found to have some physical and organoleptic properties similar to wheat flour but also provide other nutrition properties that can be beneficial to human health (Hall *et al.* 2005; Sirtori *et al.* 2004).

Australian sweet lupin (ASL) is a legume that is grown in Australia in large quantities, approximately 1 million tonnes annually (Anonymous, 2006). ASL is considered underutilised as a human food source because it is mainly being used as an animal feed (Hall and Johnson, 2004). However ASL flour has a high potential of a 'nonintrusive' ingredient that can be substituted or used as an alternative in foods such as cereal products because lupin flour is pale in colour and low in odour and flavour (Clark and Johnson, 2002). The addition of ASL flour to wheat flour-based products, including pasta and noodles, has the potential to increase dietary fibre content and improve protein content and quality as ASL flour contains comparatively higher protein (about 40% by weight) and dietary fibre (30%) contents (both soluble and insoluble) than wheat flour. A combination of lupin and wheat flour can also help improve the amino acid balance of the product. Wheat flour proteins which are poor in lysine and relatively higher in the sulphur-containing amino acids (methionine and cysteine) can be complemented by the amino acids found in lupin protein which is high in lysine and low in sulphur-rich amino acids (Mann and Truswell, 2002). ASL flour also found to provide a wide range of phytochemicals, including antioxidants and phytosterols, which may be beneficial to health (Petterson, 1998).

An increased consumption of dietary fibre in daily diet has been recommended by nutritionists for improved health. The fibre that is predominately presented in lupin is non-starch polysaccharide which is a type of insoluble fibre (Hall *et al.* 2005). Dietary

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fibres promote beneficial physiological effects including laxation, blood cholesterol attenuation and blood glucose attenuation (Mann and Truswell, 2002).

Also, ASL flour is lower in cost compared to other legume proteins such as soybean (Jayasena and Quail, 2004). Therefore, substitution of wheat flour with ASL flour can reduce the production cost and it provides a product with a higher nutritional quality.

The aim of this study was to investigate the maximum substitution of ASL flour to wheat flour to improve the nutritional quality of instant noodles without deteriorating their physical and organoleptic properties.

MATERIALS AND METHODS

RAW MATERIALS

The commercially available hard wheat flour, ASL flour, common salt, guargum and ascorbic acid was supplied by the local suppliers.

Noodles preparation

The hard wheat flour in the traditional formulation was replaced with 10, 20, 30, 40 and 50% sweet lupin flour. The flour blends were mixed with common salt (2 g/100 g flour), ascorbic acid (0.05 g /100 g flour), guar gum (0.25 g/100 g flour) and tap water (33 mL/100 g of total weight). The samples were extruded in the form of 1.2 mm diameter noodle strands using a single screw extruder (La Monferrina P3, Italy). The noodle strands were cut into approximately 20 cm lengths and folded into block shapes. Noodles prepared without addition of lupin flour served as the control sample (Hou and Kruk 1998). Each of the samples was prepared in triplicate. The noodles were then steamed for 15 minutes at 100°C followed by cooling to 25°C and deep frying in vegetable oil at 140-150°C for one minutes (Owen, 2001). Finally, the noodles were cooled to room temperature and packed in polyethylene bags.

PHYSICAL MEASUREMENTS

Cooking quality. Tap water (about 1 litre) was brought to a boil in a two-litre saucepan with the lid on to prevent any water loss. When the water started boiling, a 100 g portion of noodles were added. The cooking temperature (that is the water temperature) was maintained at 98-100°C throughout the cooking process. The cooking period began as soon as the noodles were put into the boiled water and were cooked for 3 minutes or until no white core was observed after compressing. The noodles were then removed from the saucepan, rinsed and cooled in running cold tap water for 1 minute. Cooking loss was measured by evaporating the cooking water to dryness in a oven at 100°C, as described by the AACC method (AACC, 2000).

Instrumental colour analysis before and after cooking. The Konica Minolta Spectrophotometer (CM = 500i/CM-500C) which employs the CIELAB colour system (L^* a^* b^*) was used to measure the colour of uncooked noodles. The instrument was calibrated using the white-coloured disc supplied with the instrument prior to analysis. The samples were put on the opaque white backing tile and the instrument was placed along the noodle strands. The white-coloured disc and white backing tile were used because the colour was closer to the noodles. Three different reading points of each sample were taken, at the middle, on the right and left hand sides and these readings were taken in triplicates. Data were collected for L^* (brightness or whiteness), a^* (redness and greenness) and b^* (yellowness and blueness) values (Atwell, 2001).

Textural analysis of the cooked noodles. The texture of the cooked noodles was analysed using a TA.XT2i Texture Analyser (Stable Micro System Ltd, United Kingdom) calibrated for a 5 kg load cell (Tudorica, Kuri and Brennan, 2002). A probe with 33 mm diameter was used and the Texture Analyser was set at pre-test speed, test speeds, post-test speeds of 2.0 mm/s, 2.0 mm/s and 1.0 mm/s, respectively. The amount of work required to shear three cooked strands was measured. The test was repeated in triplicate for each of the cooked samples.

CHEMICAL ANALYSIS

The moisture, protein contents (Kjeldahl nitrogen x 5.7) and fat contents were determined by AACC methods (AACC, 2000). The total dietary fibre content was calculated based on the dietary fibre contents of wheat flour and ASL flour using the following formula.

Total dietary fibre content (%) =

$$\frac{\text{Wheat flour (g) x 2.7\# + ASL flour (g) x 28*}}{\text{Total flour blend (g)}}$$

Whereas:

= Dietary fibre content of the wheat flour (g/100 g)
* = Dietary fibre content of ASL flour (g/100 g)

SENSORY EVALUATION OF COOKED NOODLES

The sensory evaluation was carried out in order to get consumer response for overall acceptability of the lupin incorporated instant noodle compared to the traditional noodle. The noodle samples were cooked as described earlier. Panellists (50 in number) were given approximately 5 g of each of the 6 samples; 5 sample containing different levels of ASL flour and the control. Each of the samples was numbered using the random three-digit numbering system. Panellists were asked to indicate their preference on a 9-point Hedonic scale with degree of liking: 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely.

DATA ANALYSIS

The data collected for physical measurements, chemical analysis and sensory evaluation were analysed using SPSS 15.0 software by applying analysis of variance (ANOVA) technique. The means were separated using Duncan's test at $P \leq 0.05$.

RESULTS AND DISCUSSION

PHYSICAL MEASUREMENT

Cooking quality. The cooking quality of pasta and noodles is one of the most important features that encompass the following characteristics: a) the uncooked to cooked weight ratio indicating the water uptake (hydration) during cooking; and b) the cooking loss, related to solid leaching during cooking and considered as an indicator of the overall cooking performance (Doxastakis, 2007). The substitution of wheat flour with ASL flour had no effect on water absorption evident by a non significant difference ($p \leq 0.05$) in uncooked to cooked weight ratio. It revealed that water absorption phase was quite constant across the different samples. Good water absorption is a required factor in determining pasta products. Hummel (1966) mentioned that good quality macaroni products should absorb at least twice their weight after boiling in water. The noodle samples here also show an uncooked to cook weight ratio of 2 (Table 1) and the addition of ASL did not reduce the water absorption capacity of the product. Similar increase in cooked weight was found in samples containing amaranth and buckwheat spaghetti which gained about 2 to 3 times their weight in water when cooked (Rayas-Duarte, Mock and Satterlee, 1996).

Cooking loss was also not different from control for the samples having up to the 40% replacement of wheat flour with ASL flour in the product (Fig. 1). However samples containing 50% ASL had significantly ($p \leq 0.05$) higher cooking loss compared with the control. The solid leaching during cooking may not have an effect on nutrient quality as instant noodles are mostly eaten along with the boiling water. However solid leaching from the noodles into the boiling water may affect on the sensory properties and texture of the cooked product.

Colour. Addition of ASL flour influenced the colour of instant noodles. Redness (a^* value) and yellowness (b^* value) of the noodle samples increased with the increase in ASL concentration (Table 1). L^* value, that represents lightness or darkness, however showed a non-significant difference with the increase in ASL flour concentration in the noodle samples. Similar results were found when ASL flour was added in other food products. Pasta samples supplemented with 10, 20 and 30% cowpea flour (Bergman *et al.* 1994) demonstrated a significant difference in the colour.

Texture. Values for textural characteristics (hardness and chewiness) as a function of the substitution level are presented in Table 2. There was no significant different in the textural characteristics across the different samples.

Chewiness is a product of (hardness x cohesiveness) x springiness; it is thus a single parameter that incorporates three of the important textural characteristics. Chewiness increased with the increase in protein content in Oriental noodles (Baik, 1994) but here chewiness show a non-significant difference in samples containing different protein contents due to the replacement of wheat flour with protein rich (Table 2) ASL flour. The results are in agreement to those of other researchers. Spaghetti samples containing 5-30% lupin flour demonstrated no significant differences in textural characteristics of firmness and pastiness (Rayas-Duarte, Mock and Satterlee, 1996).

NUTRITIONAL QUALITY

Substitution of wheat flour with ASL flour in the instant noodle formulation substantially improved its nutritional quality. There was a large increase in protein and dietary fire contents with the increase in ASL flour substitution (Table 3). By replacing only 20% wheat flour with ASL flour, there was a 42% increase in protein and 200% increase in dietary fibre contents. Fat contents, however were not much affected and demonstrated a non-significant increase up to 20% ASL substitution. Addition of ASL flour $\geq 30\%$ showed a significant increase in the fat contents.

Generally, the protein content is believed to play a role in oil absorption in instant noodles. In a qualitative study, Moss *et al.* (1987) reported that noodles made from high-protein wheat flour absorbed less oil than noodles made from low-protein flour. They proposed that the high oil absorption in low-protein flour noodle was due to the formation of coarse globules during steaming, allowing oil to penetrate easily through the noodle. In our study noodles having high protein contents due to containing protein rich ASL flour showed more oil absorption than the low protein samples. Protein content is not the sole factor influencing oil uptake, protein quality also significantly affects free oil absorption in instant noodles (Park and Baik, 2004a).

Improvement in the nutritional quality of the instant noodles by ASL flour substitution is in agreement to those of other food products in which addition of protein rich legume significantly increased the nutritional quality. Substantial increase in protein contents were found in pasta supplemented with 10, 20 and 30% cowpea flour (Bergman *et al.* 1994).

SENSORY EVALUATION

The sensory evaluation results presented in Figs 2 and 3 reveal that the sensory score for colour of cooked noodles improved by the incorporation of ASL flour. Colour of the samples containing ASL flour was preferred over the control sample that resulted in a significant score increase for ASL containing samples. It means that the yellowish colour due to ASL flour was liked by the judges as compared to whitish colour of the control noodles samples. Overall acceptability scores demonstrate no significant effect of ASL flour addition up to 40% level (Fig. 3). However texture likeness decreased significantly at ASL flour addition above 20%. Hence ASL flour can be substituted in instant noodles up to 20% level without any deteriorating effect on its sensory quality. Addition of ASL flour rather improved the colour of the product.

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Table 1. Effect of ASL flour concentration on the colour of instant noodles.

ASL flour concentration	Colour coordinates		
	L*	a*	b*
0% (control)	55.91a	-0.49e	19.27b
10%	50.68a	1.04d	29.86ab
20%	51.87a	2.39c	35.08a
30%	46.53a	4.31b	35.25a
40%	48.30a	5.03b	37.76a
50%	48.84a	6.00a	39.92a

Table 2. Effect of ASL flour concentration on the texture of cooked instant noodles.

ASL flour concentration	Hardness (g)	Chewiness (g)
0% (control)	1520a	944a
10% ASL	1661a	1020a
20% ASL	1710a	1033a
30% ASL	1823a	1104a
40% ASL	1845a	1095a
50% ASL	1814a	1082a

Table 3. Effect of ASL flour concentration on the nutritional quality of instant noodles.

ASL flour concentration	Protein (g/100 g)	Fat (g/100 g)	Dietary fibre (g/100 g)
0% (control)	10.50d	8.09b	2.7
10% ASL	12.43d	9.98b	5.2
20% ASL	14.95c	9.67b	7.8
30% ASL	16.54c	10.57ab	10.3
40% ASL	19.86b	14.44a	12.8
50% ASL	22.34a	11.54ab	15.4

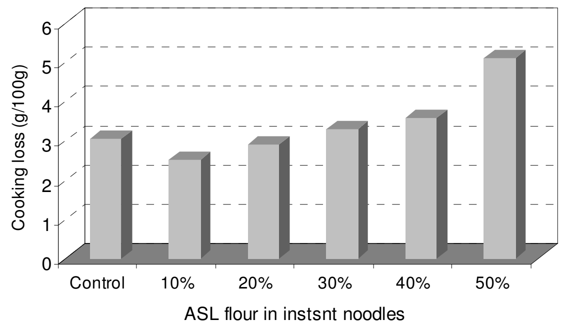

Fig. 1. Effect of ASL flour addition on the cooking quality of instant noodles. Bars with same letters are non-significantly different (P ≤ 0.05).

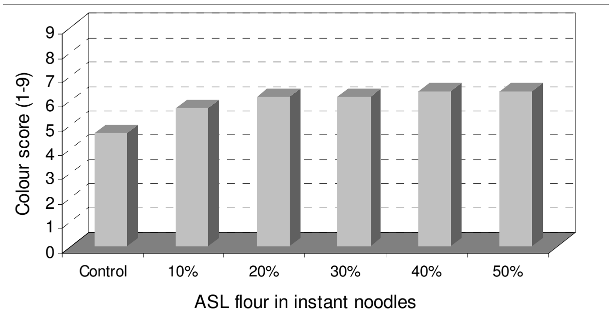

Fig. 2. Effect of ASL flour addition on sensory colour of instant noodles. Bars with same letters are non-significantly different (P ≤ 0.05).

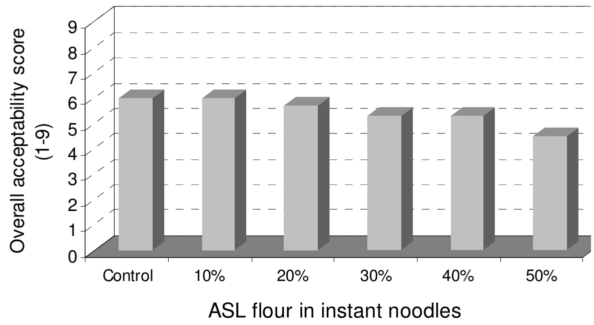

Fig. 3. Effect of ASL flour addition on overall acceptability of instant noodles. Bars with same letters are non-significantly different (P ≤ 0.05).