Roller milled black gram (*Phaseolus mungo*) semolina and its influence on the quality characteristics of high protein pasta

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Abstract Black gram (*Phaseolus mungo*) was roller milled into semolina (BGS) and was substituted at 25, 50 and 75 % levels in vermicelli making in this investigation. There was an increase in ash and protein content as the inclusion of BGS in blends increased. The quality characteristics of pasta showed marginal increase in cooking loss up to 50 % level of BGS. The firmness value did not change much up to 50 % BGS in pasta. At 75 % level of BGS, the cooking loss and stickiness value were highest (6.10 % and 0.90 N) whereas firmness value and overall quality score were lowest (4 N and 27.5/40) indicating that the pasta had mushy, indiscrete, sticky strands and had a prominent beany odour making it unacceptable. Hence 50 % BGS was considered optimum in vermicelli. The pasta made with 50 % BGS inclusion had a protein and dietary fiber content of 15.30 % and 8 % as against the control value of 11.30 and 4.20 % respectively.

Keywords Black gram semolina · Roller milling · Vermicelli Color · Firmness · Stickiness

Introduction

The production of pasta products is increasing in India and the popularity could be attributed to its, low cost, ease of preparation, sensory quality and good storage stability (Sowbhagya and Ali 2001). Pulses are important food crops in many countries due to their high levels of protein and essential

amino acid content. (Patterson et al. 2009). Pasta is recognized as low in sodium and fat and has no cholesterol and is a rich source of complex carbohydrates (Giese 1992). The lysine content of legume flours is much higher than that found in the durum semolina. Lot of studies are reported on the use of legumes added to pasta to improve the nutritional quality (Zhao et al. 2005; Herken et al. 2006; Shogren et al. 2006; Wood 2009).

Black gram is one of the major pulse crops in India. Annually India produces about 1.82 million tons of black gram and is a major producer (Wani et al. 2012). It is used in the form of whole seed or dehusked splits (Tiwari et al. 2007). In India, split black gram is mainly used in the preparation of fermented foods such as idli, papadams, dosa and other regional fermented foods (Reddy et al. 1982; Nawab 2000). Black gram split (dhal) has 24 g protein, 1.4 g fat, 154 mg calcium, 385 mg phosphorus, 3.8 mg iron and 11.7 g total dietary fibre per 100 g of dhal (Gopalan et al. 2002). Powdered legumes are generally added in the fortification studies. This study was carried out with the aim of using legume in the semolina form which is milled by employing a roller mill. It offers a great deal of convenience to the pasta industries as it can be readily added to the durum wheat during pasta processing. Reports on the roller milling of legumes, its utilization and effect on the quality characteristics of pasta are scanty.

Materials and methods

Roller milling of black gram semolina (BGS)

The flow sheet for roller milling of BGS is shown in Fig. 1. Split black gram was cleaned by using the standard apparatus labofix (Schmidt-Seeger GmbH, Germany) to remove all foreign matters like dust, dirt etc.

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Fig. 1 Flow sheet for roller milling of black gram semolina. B1 & B2: Break rolls

Buhler MLU- 202 laboratory-scale mill was used to mill the cleaned black gram (split). The Buhler mill, which is a six-pass roller mill, consists of three break (B1, B2 and B3) and three reduction rolls. Each of the passage had sifter with two siftings (above and below sifting, respectively). The B1 roll gap was so adjusted that it gave a big granular semolina with minimum flour yield. The ground stock from B1 was sifted in the sifter for the size grading. The first scalping was further processed by break passages. The over-tails (semolina) from the flour sieves of all break passages were packed. The reduction rolls were kept disconnected to the break rolls during the milling operations.

Analysis of BGS

The particle size of BGS so obtained was around 550 µ. The BGS was analyzed for ash and protein according to AACC (2000) method and fat according to AOAC (1995) methods.

Durum semolina (DS)

Durum semolina was procured from the local market and it was replaced by BGS at 25, 50 and 75 % levels in the preparation of high protein pasta.

The DS was analyzed for ash and protein according to AACC (2000) and fat according to AOAC (1995) methods respectively.

Preparation of blends

The blends were prepared in the following ratio DS: BGS 100:0 (control); 75:25; 50:50; 25:75. The chemical characteristics of these blends ash and protein were analysed according to AACC methods (2000). Fat estimation was carried out using standard AOAC methods (1995).

Vermicelli dough preparation

The vermicelli dough was prepared by mixing 500 g batch size. The DS and BGS were mixed in the ratio as follows DS: BGS; 500:0; 375: 125; 250: 250; and 125: 375. The vermicelli dough was made using a Hobart mixer model N-50, Ontario (Canada) mixing at 104 rpm for 8 min adding 195, 185, 175 and 160ml water respectively till coffee bean size dough pieces were formed. Extruder (La Monferrina, Italy) fitted with die having a perforation of 0.7 mm diameter was used for extruding vermicelli dough. The vermicelli dough was dried for 3 h at 75 °C in an hot air oven (Shrisat Electronics, Mumbai) according to the method of Jyotsna et al. (2011).

Raw vermicelli analysis

Colour measurement

The colour of raw vermicelli with different levels of BGS 0, 25, 50 and 75 % were carried out using Hunter Lab colour measuring system, Model labscan XE (Reston, USA). The L a b scale was used wherein 'L' represents degree of lightness value, 'a' is the intensity of colour in the direction of green to red, 'b' is the intensity of colour in the direction of blue to yellow.

Amylograph characteristics of dried legume pasta

The effect of incorporation of BGS on the dried pasta was studied using Micro-visco amylograph (Model No.803201, Brabender, Germany) according to AACC methods (2000).

Cooked vermicelli analysis

Colour measurement

The colour measurement of cooked pasta was carried out as described under colour measurement of raw vermicelli.

Physical characteristics of BGS pasta

Cooked weight

The vermicelli made with BGS at different levels were cooked for 11 min and drained for 5 min and cooked weight recorded and reported in grams. The average of three values were reported.

Cooking loss

The vermicelli cooking quality was evaluated according to the ISI (1993) method (IS: 1485).

Texture of cooked GGS pasta

The firmness was measured as described by Walsh et al. (1970) with the aid of a texture analyser (Model Tahdi, Stable Microsystems, Surrey, UK) using Blade set with knife. Five Cooked vermicelli strands having a length of 5 cms were kept on the sample holder and sheared at 90° angle with a cross head speed of 90 mm per minute and load cell of 5 kg. The stickiness of vermicelli was determined according to the method of Oh et al. (1983). Excess water was removed from the cooked vermicelli strands by blotting using a tissue before the test. Ten cooked vermicelli strands were placed on the sample holder and compressed under a plunger and upon lifting the plunger to measure force of adhesion of the plunger to the vermicelli. A load cell of - 5 kg, cross head speed of 5 mm per minute and compression force of 3000 g was used in the experiment.

Sensory evaluation

A panel of experienced judges carried out the sensory evaluation of cooked vermicelli with BGS at different levels for the following parameters: appearance (10), strand quality (10), mouthfeel (10), flavour (10) and overall quality score (40) is the combined score of all the above parameters. The sensory evaluation of pasta was done according the method of Jyotsna et al. (2011).

Composition of pasta

The moisture and total ash of the dried control durum pasta and pasta made with optimum level of BGS were estimated according to ISI (1993, IS 1485) method. Fat and dietary fiber estimation was carried out using standard AOAC methods (1995). Protein was analyzed according to AACC methods (2000).

Statistical analysis

Statistical analysis of data was done by using Duncan's New Multiple Range Test as described by Steel and Torrie (1960). Different experimental groups appropriate to the completely randomized design with three replicates were used.

Results and discussion

Chemical characteristics of DS-BGS blends

The particle size of BGS obtained was around 550 μ . The durum semolina had 0.75 % ash, 2.05 % fat, 11.80 % protein and 12.6 % dry gluten. BGS sample had 2.90 % ash, 1.40 % fat and 22.50 % protein.

An increase in ash and protein contents were observed when the level of BGS inclusion increased in blend (Table 1). The

Table 1 Chemical characteristics of DS-BGS blends

Semolina blends	Total ash (%)	Fat (%)	Protein (%)
DS:BGS			
100:0	0.75 $\pm$ 0.02	2.05 $\pm$ 0.02	11.50 $\pm$ 0.03
0:100	2.90 $\pm$ 0.02	1.40 $\pm$ 0.02	22.50 $\pm$ 0.02
75:25	1.29 $\pm$ 0.03	1.88 $\pm$ 0.02	14.48 $\pm$ 0.03
50:50	1.82 $\pm$ 0.03	1.72 $\pm$ 0.01	17.20 $\pm$ 0.03
25:75	2.36 $\pm$ 0.04	1.56 $\pm$ 0.01	19.85 $\pm$ 0.04

Values are means of three replicates $\pm$ standard deviation

All values are expressed on 14 % moisture basis

DS Durum Semolina, BGS Black gram semolina

protein of blends with 25–75 % BGS were 14.48–19.85 %. A similar observation was made when legume levels increased in wheat flour-legume blends by Hallen et al. (2004) and Jyotsna et al. (2012) in their studies on legume incorporated breads and cookies.

Amylograph characteristics of BGS pasta

Figure 2 represents the data on the influence of BGS on the amylograph characteristics of dried pasta. As the level of BGS increased, a decrease in peak viscosity, hot paste viscosity, cold paste viscosity and set back values were observed. This could be due to higher non starchy polysaccharide content of legumes which is higher than that of durum wheat. Wood (2009) opined that chickpea fortified spaghetti also showed a similar trend and that the non starchy polysaccharides of legumes form a less viscous gel after cooking and cooling of blends with higher amount of legume. A similar effect was observed in our studies as well.

Colour measurement of uncooked and cooked vermicelli

The data on the colour measurement of uncooked and cooked BGS pasta is presented in Table 2. It is evident from the table

Fig. 2 Effect of BGS on the amylograph characteristics of dried pasta BGS Black gram semolina, PV peak viscosity, HPV hot paste viscosity, CPV cold paste viscosity, SB set back, BU Brabender units

Table 2 Colour measurements (Measured using Hunter Lab Colour system) of uncooked and cooked BGS pasta

Uncooked Pasta	L	a	b
DS:BGS			
100:0	70.00±0.03	3.25±0.01	23.20±0.02
75:25	79.35±0.03	2.11±0.03	20.30±0.03
50:50	81.30±0.03	1.88±0.03	20.05±0.03
25:75	81.80±0.02	1.14±0.03	19.00±0.03
Cooked Pasta			
DS:BGS			
100:0	62.20±0.03	0.96±0.01	17.64±0.04
75:25	63.70±0.02	1.42±0.03	18.80±0.03
50:50	64.90±0.02	2.28±0.03	19.75±0.03
25:75	65.10±0.02	1.90±0.03	19.60±0.03

L = lightness / darkness, ± a: red / blue, ± b: yellow / green, Values are means of three replicates ± standard deviation

DS Durum Semolina, BGS Black gram semolina

that the uncooked vermicelli samples became brighter (higher 'L' values), less red in color (lower 'a' values) and less yellow (lower 'b' values) in colour as the percent BGS increased in blend. In case of cooked BGS pasta, there was an increase in L values indicating an increase in brightness. This could be due to initial higher lightness value of BGS (77.3) when compared with the value of DS (70). Zhao et al. (2005) and Wood (2009) reported that legume fortified pastas had less bright colour represented by lower L values and more red colour as the amount of legume increased.

Effect of BGS on the physical characteristics of cooked pasta

The data on the physical characteristics of cooked BGS pasta is presented in Fig. 3. The data on the physical characteristics of pasta showed that there was a decrease in the cooked weight of pasta as against the control value. The cooked weight of the

Fig. 3 Effect of BGS on the physical characteristics of cooked pasta. BGS black gram semolina

control durum pasta was 94.2 g/25 g. It ranged from 86.2 to 80.10 g /25 g for pasta made with 25–75 % of BGS. The cooking loss increased from 3.40 % to 6.10 % with 0–75 % of BGS in blend. The cooking loss was highest (6.10 %) for pasta made with 75 % BGS. The firmness value was 6.74 N for the control pasta and it decreased to 6.30, 5.90 and 4.00 N for pasta having 25, 50 and 75 % BGS respectively. The stickiness values of pasta varied marginally up to 50 % BGS whereas it increased at 75 % BGS level. Duarte et al. (1996) also reported increase in adhesiveness values at 15 % level of incorporation of lupin in spaghetti. The strands of pasta with 75 % BGS were mushy and indistinct. The strands were sticky as well. The pasta containing 75 % BGS was not acceptable. Hence pasta with 50 % BGS was optimum. Wood (2009) stated in his study on chickpea fortified pasta that the firmness, stickiness and cooking loss may be influenced by the protein and polysaccharide matrix. Other researchers have also made similar observations on legume incorporated pasta (Zhao et al. 2005; Duarte et al. 1996).

Effect of BGS on the sensory quality characteristics of pasta

The effect of different level of BGS on the sensory quality of pasta is presented in Table 3. The score for appearance was

Table 3 Effect of BGS on the sensory characteristics of pasta

Blends DS:BGS	Appearance (10)	Strand quality (10)	Mouth feel (10)	Flavour (10)	Overall quality score (40)
Control	9.5 ^b ±0.3	9.5 ^b ±0.3	9.5 ^c ±0.2	9.5 ^d ±0.2	38.0 ^d ±0.4
25	9.5 ^b ±0.1	9.5 ^b ±0.2	9.5 ^c ±0.3	9.0 ^c ±0.1	37.5 ^c ±0.3
50	9.5 ^b ±0.2	9.5 ^b ±0.2	9.0 ^b ±0.1	8.5 ^b ±0.1	36.5 ^b ±0.2
75	7.5 ^a ±0.2	7.0 ^a ±0.1	6.5 ^a ±0.1	6.0 ^a ±0.1	27.0 ^a ±0.3

Overall quality score out of 40 is the combined score of appearance, strand quality mouth feel and flavour, Values are means of three replicates ± standard deviation, Means in the same column followed by different letter differ significantly ($P \leq 0.05$)

DS Durum Semolina, BGS Black gram semolina

Table 4 Composition of pasta

Parameters	Control Pasta	50 % BGS Pasta
Moisture (%)	3.22±0.03	4.95±0.04
Total ash (g/100 g)	1.10±0.03	3.08±0.03
Protein (%)	11.30±0.02	15.30±0.03
Fat (%)	1.38±0.04	1.81±0.02
Total Dietary Fiber (%)	4.20±0.02	8.00±0.02
Carbohydrates (by calculation, %)	78.8	66.90

per 100 g of pasta, Values are means of three replicates ± standard deviation

BGS Black gram semolina

similar to that of control durum pasta up to the level of 50 % BGS. The score decreased at 75 % BGS and was the lowest as the pasta appeared very whitish in colour. The strand quality, mouth feel and flavor was good up to the level of 50 % level of BGS as shown by the score of individual parameters which were similar to the control. The pasta prepared with 75 % BGS had the lowest overall score of 27 out of 40 and the strands were sticky possessing a beany and slimy mouth feel making it undesirable. The optimum level of fortification of BGS was 50 % in vermicelli as the quality characteristics were not adversely affected. Lorenz et al. (1979) in his study on faba bean noodles observed that at 40 % level of legume the noodles had beany flavor. Sudha et al. (2011) stated that at 15 % level of defatted soya flour the instant vermicelli had a beany taste.

Composition of pasta

The data on the composition of pasta is presented in Table 4. The data showed that the protein content increased by 4 % and dietary fibre by 3.8 % with 50 % BGS incorporation in vermicelli. The BGS pasta with 50 % BGS had 15.30 and 8 % protein and dietary fibre respectively as against the control values of 11.30 and 4.20 %. Increase in protein content of pasta by legume incorporation has also been reported by Reinhard et al. (1988); Zhao et al. (2005).

Conclusions

The ash and protein contents showed an increase as the level of BGS increased in blend from 25 % to 75 %. A decrease in amylograph parameter values of dried pasta were observed as the level of BGS inclusion increased owing to higher non starch polysaccharide content in legumes. Pasta quality was adversely affected at 75 % level of BGS inclusion as shown by lower firmness values, higher stickiness values, indiscrete strands with dominant beany flavor. Thus the optimal level of BGS inclusion in pasta was 50 % and the pasta had 15.30 % protein and 8 % dietary fibre as against the control pasta values of 11.30 and 4.20 % respectively. Thus roller milled black gram semolina can be used to produce high protein pasta.

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