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# Effect of different ratios of wheat flour to black bean (*Phaseolus vulgaris* L.) flour on physicochemical properties and sensory acceptability of cooked noodle

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**Abstract**

Wheat noodles are a popular staple food and their consumption has increased worldwide due to convenience, nutritional and sensory quality, palatability as well as reasonable price. However, the refining process of wheat flour contributed to the decreasing mineral and fibre content of noodles. The present study aimed to determine the effect of different ratios of wheat flour to black bean flour on physicochemical properties and sensory acceptability of cooked noodles. Wheat flour was substituted with black bean flour at 5 levels: 0%, 5%, 10%, 15% and 20%. The cooked noodles were analyzed for proximate composition, cooking loss, colour profile and texture profile in triplicate. Sensory evaluation was carried out using an acceptance test of a 7-point hedonic scale. Proximate results showed that the ash, protein, fat and fibre content of cooked noodles had increased significantly ($p<0.05$) when the percentage of black bean flour increased. The ash content and crude fibre content of cooked noodles incorporated with 20% black bean flour were 0.63±0.02% and 0.79±0.06% respectively. The cooking loss of noodles also increased from 3.61±0.34% to 5.16±0.51% when the percentage of black bean flour increased from 0% to 20%. Although the substitution of 15-20% of black bean flour enhances the nutritional value of noodles, the sensory acceptance decreased due to the undesirable dark colour and hard texture. Therefore, this study suggested that the addition of black bean flour up to 10% is the potential to be used as a functional ingredient with promising the physical characteristics and nutritional value of the noodle without affecting their sensory quality.

## 1. Introduction

Noodles have been the staple food for many Asian countries and can be made from wheat, rice or other raw materials such as starch with the addition of salt and/or alkali (Hau, 2010). Wheat-based noodles can be classified as white-salted noodles (WSN) and yellow alkaline noodles (YAN) depending on the type of salt used (Foo *et al.,* 2011). Although whole-wheat products have many beneficial effects on health, the acceptance of whole-wheat products was limited due to unfavourable taste and texture (Hsieh *et al.,* 2017). Whole wheat pasta had weak dough properties, higher cooking loss, and reduced cooked firmness (Delcour and Poutanen, 2013).

An alternative to increase and improve the consumption of beans is by processing the bean into flours, which can be used as functional ingredients in the preparation of foods (Santiago-Ramos *et al.,* 2018). Legumes have been used in several noodle products such as the addition of mung bean in rice noodles (Wu *et al.,* 2015), the addition of legumes flour in rice pasta (Bouasla *et al.,* 2017) and the incorporation of rajma bean in noodles (Kumar and Prabhasankar, 2015). Black beans (*Phaseolus vulgaris* L.) are a rich source of protein, carbohydrate, dietary fibre, vitamins, minerals and phytochemicals. These compounds can prevent or manage chronic diseases, resistant starch content and protein digestibility (Rosa-Millan *et al.,* 2019).

The addition of other flours such as buckwheat flour, sweet potato flour, oat flour and yam flour has negatively affected the textural quality of noodles (Mitra *et al.,* 2012; Olorunsogo *et al.,* 2019; Sun *et al.,* 2019). Black bean flour is less commercially known and lacks application in food products. Dry beans are essential sources of protein, energy and dietary fibre which can be

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added to food products to enhance their nutritional qualities and will have a positive effect on improving the hardness and quality noodles. The incorporation of black beans in new product development is important to give added value to the black bean flour. Therefore, this study aimed to determine the effect of different ratios of wheat flour and black bean flour on physicochemical properties and sensory acceptability of cooked noodles.

## 2. Materials and methods

### *2.1 Materials*

Black beans were purchased from the local market in Ipoh, Perak. Wheat flour and salt were purchased from the local hypermarket in Kuala Nerus, Terengganu, Malaysia.

### *2.2 Preparation of black bean flour*

The black beans were cleaned and any broken seeds were removed. Then, 1 kg of beans was washed and drained. The cleaned black beans were dried in an oven dryer at 60°C for 24 hrs (Hashim *et al.,* 2019) and the moisture content of the black beans has been checked using a moisture analyzer (RADWAG MAC 50, Poland). The moisture content of black beans was measured and should be maintained at a moisture level of 12.0±2.0%. The dried beans were ground using a mortar grinder (RETSCH RM 100, Germany) and sieved using a 500 µm stainless steel sieve.

### *2.3 Preparation of cooked noodle*

The noodles were prepared from different ratios of wheat flour to black bean flour (100:0, 95:5, 90:10, 85:15 and 80:20) according to Mitra *et al.* (2012) and Cheng and Bhat (2016) with minor modifications as presented in Table 1. The ratios used are selected due to the suitable range of bean flour substitution to wheat flour in noodle formulation. The wheat flour, black bean flour and salt were mixed and water was added until the dough reached the desired consistency. The mixture of dough was kneaded and allowed to rest for 5 mins for gluten development. The dough was rolled into a sheet using a noodle maker (Marcato Ampia 150, Italy) with a thickness setting of 4. The noodles sheet was then cut into strands and cooked in boiling water for 1 min. The cooked noodles were drained off excess water for 2 mins. The cooked noodles were then packed in polypropylene packages and stored at 4°C until further analysis.

Table 1. Proportion of wheat flour to black bean flour in noodle

| Formulation | Weight of wheat flour (g) | Weight of black bean flour (g) | Wheat flour (%) | Black bean flour (%) |
|---|---|---|---|---|
| A | 730.0 | 0.0 | 100 | 0 |
| B | 693.5 | 36.5 | 95 | 5 |
| C | 657.0 | 73.0 | 90 | 10 |
| D | 620.5 | 109.5 | 85 | 15 |
| E | 584.0 | 146.0 | 80 | 20 |

Note: 100% of wheat flour refer to 730 g of total weight of noodle

### *2.4 Proximate analysis*

Determination of moisture, ash, crude fat, crude protein, crude fibre, and carbohydrate content of cooked noodles with different ratios of wheat flour to black bean flour was carried out according to AOAC, (2000) and all the analyses were performed in triplicate.

### *2.5 Physical analysis*

Physical analyses in terms of determination of cooking loss, colour and texture profile of cooked noodles with different ratios of wheat flour to black bean flour were carried out in triplicate.

#### *2.5.1 Determination of cooking loss*

A 10 g sample of noodles was placed into 500 mL of boiling distilled water. The boiled noodle was rinsed using 50 mL of distilled water. The cooking and rinsing water were collected and dried in an air oven at 105°C until dry. The residue was weighed and reported as a percentage of the starting material. Cooking time was evaluated by observing the time of disappearance of the core of the noodles strand during cooking (every 30 s) squeezing the noodles between two transparent glass slides. The percentages of cooking loss were calculated according to Bouasla *et al.* (2017) as follows:

$$\text{Percentage of cooking loss (\%)} = \frac{\text{Weight of dried residue (g)}}{\text{Weight of sample (g)}} \times 100$$

#### *2.5.2 Determination of colour profile*

The noodle sample was homogenized using mortar and pestle, placed in a plastic cover and measured using a chromameter (Minolta CR400 chromameter, Japan). Measurement was initiated to read the colour of the noodles according to Foo *et al.* (2011). The colour profile was measured as L*, a* and b* values. L* indicate lightness (with 0 = darkness to 100 = brightness), a* measured the extent of green colour (range from negative = greenness to positive = redness) and b* measured the extent of blue colour (range from negative = blueness to positive = yellowness).

#### *2.5.3 Determination of texture profile*

The texture of cooked noodles was determined by using a TA-XT2 texture analyser (Stable Micro system, UK). The parameters tested were hardness, adhesiveness,

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and tensile strength. Probe P20 was used to determine the hardness and adhesiveness of the noodle. The texture analyzer was calibrated and pre-test speed, test speed and post-test speed were set to 2.00 mm/s. In the determination of the tensile strength of noodles, the type of probe used was spaghetti tensile grips SPR. The pre-test speed was set to 1.00 mm/s, the test speed was set to 2.00 mm/s and the post-test speed was set to 10.00 mm/s (Cao *et al.,* 2021).

*2.6 Sensory evaluation*

Sensory evaluation was carried out using 7-points of the hedonic scale of acceptance test according to Olorunsogo *et al.* (2019) with minor modification. A total of fifty untrained panellists from Universiti Malaysia Terengganu were randomly chosen. Twenty grams of noodle samples for each formulation were served warm with chicken soup. The noodles were cooked in boiling water for 1 min while the chicken soup was prepared by mixing two chicken stock cubes with 1 L of boiling water until dissolved. All the samples were labelled with three digits random numbers. The noodles were evaluated for their colour, appearance, odour, hardness, elasticity, flavour and overall acceptability attributes.

*2.7 Statistical analysis*

Data were expressed as mean±standard deviation. One-way Analysis of Variance (ANOVA) followed by post hoc test of Fisher's Least Significant Difference (LSD) at $p<0.05$ was conducted to determine the significant differences between mean values using MINITAB 14 software (MINITAB Inc., PA, USA).

## 3. Results and discussion

*3.1 Proximate composition of cooked noodle*

*3.1.1 Moisture content*

Table 2 shows the moisture content of cooked noodles with different ratios of wheat flour to black bean flour. The moisture content of cooked noodles significantly decreased ($p<0.05$) as the amount of black bean flour (BBF) increased and wheat flour (WF) decreased. The 100% wheat flour noodle had the highest moisture content (61.08±0.87%), while 80% WF + 20% BBF exhibited the lowest moisture content (56.74±0.70%). The results were in good agreement with the studies done on cookies with the addition of pre-gelatinized black bean flour (Bassinello *et al.,* 2011) and noodles with the addition of rajma beans (Kumar and Prabhasankar, 2015). The high fibre content contributed by the increasing amount of BBF causes the disruption of the gluten matrix in noodles (Makhlouf *et al.,* 2019). Hence, the migration of water is enhanced and leads to the loss in moisture content of the end product (Wang *et al.,* 2018).

*3.1.2 Ash content*

Noodles made from 100% wheat flour had the lowest ash content (0.36±0.05%) while noodles with 80% WF + 20% BBF had the highest value (0.63±0.02%) as illustrated in Table 2. Similar findings were reported on the ash content of cookies with the addition of black bean flour (Bassinello *et al.,* 2011) and flaxseed flour (Kaur *et al.,* 2017). The wheat flour used in this study was a refined milling wheat flour or known as white flour, in which most of the bran and germ had been removed. The removal of the bran and germ during the production of white flour contributes to the loss of many nutrients and minerals (Heshe *et al.,* 2016). Therefore, noodles with 100% wheat flour contain the lowest ash content. In contrast, the addition of black bean flour containing 4.04±0.08% of ash (Du *et al.,* 2014) increased the mineral content of the noodle, especially iron, zinc and copper (Feitosa *et al.,* 2018).

*3.1.3 Crude fat content*

There is a significant difference ($p<0.05$) in the crude fat content of noodles at incorporation levels of 10%, 15% and 20% of black bean flour when compared to the control sample (100% wheat flour noodle) as shown in Table 2. According to Romero and Zhang, (2019) bean flours such as garbanzo, great northern, red kidney and navy beans had higher lipid content as compared to wheat flour. Black bean had 1.90±0.04% of fat content (Du *et al.,* 2014) while refined wheat flour

Table 2. Proximate composition (n = 3) of noodle prepared with different ratios of wheat flour to black bean flour

| Noodle | Moisture (%) | Ash (%) | Fat (%) | Protein (%) | Fibre (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| A | 61.08±0.87$^{a}$ | 0.36±0.05$^{d}$ | 0.81±0.05$^{d}$ | 4.98±0.46$^{d}$ | 0.34±0.04$^{d}$ | 32.43±0.50$^{a}$ |
| B | 59.72±1.58$^{ab}$ | 0.48±0.03$^{c}$ | 0.92±0.06$^{d}$ | 5.60±0.21$^{cd}$ | 0.46±0.05$^{c}$ | 32.82±1.53$^{a}$ |
| C | 59.13±0.81$^{b}$ | 0.55±0.02$^{b}$ | 1.16±0.06$^{c}$ | 6.14±0.19$^{bc}$ | 0.57±0.03$^{b}$ | 32.45±1.03$^{a}$ |
| D | 58.04±1.13$^{bc}$ | 0.60±0.01$^{ab}$ | 1.43±0.13$^{b}$ | 6.76±0.61$^{ab}$ | 0.71±0.06$^{a}$ | 32.46±1.64$^{a}$ |
| E | 56.74±0.70$^{c}$ | 0.63±0.02$^{a}$ | 2.01±0.12$^{a}$ | 7.30±0.59$^{a}$ | 0.79±0.06$^{a}$ | 32.54±0.16$^{a}$ |

Values are presented mean±standard deviation. Values with the different superscript letters in the same column are significantly different ($p< 0.05$). WF – wheat flour, BBF - black bean flour. A: Cooked noodle made from 100% WF + 0% BBF, B: Cooked noodle made from 95% WF + 5% BBF, C: Cooked noodle made from 90% WF + 10% BBF, D: Cooked noodle made from 85% WF + 15% BBF, and E: Cooked noodle made from 80% WF + 20% BBF obtained only 0.72 to 0.92% (Cardoso *et al.,* 2019). Therefore, the addition of bean flours in noodle products will increase their fat content.

*3.1.4 Crude protein content*

The crude protein content of cooked noodles with different ratios of wheat flour to black bean flour is shown in Table 2. The protein content of 100% wheat flour noodles was not significantly different (p>0.05) with the addition of 5% of BBF noodles. While increased the percentage from 10% to 20% of BBF significantly increased the protein content of noodles. A similar observation was reported for pasta made with different beans (Petitot *et al.,* 2010) and gluten-free pasta made with different levels of bean flour (Giuberti *et al.,* 2015). The addition of legumes has been used to increase protein levels and to improve the protein quality of food products (Ramírez-Jiménez *et al.,* 2018). Black bean is a rich source of protein (Los *et al.,* 2018) with 25.37±0.39% (Du *et al.,* 2014) while wheat flour had a protein content of 13.20±0.80% (Cardoso *et al.,* 2019).

*3.1.5 Crude fibre content*

The crude fibre content of noodles increased significantly ($p$<0.05) as the amount of black bean flour increased and wheat flour decreased in the formulation. The noodle made from 100% wheat flour had the lowest crude fibre content (0.34±0.04%), while noodles with 80% WF + 20% BBF had the highest value (0.79±0.06%). A similar result was observed on cookies added with black bean flour (Bassinello *et al.*, 2011) as the common black bean is reported a rich source of dietary fibre with up to 35.7% (Los *et al.,* 2018).

*3.1.6 Carbohydrate content*

Interesting to note that the carbohydrate content of cooked noodles was not significantly affected ($p$>0.05) by the different ratios of WF to BBF. The mean value of carbohydrate content was in the range of 32.43% to 32.82% (Table 2). However, this result was in contrast with studies done with jering seed flour added cookies (Cheng and Bhat, 2016) and noodles enriched with soybean (Rani *et al.,* 2019) which showed a decrease in carbohydrate content. The carbohydrate content of black beans was 44.02±0.40% (Du *et al.*, 2014), while the wheat flour had a carbohydrate content of 85.20±0.80% (Cardoso *et al.,* 2019).

*3.2 Physical properties of cooked noodles*

*3.2.1 Cooking loss of cooked noodles*

The cooking loss of noodles increased significantly ($p$<0.05) as the amount of BBF increased and wheat flour decreased (Table 3). The lowest cooking loss was observed in noodles made from 100% WF (3.61±0.34%), while the highest cooking loss was observed in noodles made from 80% WF + 20% BBF (5.16±0.51%). These results are consistent with a study done by El-Sohaimy *et al.* (2020) with cooking loss of chickpea fortified pasta obtained in the range of 3.37% to 5.79%. The author and co-workers also reported that all the cooking loss obtained values within the acceptable limits since the solid loss was below 10%. Therefore, noodles incorporated with black bean flour in the present study are still of good quality. The starch granule absorbs water and swells rapidly until it breaks and leaching of more solid components into the cooking water (Petitot *et al.,* 2010) while the two gluten proteins, which are gliadin and glutelin, will coagulate and form a compact lattice that envelopes the starch granules. As black bean flour is incorporated into the noodle, non-gluten protein and insoluble fibre play important role in weakening the overall structure of the noodle and thus causing the dissociation of noodle components during cooking (Wojtowicz and Moscicki, 2014).

Table 3: Percentage of cooking loss (n = 3) of cooked noodle prepared with different ratios of wheat flour to black bean flour

| Noodle | Cooking loss (%) |
|---|---|
| A | 3.61±0.34$^{c}$ |
| B | 4.24±0.44$^{bc}$ |
| C | 4.73±0.34$^{ab}$ |
| D | 4.86±0.36$^{ab}$ |
| E | 5.16±0.51$^{a}$ |

Values are presented mean±standard deviation. Values with the different superscript letters in the same column are significantly different ($p$<0.05). WF – wheat flour, BBF - black bean flour. A: Cooked noodle made from 100% WF + 0% BBF, B: Cooked noodle made from 95% WF + 5% BBF, C: Cooked noodle made from 90% WF + 10% BBF, D: Cooked noodle made from 85% WF + 15% BBF, and E: Cooked noodle made from 80% WF + 20% BBF.

*3.2.2 Colour profile of cooked noodle*

The lightness value (L*) of the noodles decreased significantly ($p$<0.05) with increasing the BBF in noodles formulation as illustrated in Table 4. Control sample (100% wheat flour) had highest L* value (75.84±1.99), while noodles made from 80% WF + 20% BBF had lowest L* value (67.08±1.51). Similar results were obtained in the study on pasta fortified with split pea and faba bean due to the high ash content of legume flour (Petitot *et al.,* 2010). As expected, the dark colour of the black bean resulted in the darker colour of flour as well as the end product of noodles. The a* and b* values of noodles were significantly increased ($p$<0.05) with the increasing amount of BBF from -2.61 to -1.09 and 17.67 to 27.22 respectively (Table 4). The addition of black bean flour had changed the noodle to approach brown and yellowish in colour due to the presence of anthocyanin (Mojica *et al.,* 2017) and carotenoid compounds (Hidalgo *et al.,* 2010).

Table 4. Colour profile (n = 3) of cooked noodle prepared with different ratios of wheat flour to black bean flour

| Noodle | Colour profile | | |
|---|---|---|---|
| | L* | a* | b* |
| A | 75.84±1.99$^{a}$ | -2.61±0.03$^{e}$ | 17.67±0.85$^{c}$ |
| B | 73.62±1.65$^{ab}$ | -1.90±0.12$^{d}$ | 19.66±1.38$^{c}$ |
| C | 72.29±1.47$^{bc}$ | -1.45±0.02$^{c}$ | 22.84±1.13$^{b}$ |
| D | 69.85±1.39$^{cd}$ | -1.27±0.06$^{b}$ | 24.69±1.52$^{b}$ |
| E | 67.08±1.51$^{d}$ | -1.09±0.07$^{a}$ | 27.22±1.13$^{a}$ |

Values are presented mean±standard deviation. Values with the different superscript letters in the same column are significantly different ($p < 0.05$). WF – wheat flour, BBF - black bean flour. A: Cooked noodle made from 100% WF + 0% BBF, B: Cooked noodle made from 95% WF + 5% BBF, C: Cooked noodle made from 90% WF + 10% BBF, D: Cooked noodle made from 85% WF + 15% BBF, and E: Cooked noodle made from 80% WF + 20% BBF

*3.2.3 Texture profile of cooked noodle*

The hardness, adhesiveness and tensile strength value of noodles increased significantly ($p<0.05$) with the increasing amount of black bean flour (Table 5). Similar results were observed on noodles with the addition of rajma beans (Kumar and Prabhasankar, 2015), rice noodles with mung bean (Wu *et al.,* 2015) and cooked pasta with legume flour (Bouasla *et al.*, 2017). The hardness and tensile strength value of noodles are associated with the formation of the protein-starch matrix as well as contributed by the fibre of black beans. Increased protein also can lead to a decrease in the water absorption of the gluten network (Sun *et al.,* 2019). While the adhesiveness value contributed by high solubility compounds leached out from enriched noodles during hydration (Bouasla *et al.,* 2017; Zhu and Li, 2019).

*3.3 Sensory acceptability of cooked noodle*

Table 6 shows the mean score of sensory acceptability of cooked noodles prepared from different ratios of wheat flour to black bean flour. There were no significant differences ($p>0.05$) in the mean score of colour, appearance, odour and flavour attributes of noodles adding up to 10% of BBF when compared to 100% wheat flour noodles. As expected, a high percentage of BBF, which is more than 10% of addition promotes darker colour, presence of some particles of black beans on the surface of noodle, harder texture, less elasticity and reduced noodle flavour. Petitot *et al.* (2010) reported a similar trend of decline in sensory acceptability of pasta fortified with split pea and faba bean as well as pasta enriched with legume flour (Wojtowicz and Moscicki, 2014), gluten-free pasta added with pea and lentil (Bouasla *et al.,* 2017) and Mantou (Chinese steam bread) with whole-grain substitution of brown rice and oat (Hsieh *et al.,* 2017). Interestingly to note that the odour acceptability of noodles was not significantly affected by the addition of BBF until up to 20%. This result was in contrast with the addition of the high amount of soybean in the development of food products that generally produced undesirable beany off-flavour (Wang *et al.,* 2021).

Table 5. Texture profile (n = 3) of cooked noodle prepared with different ratios of wheat flour to black bean flour

| Noodle | Texture profile | | |
|---|---|---|---|
| | Hardness (g) | Adhesiveness (gs) | Tensile strength (kPa) |
| A | 5700.58±134.76$^{d}$ | -178.17±9.11$^{e}$ | 38.0±1.3$^{d}$ |
| B | 6238.37±141.95$^{c}$ | -194.37±2.11$^{d}$ | 43.3±2.1$^{d}$ |
| C | 6601.42±183.11$^{b}$ | -221.79±6.32$^{c}$ | 54.4±2.6$^{c}$ |
| D | 7052.60±107.67$^{a}$ | -249.12±1.45$^{b}$ | 61.8±5.2$^{b}$ |
| E | 7287.94±93.15$^{a}$ | -282.21±8.13$^{a}$ | 71.2±1.6$^{a}$ |

Values are presented mean±standard deviation. Values with the different superscript letters in the same column are significantly different ($p < 0.05$). WF – wheat flour, BBF - black bean flour. A: Cooked noodle made from 100% WF + 0% BBF, B: Cooked noodle made from 95% WF + 5% BBF, C: Cooked noodle made from 90% WF + 10% BBF, D: Cooked noodle made from 85% WF + 15% BBF, and E: Cooked noodle made from 80% WF + 20% BBF

Table 6. Sensory acceptability mean score (n = 50) of cooked noodle prepared with different ratios of wheat flour and black bean flour

| Noodle | Colour | Appearance | Odour | Hardness | Elasticity | Flavour | Overall acceptance |
|---|---|---|---|---|---|---|---|
| A | 5.38±1.54$^{ab}$ | 5.42±1.51$^{a}$ | 5.22±1.33$^{a}$ | 5.92±0.99$^{a}$ | 5.82±1.22$^{a}$ | 5.24±1.38$^{a}$ | 5.72±1.20$^{a}$ |
| B | 5.48±1.04$^{a}$ | 5.44±1.13$^{a}$ | 5.18±1.10$^{a}$ | 5.44±1.07$^{ab}$ | 5.36±1.19$^{ab}$ | 5.06±1.41$^{a}$ | 5.26±1.05$^{ab}$ |
| C | 5.36±1.21$^{ab}$ | 5.28±1.21$^{a}$ | 5.12±1.29$^{a}$ | 5.10±1.37$^{bc}$ | 5.14±1.37$^{bc}$ | 4.92±1.24$^{ab}$ | 5.04±1.25$^{bc}$ |
| D | 4.86±1.53$^{bc}$ | 4.72±1.46$^{b}$ | 4.82±1.42$^{a}$ | 4.88±1.51$^{c}$ | 4.74±1.54$^{c}$ | 4.38±1.47$^{b}$ | 4.54±1.42$^{d}$ |
| E | 4.50±1.53$^{c}$ | 4.54±1.46$^{b}$ | 4.92±1.19$^{a}$ | 5.12±1.29$^{bc}$ | 4.80±1.40$^{c}$ | 4.38±1.48$^{b}$ | 4.66±1.29$^{cd}$ |

Values are presented mean scores±standard deviation. Values with the different superscript letters in the same column are significantly different ($p < 0.05$). WF – wheat flour, BBF - black bean flour. A: Cooked noodle made from 100% WF + 0% BBF, B: Cooked noodle made from 95% WF + 5% BBF, C: Cooked noodle made from 90% WF + 10% BBF, D: Cooked noodle made from 85% WF + 15% BBF, and E: Cooked noodle made from 80% WF + 20% BBF. Score 1 (dislike extremely) - 7 (like extremely).

 

## 4. Conclusion

The addition of black bean flour into the noodle had increased its ash, protein, fat and fibre content. Although the nutritional content of noodles had improved, other aspects such as its cooking loss and textural quality had been negatively affected when the amount of black bean flour increased. However, the noodles produced by the addition of black bean flour can be considered to have good cooking quality since the cooking loss value is less than 10%. The incorporation of a high amount of black bean flour had increased the hardness, adhesiveness and tensile strength properties which also contributed to the decrease in the eating quality of the noodle. In terms of sensory quality, noodle incorporated with 10% black bean flour are considered to have better acceptability to the panellists and shows no significant difference with 100% wheat flour noodles. This study suggested that black bean flour has a potential functional food ingredient to be applied in food products.

## Conflict of interest

The authors declare no conflict of interest.

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## References

AOAC. (2000). Official Methods of Analysis of AOAC International. 17th ed. Washington DC. USA: AOAC.

Bassinello, P.Z., Freitas, D.G.C., Ascheri, J.L.R., Takeiti, C.Y., Carvalho, R.N., Koakuzu, S.N. and Carvalho, A.V. (2011). Characterization of cookies formulated with rice and black bean extruded flours. *Procedia Food Science,* 1, 1645-1652. https://doi.org/10.1016/j.profoo.2011.09.243

Bouasla, A., Wojtowicz, A. and Zidoune, M.N. (2017). Gluten-free precooked rice pasta enriched with legumes flours: physical properties, texture, sensory attributes and microstructure. *LWT - Food Science and Technology*, 75, 569-577. https://doi.org/10.1016/j.lwt.2016.10.005

Cao, Z.-B., Yu, C., Yang, Z., Xing, J.-J., Guo, X.-N. and Zhu, K.-X. (2021). Impact of gluten quality on textural stability of cooked noodles and the underlying mechanism. *Food Hydrocolloids,* 119, 106842. https://doi.org/10.1016/j.foodhyd.2021.106842

Cardoso, R.V.C., Fernandes, A., Heleno, S.A., Rodrigues, P., Gonzaléz-Paramás, A.M., Barros, L. and Ferreira I.C.F.R. (2019). Physicochemical characterization and microbiology of wheat and rye flours. *Food Chemistry,* 280, 123-129. https://doi.org/10.1016/j.foodchem.2018.12.063

Cheng, Y.F. and Bhat, R. (2016). Functional, physicochemical and sensory properties of novel cookies produced by utilizing underutilized jering (*Pithecellobium jiringa jack.*) legume flour. *Food Bioscience,* 14, 54-61. https://doi.org/10.1016/j.fbio.2016.03.002

Delcour, J.A. and Poutanen, K. (2013). Fibre-rich and wholegrain foods, p. 291-308. Cambridge, United Kingdom: Woodhead Publishing Series in Food Science, Technology and Nutrition. https://doi.org/10.1533/9780857095787

Du, S-K., Jiang, H., Yu, X. and Jane, J. (2014). Physicochemical and functional properties of whole legume flour. *LWT - Food Science and Technology,* 55(1), 308-313. https://doi.org/10.1016/j.lwt.2013.06.001

El-Sohaimy, S.A., Brennan, M., Darwish, A.M.G. and Brennan, C. (2020). Physicochemical, texture, and sensorial evaluation of pasta enriched with chickpea flour and protein isolate. *Annals of Agricultural Sciences,* 65(1), 28-34. https://doi.org/10.1016/j.aoas.2020.05.005

Feitosa, S., Greiner, R., Meinhardt, A-K., Muller, A., Almeida, D.T. and Posten, C. (2018). Effect of traditional household processes on iron, zinc and copper bio accessibility in black bean (*Phaseolus vulgaris* L.). *Foods,* 7(8), 123-132. https://doi.org/10.3390/foods7080123

Foo, W.T., Yew, H.S., Liong, M.T. and Azhar, M.E. (2011). Influence of formulations on textural, mechanical and structural breakdown properties of cooked yellow alkaline noodles. *International Food Research Journal,* 18(4), 1295-1301.

Giuberti, G., Gallo, A., Cerioli, C., Fortunati, P. and Masoero, F. (2015). Cooking quality and starch digestibility of gluten free pasta using new bean flour. *Food Chemistry,* 175, 43-49. https://doi.org/10.1016/j.foodchem.2014.11.127

Hashim, M.A., Yahya, F. and Mustapha, W.A.W. (2019). Effect of different drying methods on the morphological structure, colour profile and citral concentration of lemongrass (*Cymbopogon citratus*) powder. *Asian Journal of Agriculture and Biology,* 7 (1), 93-102.

Hau, G.G. (2010). Asian noodles: Science, Technology and Processing. USA: John Wiley and Son, Inc. https://doi.org/10.1002/9780470634370

 

Heshe, G.G., Haki, G.D., Woldegiorgis, A.Z. and Gemede, H.F. (2016). Effect of conventional milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. *Food Science and Nutrition*, 4(4), 534-543. https://doi.org/10.1002/fsn3.315

Hidalgo, A., Brandolini, A. and Pompei, C. (2010). Carotenoids evolution during pasta, bread and water biscuit preparation from wheat flours. *Food Chemistry,* 121(3), 746-751. https://doi.org/10.1016/j.foodchem.2010.01.034

Hsieh, P-H., Weng, Y-M., Yu, Z-R. and Wang, B-J. (2017). Substitution of wheat flour with wholegrain flours affects physical properties, sensory acceptance, and starch digestion of Chinese steam bread (Mantou). *LWT - Food Science and Technology,* 86(1), 571-576. https://doi.org/10.1016/j.lwt.2017.08.051

Kaur, P., Sharma, P., Kumar, V., Panghal, A., Kaur, J. and Gat, Y. (2017). Effect of addition of flaxseed flour on phytochemical, physicochemical, nutritional, and textural properties of cookies. *Journal of the Saudi Society of Agricultural Sciences,* 18(4), 372-377. https://doi.org/10.1016/j.jssas.2017.12.004

Kumar, S.B. and Prabhasankar, P. (2015). A study on starch profile of rajma bean (*Phaseolus vulgaris*) incorporated noodle dough and its functional characteristics. *Food Chemistry,* 180, 124-132. https://doi.org/10.1016/j.foodchem.2015.02.030

Los, F.G.B., Zielinski, A.A.F., Wojeicchowski, J.P., Nogueira, A. and Demiate, I.M. (2018). Beans (*Phaseolus vulgaris* L.): whole seeds with complex chemical composition. *Current Opinion in Food Science,* 19(2), 63-71. https://doi.org/10.1016/j.cofs.2018.01.010

Makhlouf, S., Jones, S., Ye, S.H., Sancho-Madriz, M., Burns-Whitmore, B. and Li, Y.O. (2019). Effect of selected dietary fibre sources and addition levels on physical and cooking quality attributes of fibre-enhanced pasta. *Food Quality and Safety,* 3(2), 117–127. https://doi.org/10.1093/fqsafe/fyz010

Mitra, S., Cato, L., James, A.P. and Solah, V.A. (2012). Evaluation of white salted noodles enriched with oat flour. *Cereal Chemistry,* 89(2), 117-125. https://doi.org/10.1094/CCHEM-07-11-0085

Mojica, L., Berhow, M. and de Mejia, E.G. (2017). Black bean anthocyanin-rich extracts as food colorants: Physicochemical stability and antidiabetics potential. *Food Chemistry,* 229, 628-639. https://doi.org/10.1016/j.foodchem.2017.02.124

Olorunsogo, S.T., Adebayo, S.E., Orhevba, B.A. and Awoyinka, T.B. (2019). Sensory evaluation of instant noodles produced from blends of sweet potato, soy bean and corn flour. *Food Research,* 3 (5), 515-524. https://doi.org/10.26656/fr.2017.3(5).305

Petitot, M., Boyer, L., Minier, C. and Micard, V. (2010). Fortification of pasta with split pea and faba bean flours: Pasta processing and quality evaluation. *Food Research International*, 43(2), 634-641. https://doi.org/10.1016/j.foodres.2009.07.020

Ramírez-Jiménez, A.K., Gaytán-Martínez, M., Morales-Sánchez, E. and Loarca-Piña, G. (2018). Functional properties and sensory value of snack bars added with common bean flour as a source of bioactive compounds. *LWT-Food Science and Technology,* 89, 674-680. https://doi.org/10.1016/j.lwt.2017.11.043

Rani, S., Singh, R., Kamble, D.B., Upadhyay, A. and Kaur, B.P. (2019). Structural and quality evaluation of soy enriched functional noodles. *Food Bioscience,* 32, 100465. https://doi.org/10.1016/j.fbio.2019.100465

Romero, H.M. and Zhang, Y. (2019). Physicochemical properties and rheological behaviour of flours and starches from four bean varieties for gluten-free pasta formulation. *Journal of Agriculture and Food Research,* 1, 100001. https://doi.org/10.1016/j.jafr.2019.100001

Rosa-Millan, J., Heredia-Olea, E., Perez-Carrillo, E., Guajardo-Flores, D. and Serna-Saldívar S.R.O. (2019). Effect of decortication, germination and extrusion on physicochemical and in vitro protein and starch digestion characteristics of black beans (*Phaseolus vulgaris* L.). *LWT – Food Science and Technology,* 102, 330-337. https://doi.org/10.1016/j.lwt.2018.12.039

Santiago-Ramos, D., Figueroa-cárdenas, J.D., Véles-medina, J.J. and Salazar, R. (2018). Physicochemical properties of nixtamalized black bean (*Phaseolus vulgaris* L.) flours. *Food Chemistry,* 240, 456-462. https://doi.org/10.1016/j.foodchem.2017.07.156

Sun, K-N., Liao, A-M., Zhang, F., Thakur, K., Zhang, J-G., Huang, J-H. and Wei, Z.J. (2019). Microstructural, textural, sensory properties and quality of wheat-yam composite flour noodles. *Foods,* 8(10), 519-532. https://doi.org/10.3390/foods8100519

Wang, B., Zhang, Q., Zhang, N., Bak, K.H., Soladoye, O.P., Aluko, R.E., Fu, Y. and Zhang, Y. (2021). Insights into information, detection, and removal of the beany flavour in soybean protein. *Trends in Food Science and Technology,* 112, 336-347. https://doi.org/10.1016/j.tifs.2021.04.018



 

Wang, Z., Yu, X., Zhang, Y., Zhang, B., Zhang, M. and Wei, Y. (2018). Effects of gluten and moisture content on water mobility during the drying process for Chinese dried noodles. *Drying Technology,* 37 (6), 759-769. https://doi.org/10.1080/07373937.2018.1458733

Wu, F., Meng, Y., Yang, N., Tao, H. and Xu, X. (2015). Effects of mung bean starch on quality of rice noodles made by direct dry flour extrusion. *LWT - Food Science and Technology,* 63(2), 1199-1205. https://doi.org/10.1016/j.lwt.2015.04.063

Wojtowicz, A. and Moscicki, L. (2014). Influence of legume type and addition level on quality characteristics, texture and microstructure of enriched precooked pasta. *LWT-Food Science and Technology,* 59(2), 1175-1185. https://doi.org/10.1016/j.lwt.2014.06.010

Zhu, F. and Li, J. (2019). Physicochemical and sensory properties of fresh noodles fortified with ground linseed (*Linum usitatissimum*). *LWT- Food Science and Technology,* 101(2), 847-853. https://doi.org/10.1016/j.lwt.2018.12.003

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