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Quality evaluation of noodles based on black bean flour and wheat flour

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Abstract

This study aims to obtain and present the effects on the sensory and physicochemical properties of noodles made from wheat flour with additions of black bean flour in different proportions, as well as research the health benefits of black bean consumption. According to the studies carried out, it was found that black beans are a source of nutrients with multiple health benefits, such as iron, calcium, magnesium, selenium, phosphorus, folates, dietary fibers, quercetin, saponins, etc., the consumption of black beans being beneficial in reducing the risk of obesity, diabetes, heart disease, cancer, as well as in lowering blood pressure and maintaining bone health. To analyze the effects on the physico-chemical and sensory properties of the noodles caused by the addition of black bean flour, four samples of noodles were made from mixtures of wheat flour with black bean flour in proportions of 0%, 5%, 10% and 15%, respectively. Noodle samples were analyzed in order to obtain information regarding the proximate composition, cooking properties and sensory evaluation. Regarding the proximate composition, significant changes were observed in the amount of fat, protein, ash and fiber with the increase in the percentage of black bean flour in the noodle sample. Thus, the noodle sample with 15% black bean flour presented amounts of 1.44±0.11% fat, 7.93±0.33% protein, 0.98±0.05% ash and 0.97±0.59% fiber compared to 0.76±0.04% fat, 6.28±0.27 % protein, 0.46±0.22% ash and 0.36±0.33% fiber present in the noodle sample made from 100% wheat flour. An increase in cooking time and cooking losses was also observed in the case of noodle samples with larger amounts of black bean flour. Regarding the sensory evaluation, a decrease in the overall acceptability of the noodles was observed with the increase in the percentage of black bean flour in the samples, the most appreciated noodle sample, both from a nutritional and sensory point of view, being the noodle sample with 10% black bean flour.

Keywords: black bean flour, noodles, sensory evaluation, physico-chemical properties, health benefits

1.Introduction

Noodles are staple food in many regions of the world. It is widely recognized that wheat noodles are one of the most popular types of noodles among consumers thanks to their convenience of preparation, unique taste, and affordable price. The expansion of the world economy and increasing awareness of health and nutrition has led consumers to demand higher standards for nutritional qualities, texture, taste and flavor of food products [1]. As noodle production has become increasingly automated, noodle manufacturers are seeking to produce noodles that have good and consistent processing properties.

In order to satisfy these new demands, a wide variety of functional ingredients have been successfully incorporated into noodles to improve processing and eating qualities, as well as increasing the product`s functionality. In recent years, the noodle processing industry has experienced rapid growth as a result of these functional ingredients [1]. In Asian countries, almost 40% of wheat flour is used in the production of noodles. Noodles based on WF are divided into regular salted and alkaline noodles. Yellow alkaline noodles are prepared from hard WF (high-protein content), while soft wheat (low-protein content) are used for the production of white salted noodles [2].

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Supplementing or fortifying noodles with nutrient-enriched ingredients could add extra nutrients to the traditional noodles. Noodles fortified with legumes showed significant qualitative improvement. Applications of legume flour have been studied in many foods. This study was carried out with the aim of producing healthy noodles using functional ingredients available on the market at affordable prices and showing good nutritional properties, such as black beans [2, 3]. For this purpose, in order to obtain noodles with better functional and nutritional properties, several noodle samples were made in which part of the amount of wheat flour was replaced with black bean flour. These samples were later analyzed to determine the physico-chemical and sensory properties of cooked noodles made from wheat and black bean flour [4].

Black beans (*Phaseolus vulgaris*), represent an important source of nutrients, minerals and bioactive principles necessary for the human body and with multiple health benefits, such as proteins, carbohydrates, lipids, iron, calcium, magnesium, selenium, phosphorus, folates, dietary fibers, quercetin, saponins, etc., the consumption of black beans being beneficial in reducing the risk of obesity, diabetes, heart disease, cancer, as well as in lowering blood pressure and maintaining bone health [3, 5]. According to studies, black bean flour contains 22,7% proteins, 2.5% lipids, 2.4% resistant starch, 25.6% dietary fibers, of which 5.6% soluble and 20% insoluble, and 38.2 g essential amino acids/100 grams of protein, as well as minerals such as Ca (158.6 mg/100 g), Cu (1 mg/100 g), Fe (4.1 mg/100 g), K (351.4 mg/100 g), Mg (156.4 mg/100 g), P (318.2 mg/100 g), Zn (1.9 mg/100 g), thus proving that it is a functional food with important nutritional properties [3, 6, 7].

Information on the physico-chemical properties, cooking properties and sensory properties of WF and BBF noodles is important from a nutritional and production industry point of view. WF supplemented with BBF might offer a promising nutritious and healthy alternative to consumers due to the high dietary fibers, minerals, and essential amino acids content in BBF.

Based on these observations, the purpose of this study was to obtain an assortment of noodles with superior nutritional properties conferred by the addition of BBF; establishing the optimal manufacturing recipe and the optimal dose of BBF that can be added to noodles without affecting their quality.

2. Material and methods

2.1. Materials

All the materials used in this study to prepare wheat noodles with various additions of black bean flour were purchased from local specialized stores in Timisoara, Romania.

2.2. Proximate analysis

To determine the proximate composition of the control sample and the three noodle samples made from wheat flour and black bean flour, the following parameters of the cooked product were analyzed: moisture content, protein content, fiber content, fat content, carbohydrate content and ash content. All determinations were made according to standard methods A.O.A.C. 2000 and were performed in triplicate [8].

2.3. Blending formulations

The noodles were prepared from different amounts of wheat flour (WF) and black bean flour (BBF), with a control sample made only from wheat flour, thus obtaining four noodle samples:

NC - Noodle control sample made from 100% WF and 0% BBF;
N5 - Noodles made from 95% WF and 5% BBF;
N10 - Noodles made from 90% WF and 10% BBF;
N15 - Noodles made from 85% WF and 15% BBF.

Table 1. Proportions of WF and BBF used in noodles

Sample	WF (%)	BBF (%)
NC	100	0
N5	95	5
N10	90	10
N15	85	15

2.4. Technological process for obtaining noodles

For each sample, the WF and BBF were mixed with water until the dough reached the desired consistency, as for the control sample, only WF was mixed with water. Then, each sample was kneaded into a firm and homogeneous dough and allowed to rest for 1 hour. After the dough was left to rest for gluten formation, the dough was rolled into thin sheets of about 2 mm thickness using a kitchen noodle maker. The noodle sheets were then cut into strands and the noodles were dried at 50°C, until the moisture content was around 11-13%.

The noodle samples were cooled at room temperature, packed in polypropylene packages and stored for further analysis [4, 9].

2.5. Cooking properties

In order to determine the cooking properties of the noodle samples, the cooking time, cooked weight and cooking loss of cooked noodles with different ratios of WF to BBF, were analyzed [4, 10, 11].

Cooking time: the cooking time of each dried noodle sample was determined by placing 1 g of noodles in a pot with 60 mL boiling distilled water and cooking them with periodic stirring. The optimal cooking time was evaluated by squeezing the noodles between two transparent glass slides every 30 seconds and observing the time of disappearance of the white core of the noodle strands.

Cooked weight: Each noodle sample was cooked in boiling distilled water for its optimal cooking time and then rinsed with 20 mL distilled water and drained for 2 minutes. Cooked weight was determined by weighing the wet mass of noodles.

Cooking loss: The cooking and rinsing water of each noodle sample were collected in pre-weighed containers and dried in an oven at 105°C until dry. The residues of cooking and rinsing water were weighed after cooling in a desiccator to determine the percentage of cooking loss, calculated with the following equation according to Bouasla et al. (2017) [10]:

$$Cooking\ loss(\%) = \frac{\text{Dried residue(g)}}{\text{Noodle sample(g)}} \times 100$$

2.6. Sensory evaluation

Sensory evaluation of the cooked noodles was carried out for consumer acceptability and preference using 25 untrained panelists randomly chosen from University of Life Sciences "King Mihai I of Romania", Faculty of Food Engineering, Timisoara. The noodle samples were evaluated after cooking and cooling for their color, appearance, odor, flavor, and overall acceptance using a 7-point hedonic scale (1 = dislike very much, 2 = dislike moderately, 3 = dislike slightly, 4 = neither like nor dislike, 5 = like slightly, 6 = like moderately, and 7 = like very much) [4].

3. Results and Discussion

3.1. Proximate composition

In *Table 2* are shown the results obtained from the proximate analysis of cooked noodles. The proximate compositions of cooked noodles were significantly influenced with the incorporation of black bean flour in different proportions.

Table 2. Proximate composition of noodle supplemented with different levels of BBF

Proximate composition (%)	Noodles			
	NC	**N5**	**N10**	**N15**
Moisture	58.84 ± 0.87	56.26 ± 1.59	55.53 ± 0.03	54.22 ± 0.02
Fat	0.76 ± 0.04	0.98 ± 0.12	1.12 ± 0.14	1.44 ± 0.11
Protein	6.28 ± 0.27	7.03 ± 0.20	7.56 ± 0.61	7.93 ± 0.33
Ash	0.46 ± 0.22	0.64 ± 0.13	0.80 ± 0.05	0.98 ± 0.05
Fiber	0.36 ± 0.33	0.55 ± 0.18	0.75 ± 0.25	0.97 ± 0.59
Carbohydrates	33.30 ± 0.08	34.54 ± 0.46	34.24 ± 0.23	34.46 ± 0.31

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD). WF – wheat flour, BBF - black bean flour; ***NC*** *– Noodle control sample made from 100% WF + 0% BBF;* ***N5*** *- Noodles made from 95% WF + 5% BBF;* ***N10*** *- Noodles made from 90% WF + 10% BBF;* ***N15*** *- Noodles made from 85% WF + 15% BBF.*

3.1.1. Moisture content

Following the analyses, significant changes were observed in the moisture content of the cooked noodle samples. The moisture content decreased significantly with the increase in the content of BBF and the decrease in the amount of WF in the noodle sample. The highest moisture content was observed in the control sample of noodles made from 100% WF (58±0.87%), while the lowest moisture content was recorded in the noodle sample made with 15% BBF (54.22±0.02%). These changes are determined by the increase in fiber content caused by the increase in the amount of BBF in the noodle sample, which causes disruption of the gluten matrix [4, 12].

3.1.2. Protein content

Table 2 shows the results of the analyzes regarding the protein content of the four samples of cooked noodles. An increase in the protein content of the samples can be observed from the addition of 5% BBF in the noodle recipe, the amount of protein increasing with the increase in the percentage of BBF used to obtain the noodles. Thus, the control sample presented a protein content of 6.28±0.27%, while the noodle sample with 5% BBF presented 7.03±0.20% protein content, the noodle sample with 10% BBF 7.56 ±0.61% protein content, the noodle sample with 15% BBF presenting the highest protein content, of 7.93±0.33%. These results are similar to the studies made by Petitot et al. (2010) and Ramirez et al. (2018) [13, 14] and show the potential of using black beans and black bean flour in supplementing various food products with proteins.

3.1.3. Fiber content

BBF also had significant influences on the fiber content of the cooked noodles, as can be seen in *Table 2*. The dietary fiber content increased considerably with the increase in the percentage of BBF and the decrease in the amount of WF used, the control sample made from 100% WF with a fiber content of only 0.36±0.33%, while the noodle sample with 15% BBF and only 85% WF presented a fiber content of 0.97 ±0.59% [5, 15].

3.1.4. Fat content

Along with the increase in the amount of BBF and the decrease in the amount of WF in the noodle recipe, an increase in the fat content was also observed, as can be seen in *Table 2*. Thus, an increase in the fat content of the cooked noodles was observed from 0.76±0.04% present in the control sample, up to a fat content of 1.44±0.11% present in the noodle sample with 15% BBF. These results coincide with studies carried out for example by Romero and Zhang (2019) [16], which showed that bean flours have a higher fat content compared to WF. Thus, the addition of bean flour in food products will also increase their fat content [4, 16-18].

3.1.5. Carbohydrate content

Unlike the other properties analyzed regarding the proximate composition of the noodles made from WF and BBF, no significant changes were found regarding the carbohydrate content present in the samples, as can be seen in *Table 2*. The carbohydrate content varied from 33.30±0.08% in the control sample, to 34.54±0.46% in the noodle sample with 5% BBF.

The noodle samples with 10% and 15% BBF presented a lower carbohydrate content than the noodle sample with 5% BBF, of 34.24±0.23%, respectively 34.46±0.31%, but still higher than the control sample, being in contrast to other studies that showed a decrease in carbohydrate content with the decrease in the amount of WF in the product and its replacement with a type of bean flour [4, 17-19].

3.1.6. Ash content

As can be seen in *Table 2*, the addition of BBF in the noodles recipe had a great impact on the ash content of the product. While the cooked noodles from the control sample made from 100% WF presented an ash content of 0.46±0.22%, the noodle sample with 15% BBF and 85% WF presented an ash content of 0.98±0.05%. Similar results regarding the ash content were also reported by Bassinello et al. (2011) [5] in the case of cookies with the addition of BBF. Thus, a positive effect of the addition of BBF on the ash content, and therefore on the mineral content, of food products can be observed [4, 5, 17, 20].

3.2. Cooking properties

Table 3 shows the changes caused by the addition of BBF in the noodles on the cooking properties, and more precisely on the cooking time, the cooked weight and on the cooking loss.

3.2.1. Cooking time

In terms of cooking time, an increase was observed as the percentage of BBF used increased. Therefore, the shortest cooking time was found in the control sample, 6.20±0.17, and the longest cooking time in the noodle sample with 15% BBF, 8.93±0.33. These differences in cooking time are due to the different gelatinization temperatures of the starches from WF (60°C) and BBF (64°C) [6, 11, 21].

3.2.2. Cooked weight

In the case of the cooking weight, it can be observed that it decreases with increasing the amount of BBF used. Thus, the highest cooking weight was observed in the control sample, of 4.16±0.04, this gradually decreased with increasing percentage of BBF used, the lowest value being 3.27±0.20, obtained by the noodle sample with 15% BBF. This is due to the high protein content of BBF, so the higher the protein content of the noodle sample, the lower the starch's ability to retain water, which causes the weight of the product when cooked to decrease [6, 21-23].

3.2.3. Cooking loss

As in the case of cooking time, an increase in cooking loss was also observed with the increase in the amount of BBF and the decrease in the amount of WF used in the noodle recipe. The lowest cooking loss was 3.46±0.28 in the control sample, while the highest cooking loss was 4.97±0.25 in the noodle sample with 15% BBF. These results are consistent with the results obtained in other studies, such as those of El-Sohaimy et al (2020) and Too et al (2021) [2, 22]. These results regarding cooking loss are due to the chemical composition of BBF, which, being rich in protein, dietary fiber, resistant starch, etc., weakens the overall structure of the noodles, thus causing their components to dissociate during cooking. However, since the cooking loss values are lower than 5%, it can be considered that the noodles with the addition of BBF obtained in this study are of good quality [2, 4, 22-28].

3.3. Sensory evaluation

The results of the sensory evaluation of noodles with WR and BBF can be seen in *Table 4*.

The four samples of cooked noodles were analyzed by fifteen untrained panelists in order to evaluate their color, appearance, odor, flavor and overall acceptance. Regarding the color, no big differences were found between the samples, however, a greater appreciation was observed with the increase in the amount of BBF in the recipe, the best result being obtained by the noodle sample with 15% BBF (5.62±0.02), and the lowest by the control sample, made from 100% WF (5.14±0.87). Regarding the other evaluated aspects, on the other hand, the panelists preferred the noodle sample made from 100% WF, as a decrease in the values regarding appearance, odor, flavor and overall acceptance was observed with the increase in the amount of BBF in the noodles. Thus, the values varied between 4.34±0.14 and 5.72±0.14 in terms of appearance, between 4.23±0.33 and 5.28±0.17 in terms of odor, between 4.48±0.09 and 5.56±0.47 in terms of flavor and between 4.27±0.44 and 5.36 ±0.33 in terms of overall acceptance, the lowest values being obtained by the noodle sample with 15% BBF, and the highest values by the control sample.

Table 3. Cooking properties of noodles supplemented with different levels of BBF

Treatments	**Noodles**			
	NC	**N5**	**N10**	**N15**
Cooking time (min)	6.20 ± 0.17	6.92 ± 0.09	7.66 ± 0.23	8.93 ± 0.33
Cooked weight (g)	4.16 ± 0.04	3.84 ± 0.33	3.42 ± 0.52	3.27 ± 0.20
Cooking loss (%)	3.46 ± 0.28	4.64 ± 0.33	4.80 ± 0.05	4.97 ± 0.25

*All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD). WF – wheat flour, BBF - black bean flour; **NC** - Noodle control sample made from 100% WF + 0% BBF; **N5** - Noodles made from 95% WF + 5% BBF; **N10** - Noodles made from 90% WF + 10% BBF; **N15** - Noodles made from 85% WF + 15% BBF.*

Table 4. Sensory evaluation of noodles supplemented with different levels of BBF

Sensory evaluation	**Noodles**			
	NC	**N5**	**N10**	**N15**
Color	5.14 ± 0.87	5.26 ± 1.22	5.44 ± 0.13	5.62 ± 0.02
Appearance	5.72 ± 0.14	4.98 ± 0.12	4.66 ± 0.04	4.34 ± 0.14
Odor	5.28 ± 0.17	5.03 ± 0.36	4.86 ± 0.11	4.23 ± 0.33
Flavor	5.56 ± 0.47	5.04 ± 0.13	4.80 ± 0.55	4.48 ± 0.09
Overall acceptance	5.36 ± 0.33	4.85 ± 0.18	4.40 ± 0.22	4.27 ± 0.44

*All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD). WF – wheat flour, BBF - black bean flour; **NC** – Noodle control sample made from 100% WF + 0% BBF; **N5** - Noodles made from 95% WF + 5% BBF; **N10** - Noodles made from 90% WF + 10% BBF; **N15** - Noodles made from 85% WF + 15% BBF.*

Even if these values are not much lower than those obtained by the control noodle sample, an addition of more than 10% BBF seems to negatively influence the sensory acceptance of the noodles. The results obtained are consistent with other studies, which reported the same decrease in sensory properties of the products with the replacement of WF, in noodles with flour from other vegetables or beans, such as the studies carried out by Yahya et al (2022), Petitot et al (2010), Bouasla et al (2017) and Hsieh et al (2017) [4, 5, 10, 24].

Therefore, BBF is an attractive and sustainable ingredient that could be considered for the development of noodles, given its excellent nutritional and sensory properties [4, 5, 10, 24].

Conclusion

The data obtained from this study demonstrates that BBF can be used to design and develop food products with improved functionality. With the substitution of an amount of WF in the noodle recipe with BBF, an improvement in their nutritional properties was observed, along with an increase in protein, fiber, fat, carbohydrate and ash content, thus confirming the possible health benefits. However, the incorporation of BBF in the noodle's recipe had negative effects on other aspects such as cooked weight, cooking loss and on sensory acceptance, an addition of more than 10% BBF negatively influencing the product. Thus, the results of this study show that noodles with an addition of up to 10% BBF can be considered a functional food with a higher nutritional profile than the usual product made from 100% WF, being rich in protein, fiber, fat and minerals with a positive impact on health and various diseases, having the potential to be incorporated into a wide range of functional food products.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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