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Effect of lupin flour incorporation on the physical and sensory properties of muffins

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Abstract

Introduction Muffins are popular as breakfast or snack in advanced nations but poor in nutritional value by having low protein and dietary fibre contents. *Objectives* To improve the nutritional value of muffins incorporation of protein and dietary fibre rich lupin flour was investigated. *Methods* Muffins were prepared by replacing wheat flour with lupin flour at 10 to 50% levels. The sample were store at refrigerated temperature (5 ± 1°C) for 7 days and changes in physicochemical and sensory properties, as affected by lupin flour concentration and storage period, were analysed. *Results* Studies on the physical properties revealed that substitution with lupin flour at ≤30% level had no significant effect on the density and height of the muffins. Instrumental colour analysis showed an increase in a^* and b^* values with increase in lupin substitution. Most of the textural parameters demonstrated a non-significant change at ≤30% lupin flour substitution levels. Sensory evaluation revealed an improvement in colour with up to 30% lupin flour substitution with no significant change in taste, flavour, texture and overall acceptability. Storage period caused substantial changes in the texture of muffins. With moisture content remained unchanged, there was an increase in hardness and a decrease in springiness of all samples including the control. *Conclusion* A substantial improvement in nutritional value (increase in protein and dietary fibre content) of muffins could be achieved by replacing wheat flour with lupin flour up to 30% level without any significant loss in physical measurements, textural quality and sensory values.

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Introduction

Dietary fibre is one of the most important food ingredients used in nutritional and functional foods as it is one of the first ingredients to be associated with the health trend in the 1980s, particularly in bakery and cereal products (Trumbo *et al.*, 2002). Several epidemiological studies have suggested a relationship between a decrease in the consumption of dietary fibre and an increase in certain illnesses such as gastrointestinal disease (Mendeloff, 1987), hypercholesterolaemia (Tinker *et al.*, 1991) and colorectal cancer (Cassidy *et al.*, 1994; Peters *et al.*, 2003). Dietary fibre also has a positive effect on the calcium bioavailability and immune function (Tungland & Meyer, 2002). In addition, the incorporation of fibre in foods results in a reduction in their caloric content, which benefits overweight or obese persons by reducing energy intake.

Muffins are very popular as a breakfast or snack in advanced nations, but by having low protein and dietary fibre contents, are poor in nutritional value. To improve the dietary fibre contents of muffins and other baked products, researchers have used different ingredients high in dietary fibre contents such as sunflower hull flour (Dreher & Padmanaban, 1983), dried distillers grain flour (Reddy *et al.*, 1986), potato peel (Arora & Camire, 1994), apple pomace (Wang & Thomas, 1989), oat bran, rice bran or barley fibre fractions (Hudson *et al.*, 1992), peach dietary fibre (Grigelmo-Miguel *et al.*, 1999, 2001), flaxseed meal (Shearer & Davies, 2005) and apple skin powder (Rupasinghe *et al.*, 2008). However, these studies showed that the use of these kinds of dietary fibres resulted in poor-quality food products, including deterioration in appearance, flavour and texture depending upon the source.

Sweet lupin (*Lupinus angustifolius*) is a grain legume grown in Australia, Europe and South America and is underutilised as a human food source. Lupin flour, prepared by grinding dehulled kernels, has been found to be a very valuable food ingredient containing high amounts of both soluble and insoluble dietary fibre fractions (Hall *et al.*, 2005). The dietary fibre content of lupin flour is higher than that of most other legumes, making up 27–31% of the kernel weight. Lupin flour is not only high in dietary fibre but it is also high in protein contents (41–44%) which make it a unique ingredient of high nutritional and commercial value (Evans *et al.*, 1993). Lupin flour has shown potential for the manufacture of a range of fibre-enriched products with high consumer acceptability (Jayasena & Quail, 2004; Jayasena *et al.*, 2008 ,2009; Jayasena & Nasar-Abbas, 2011).

Consumption of lupin flour-enriched foods has been proven to have many health benefits. Bread prepared by adding lupin flour helped in reducing blood pressure and cardiovascular risk (Lee *et al.*, 2009). Addition of lupin fibre to the diet provided favourable changes to some serum lipid measures in men which suggested this novel ingredient may be useful in the dietary reduction of coronary heart disease risk (Hall *et al.*, 2005). Breakfasts with lupin flour-enriched bread resulted in significantly higher self-reported satiety and lower energy intake at lunch than normal breakfast (Lee *et al.*, 2006). Increasing both protein and fibre intakes, at the expense of refined carbohydrate, may benefit blood pressure. Studies by Burke *et al.* (2001) demonstrated a combined effect of an additional intake of 66 g per day dietary protein and 15 g per day soluble fibre that resulted in significant effects in lowering the systolic blood pressure by ~10 mm Hg. Lupin flour, which is high in both protein and dietary fibre contents, could be an ideal food ingredient that can be used to get the combined effect of protein and fibre in lowering the blood pressure.

The purpose of this study was to utilise protein and dietary fibre-rich lupin flour in muffins to increase lupin flour utilisation in foods and to improve the nutritional value of muffins that would help improve the health of consumers.

Materials and methods

Wheat and lupin flour

Wheat flour (Anchor Foods Ltd., Fremantle, WA, Australia) with mean particle size of 175 μ was purchased from a local supplier. Lupin (*L. angustifolius* L.) flour with mean particle size of 125 μ was supplied by Coorow Seeds (Coorow, WA, Australia). The protein contents of wheat flour and lupin flour were 10.1% and 42.1%, and dietary fibre contents were 3.2% and 31.6%, respectively (lupin flour samples analysed by BRI Australia Pty Ltd).

Muffin formulations and preparation

A standard recipe was used as the control. Wheat flour in the control recipe was replaced with lupin flour at 10%,

Table 1 Dough formulations used for the preparation of lupin incorporated muffins

Ingredients (g)	Control	10% lupin	20% lupin	30% lupin	40% lupin	50% lupin
Baker's wheat flour	1100	990	880	770	660	550
Lupin flour	0	110	220	330	440	550
Sugar	550	550	550	550	550	550
Fresh egg	150	150	150	150	150	150
Milk	600	600	600	600	600	600
Vegetable oil	400	400	400	400	400	400
Baking powder	50	50	50	50	50	50
Wheat gluten	0	10	20	30	40	50
Table salt	7	7	7	7	7	7
Water	0	25	50	75	100	125
Vanilla essence	10	10	10	10	10	10
Total dough weight	2867	2902	2937	2972	3007	3042

20%, 30%, 40% and 50% levels (Table 1). The addition of lupin flour resulted in an increase in the amount of water in the formulation. Incremental amounts of water and wheat gluten were added to the lupin-containing muffin formulations (Table 1). Wheat flour, lupin flour, baking powder and gluten were blended for 5 min using a mechanical blender (N-50G; Hobart Corporation, Troy, OH, USA) to get a uniform distribution. Sugar, salt, eggs, vegetable oil, fresh milk, water and vanilla essence were creamed for 2 min using a handheld mixer (MP23/509; General Electric, Auckland, New Zealand). The cream was added into the dry mix and the dough was mixed for 1 min. The dough was poured into muffin moulds (90 g in each mould) lined with muffin paper cases and baked at 190 °C for 25 min in a hot air oven (Thermotec 2000, Contherm Scientific Ltd., Lowe Hutt, Wellington, New Zealand) and then cooled for 2 h at room temperature. The prepared muffins were packed in sealed polyethylene bags and stored at refrigeration temperature (5 °C ± 1 °C) for 7 days. Samples were taken for testing at 0, 3 and 7 days. When taken out of refrigerator at the third and seventh day, the samples were kept at room temperature (20 °C ± 2 °C) for 2 h before testing.

Analysis of some physical properties

The volume of the muffin was measured using rapeseed volume apparatus according to the Approved Method 10-05 (AACC, 2000). Muffin weight was determined with the aid of a precision scale (HF-2000G; A & D Company Ltd, Tokyo, Japan). The muffin density was calculated by dividing the muffin weight (g) by muffin volume (mL). Muffin height was measured to the nearest millimetre with a digital calliper (Kincrome Australia Pty Ltd, Scoresby VIC, Australia). Three replicates were used for each measurement.

Moisture content

The moisture content was determined according to AACC (2000) method using samples in triplicates.

Instrumental colour analysis

The Konica Minolta Spectrophotometer (CM = 500i/CM-500C; Konica Minolta Holdings, Inc. Ramsey, NJ, USA), which employs the CieLab colour system (L^* a^* b^*), was used to measure the colour of muffin samples. The instrument was equipped with a pulsed xenon arc lamp as light source, a silicon photodiode array detector and has the illumination/measurement area of Ø11 mm. The instrument was calibrated using the white-coloured disc ($L^* = 98.82$, $a^* = -0.07$ and $b^* = -0.45$) supplied with the instrument prior to analysis. Muffins were cut into half and put on the opaque white backing tile and colour of the inner part (crumb) of the muffin was measure directly. The readings were taken in triplicates. The L^* (brightness or whiteness), a^* (redness and greenness) and b^* (yellowness and blueness) values were recorded and compared between the control and samples containing lupin flour.

Texture profile analysis (TPA)

TPA of muffins was carried out at room temperature using a TA-XT2 Texture Analyser (Stable Micro Systems Ltd, Surrey, England, UK). Cubes of 2.5 cm were cut out of the centre of the muffins using a sharp knife. The cubes were evaluated by compressing twice to 50% their original height with a cross-head speed of 5.0 mm s^{-1} and a time of 5 s between compressions (Grigelmo-Miguel *et al.*, 2001). Textural variables from force and area measurements were (Bourne, 1978): hardness = peak force (g) during the first compression cycle; cohesiveness = ratio of the positive force area during the second compression to that during the first compression; springiness = height that the sample recovers during the time that elapses between the end of the first bite and the start of the second bite (cm); and chewiness = hardness × cohesiveness × springiness (g cm). Three muffins from each formulation were used to evaluate textural parameters.

Sensory evaluation

A panel of 20 semi-trained judges of both genders aged 18–50 years evaluated the muffins on a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely). Muffins were sliced into half and identified by a three-digit random number. The samples were offered to the judges on a white plate at room temperature in individual booths under white light. Panellists were given room-temperature water to cleanse the palate before tasting the samples from each formulation.

Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) for Windows, version 17.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance was applied followed by the Duncan's test to determine differences between the treatments. Statistical significance was established at $P \leq 0.05$.

Results and discussion

Proximate composition

Proximate analysis was not carried out except for moisture contents as it could be possible to estimate changes in protein and dietary fibre contents (main nutritional changes) from the compositions of wheat flour and lupin flour. It was obvious that replacement of wheat flour, containing 10.1% protein and 3.2% dietary fibre, with lupin flour containing 42.1% protein and 31.6% dietary fibre would result in a significant increase in protein and dietary fibre contents of muffins. However, our main focus was to study the effect of adding protein and dietary fibre-rich lupin flour on the physical and sensory properties of muffins.

Muffin samples with lupin flour showed a higher moisture content than the control (Figure 1) with no changes during 7-day storage. It might be due to higher amount of water added in the lupin flour containing muffin formulations, and/or it may be due to the higher water-holding capacity of lupin flour than the wheat flour. High dietary fibre contents including soluble fibres may retain water by preventing evaporation during baking. The results are in agreement with those of other researchers such as Grigelmo-Miguel *et al.* (2001) whose research work demonstrated that muffins prepared by adding peach dietary fibre had higher moisture contents than the control. The moisture contents of the samples (packed in zipped polyethylene bags) remained unchanged during storage at refrigeration conditions (5 °C ± 1 °C) for 7 days (Figure 1).

Height and density

There was no significant effect on muffin height and density with up to 30% wheat flour replacement with lupin flour (Table 2). However, wheat flour substitution with lupin flour at ≥40% caused a significant decrease in height and increase in density of muffins. It was mainly due to decrease in muffin volume at high (≥40%) lupin flour substitution. There was a clear difference in the shape of the muffins other than maximum height. The samples with high lupin concentration (≥40%) were less peaked and had dense internal appearance (structure) than the other samples. The decrease in expansion (height and volume) during baking of muffins containing more than 30% lupin flour may be due to high dietary fibre content. The volume of muffins and other baked products reduces when incorporated with high dietary fibre sources such as peach dietary fibre (Grigelmo-Miguel *et al.*, 1999, 2001), potato peel (Arora & Camire, 1994), wheat bran (Zabik *et al.*, 1977) and distillers' dried-grain flours (Tsen *et al.*, 1982). The addition of lupin flour containing higher amounts of dietary fibre might have reduced the air entrapment capacity of dough during baking. In general, the addition of dietary fibre to baked products is associated with a decrease in volume and height, which is partly due to the dilution of gluten (Pomeranz *et al.*, 1977). Thus, wheat gluten was added to compensate gluten dilution in the samples containing lupin flour (Table 1). However, because of high fibre contents at ≥40% lupin flour substitution, additional gluten was not enough to maintain the volume.

Instrumental colour

Lupin flour is naturally more yellow than wheat flour. Replacement of wheat flour with lupin flour in the formulation affected muffin colour. L^*value, which reflects lightness of the product, showed no significant change up to 30% lupin flour incorporation (Table 3). There was a decrease in lightness at ≥40% lupin flour substitution because of the loss of the characteristic white colour of the wheat flour. This observation coincided with previous results obtained in muffins made with some cereals (Holt *et al.*, 1992), potato peel (Arora & Camire, 1994) and peach dietary fibre (Grigelmo-Miguel *et al.*, 2001).

As the percentage of lupin flour increased, the greenness ($-a^*$) and yellowness (b^*) were increased (Table 3). This could be due to the fact that lupin flour, which contains naturally occurring yellow pigments imparts yellowness to the product when mixed with wheat flour (off white in colour). Similar results have been reported in other studies. The pasta and instant noodle samples prepared by incorporating >10% lupin intensified the overall colour shade by significantly increasing a^* and b^* values (Jayasena *et al.*, 2008; Svec *et al.*, 2008). Replacement of wheat flour with other dietary fibre sources such as cellulose, peach dietary fibre and cereal brans also caused an increase in b^* values of muffins and other baked products (Zabik *et al.*, 1977; Shafer & Zabik, 1978; Grigelmo-Miguel *et al.*, 2001).

Textural properties

There were significant changes in the textural properties of muffins because of the addition of lupin flour. Hardness increased and springiness decreased with the increase in lupin flour incorporation at levels ≥20% (Table 4). The increase in hardness and decrease in springiness might be due to the reduction in air cells in the body of muffins, increasing the force needed for compression. Decrease in

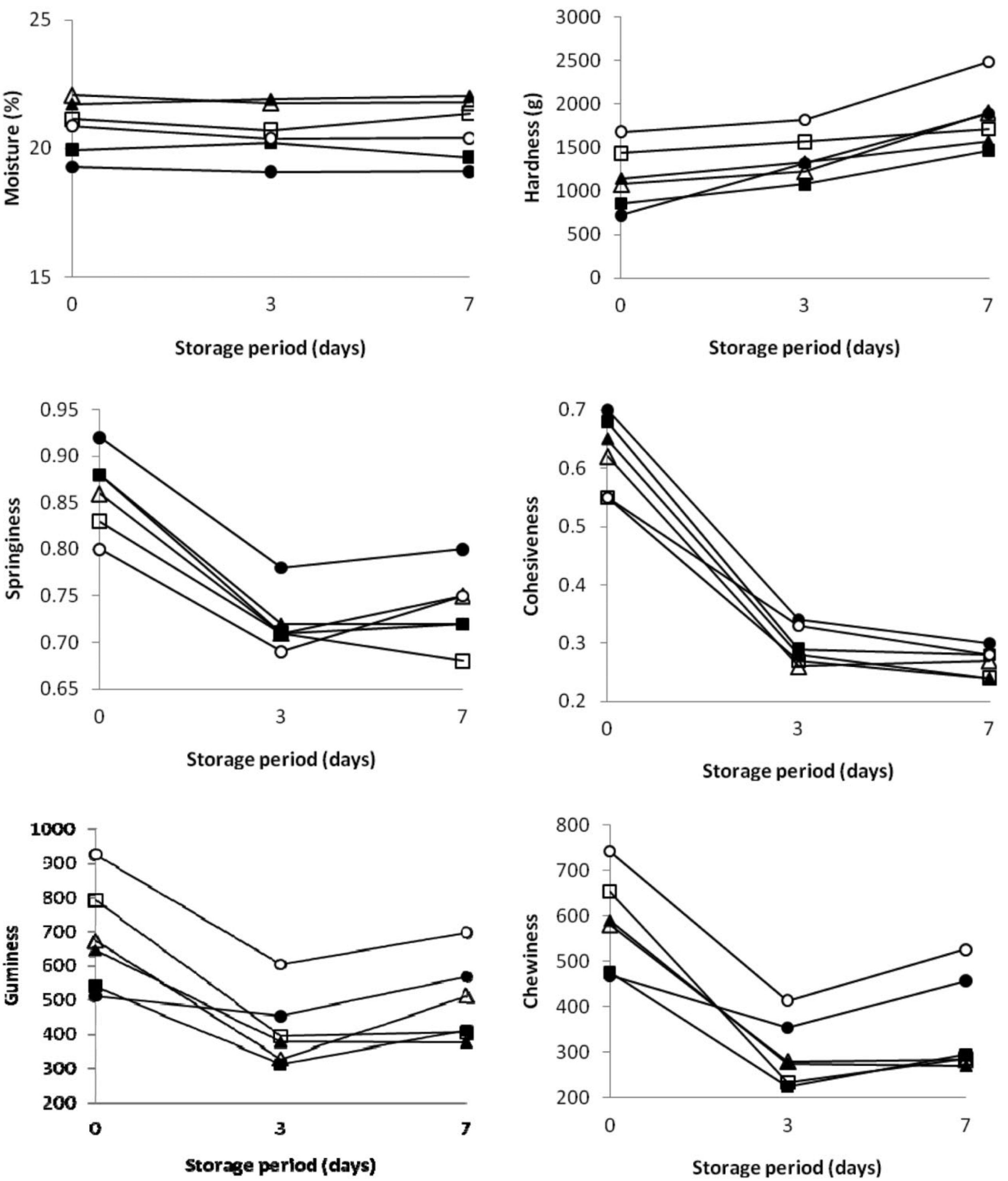

Figure 1 Effect of storage period on the moisture contents and the textural properties of muffins substituted with different levels of lupin flour (-●-, control; -■-, 10% lupin; -▲-, 20% lupin; -○-, 30% lupin; -□-, 40% lupin; -△-, 50% lupin).

Table 2 Effect of lupin flour substitution on the physical properties of freshly prepared muffins

Sample	Height (mm)	Density
Control	60.7 ± 1.7[a]	0.433 ± 0.006[a]
10% lupin	59.7 ± 1.4[ab]	0.440 ± 0.003[ab]
20% lupin	59.3 ± 1.5[ab]	0.443 ± 0.005[ab]
30% lupin	58.3 ± 0.7[ab]	0.447 ± 0.006[ab]
40% lupin	57.8 ± 1.4[b]	0.453 ± 0.005[b]
50% lupin	57.5 ± 1.1[b]	0.483 ± 0.006[c]

Means with different superscripts within the same column are significantly different ($P < 0.05$).

Table 3 Effect of lupin flour substitution on the colour of freshly prepared muffins

	Colour		
Sample	*L**	*a**	*b**
Control	74.67 ± 1.05[a]	–1.28 ± 0.12[c]	21.28 ± 1.13[a]
10% lupin	73.02 ± 0.64[ab]	–2.93 ± 0.16[a]	31.31 ± 0.75[b]
20% lupin	72.90 ± 0.75[ab]	–3.16 ± 0.12[a]	35.58 ± 0.47[c]
30% lupin	72.85 ± 1.25[ab]	–3.05 ± 0.20[a]	39.29 ± 0.24[d]
40% lupin	72.41 ± 1.32[b]	–2.51 ± 0.49[ab]	40.78 ± 1.18[e]
50% lupin	71.81 ± 0.89[b]	–1.96 ± 0.40[bc]	42.05 ± 0.55[e]

Means with different superscripts within the same column are significantly different ($P < 0.05$).

muffin height and diameter (Table 2), with weight remains constant, indicates the reduction of air cells and increase in density because of lupin flour incorporation. Addition of dietary fibre into muffins and other baked products from different sources such as peach dietary fibre (Grigelmo-Miguel *et al.*, 1999, 2001), potato peel (Arora & Camire, 1994) and wheat bran (Zabik *et al.*, 1977) resulted in reduction in the volume, hence affecting the texture of the product. Freshly baked muffins prepared with flaxseed meal were firmer and less elastic than the control muffins (Shearer & Davies, 2005).

Other texture parameters such as cohesiveness, gumminess and chewiness were quite stable. There was no significant effect up to 30% lupin flour incorporation. However, cohesiveness decreased, and gumminess and chewiness increased significantly at ≥40% lupin flour incorporation. Increase in gumminess and chewiness at higher levels of lupin incorporation might be due to soluble fibre fraction, which acts as a gum when mixed with water. Because the perceived softness and freshness of baked goods can be enhanced by the use of gums with good water-binding properties (Heflich, 1996), lupin with some gummy properties could help in giving softness to the baked products. However, the muffin samples were not softened by the addition of lupin flour. This could be due to the higher insoluble dietary fibre contents, which may cause hardness. Lupin flour contains 27–31% dietary fibre with soluble fibre fraction only ~3% (Evans *et al.*, 1993).

Storage at refrigeration temperature caused substantial changes in the texture of muffins. All of the muffin samples including the control demonstrated a linier increase in hardness values. However, other textural parameter such as springiness, gumminess, cohesiveness and chewiness showed a sharp decrease on the third day of storage (Figure 1). There were minor changes from day 3 to day 7. The changes in textural properties could be related to the moisture movement within the muffin body. The crust or cap of freshly baked muffin is much harder and drier as compared with the inner part (crumb). However, during storage, moisture moves from the moister inner part of the muffin to the dry top portion until equilibrium is established. This moisture migration causes a decrease in the moisture content of the crumb but keeps the total moisture content of the muffin constant. Because only the inner parts of the muffins were used for texture analysis, increase in hardness could be due to loss of moisture. Relative vapour pressure of flaxseed meal incorporated muffins increased in the first 4 days of storage followed by a decrease (Shearer & Davies, 2005). Loss of moisture may be a main reason, but other chemical changes might be involved in hardening during storage. Loss of moisture content of muffins prepared with flaxseed meal was not found to be the only variable contributing to the change in texture (Shearer & Davies, 2005). Texture hardening with the passage of time is a complex phenomenon that needs more detailed studies.

Sensory characteristics

The sensory evaluation results for colour, taste, flavour, texture and overall acceptability are presented in Table 5. The sensory data revealed that the sensory score for colour (consumer likeness of colour) of muffins improved by the incorporation of lupin flour. A light yellow colour imparted by the natural yellow colour of lupin flour was attractive to the judges as compared with the whitish colour of the control sample. Yellowness increased with the increase in lupin substitution as tested by instrumental method (increase in *b** value – Table 3) but it was preferred by the judges up to 40% level. However, at 50% lupin flour substitution, the colour of the muffins was too yellow to get better scores than the control. Similar improvements in colour of different foods by lupin incorporation have been reported in other studies. Colour scores of spaghetti containing 15–30%

Table 4 Effect of lupin flour substitution on the textural properties of freshly prepared muffins

Sample	Hardness (g)	Springiness (cm)	Cohesiveness	Gumminess	Chewiness (g cm)
Control	722 ± 84^{d}	0.92 ± 0.01^{a}	0.70 ± 0.10^{a}	510 ± 89^{c}	469 ± 99^{b}
10% lupin	797 ± 63^{d}	0.89 ± 0.01^{ab}	0.68 ± 0.01^{a}	540 ± 51^{c}	476 ± 40^{b}
20% lupin	1144 ± 98^{c}	0.88 ± 0.01^{b}	0.65 ± 0.03^{ab}	645 ± 13^{bc}	590 ± 38^{ab}
30% lupin	1280 ± 30^{c}	0.86 ± 0.01^{b}	0.62 ± 0.02^{ab}	673 ± 12^{bc}	581 ± 10^{ab}
40% lupin	1435 ± 93^{b}	0.83 ± 0.02^{c}	0.55 ± 0.02^{c}	792 ± 76^{ab}	654 ± 55^{a}
50% lupin	1683 ± 38^{a}	0.80 ± 0.01^{c}	0.55 ± 0.02^{c}	926 ± 43^{a}	742 ± 38^{a}

Means with different superscripts within the same column are significantly different ($P < 0.05$).

Table 5 Effect of lupin flour substitution on the sensory properties of freshly prepared muffins

Sample	Colour	Taste	Flavour	Texture	Overall acceptability
Control	5.4 ± 2.3^{b}	6.2 ± 2.1^{a}	6.2 ± 1.8^{a}	5.8 ± 1.8^{b}	6.3 ± 1.9^{ab}
10% lupin	6.7 ± 1.2^{a}	7.0 ± 1.4^{a}	6.7 ± 1.5^{a}	7.1 ± 1.2^{a}	7.1 ± 1.0^{a}
20% lupin	6.8 ± 1.1^{a}	6.5 ± 1.2^{a}	6.2 ± 1.6^{a}	6.6 ± 1.6^{ab}	6.4 ± 1.3^{ab}
30% lupin	6.5 ± 1.0^{a}	6.6 ± 1.3^{a}	6.3 ± 1.7^{a}	6.6 ± 1.1^{ab}	6.6 ± 1.2^{ab}
40% lupin	5.9 ± 1.4^{ab}	5.8 ± 1.8^{ab}	6.0 ± 2.2^{ab}	6.3 ± 1.5^{ab}	5.9 ± 1.8^{ab}
50% lupin	5.4 ± 1.5^{b}	4.8 ± 2.1^{b}	4.8 ± 2.1^{b}	5.4 ± 1.5^{b}	5.5 ± 1.9^{b}

Means with different superscripts within the same column are significantly different ($P < 0.05$).

lupin flour were much higher than those prepared by adding 15–30% light buck wheat or amaranth (Rayas-Duarte *et al.*, 1996). Instant noodle samples containing up to 30% lupin flour had higher colour scores than those prepared solely with wheat flour (Jayasena *et al.*, 2008).

Taste and flavour scores of the muffin samples were not affected by the lupin substitution up to 40% level. However, at 50% lupin substitution level, the mean taste and flavour scores decreased significantly (Table 5). It might be due to the beany flavour associated with lupin flour. Taste and flavour of other products was also affected by lupin flour addition at higher levels (>30% levels) mainly due to a beany flavour and an aftertaste (Hall & Johnson, 2004; Jayasena *et al.*, 2008).

Substitution of wheat flour with lupin flour in the muffin demonstrated an improvement in the texture liking by the judges especially at 10% level. It might be due to the gumminess produced by the soluble fibre fraction of lupin flour, which gave a better texture to the products making it more acceptable to the judges. The texture score were significantly lower than that of control at ≥50% levels. This may be due to over gumminess or dryness. Similar results were found in another study in which muffins were prepared by replacing wheat flour with lupin flour at 60% level (Hall & Johnson, 2004). The change in textural properties (increase in hardness and decrease in springiness) of muffins measured by instrumental method looks favourable when compared with sensory texture analysis.

Overall acceptability scores provide a general acceptability of the product based on all the sensory parameters. The muffin samples prepared by replacing wheat flour with up to 40% lupin flour had demonstrate no significant difference from the control sample. At 50% replacement level; however, a significant decrease ($P \leq 0.05$) in the overall acceptability score was observed.

The sensory evaluation results revealed that replacement of wheat flour with lupin flour up to 40% level cause no negative effect on the sensory quality of muffins. It rather improved the sensory quality of the muffins by improving colour and texture qualities. Compared with other similar high dietary fibre flours, lupin flour is more versatile to be added into muffins. Whole mesquite (*Prosopis glandulosa*) flour containing 23–26% crude fibre could only be added to muffins at 10% level (Zolfaghari *et al.*, 1986). Lupin flour can also be added into a range of other products at variable levels (depending upon the type of product) such as bread, pasta, instant noodles, cookies, tofu and tempe (Hall & Johnson, 2004; Jayasena *et al.*, 2007, 2008, 2010).

Conclusions

Lupin flour can be successfully incorporated into muffins by replacing up to 30% of the wheat flour. By replacing wheat flour with lupin flour at 30% level in muffin formulation, substantial improvement in the protein and fibre contents can be achieved without affecting physical and sensory properties. Addition of lupin rather improved the sensory properties of colour and texture of muffins making it more attractive to the consumers. As compared with other natural protein and dietary fibre sources, lupin flour is lower in cost. Therefore, substitution of sweet lupin flour would improve the nutritional value and quality of muffins at economically affordable price.

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