

Effect of Cooking Conditions on Black Bean Flour Properties and Its Utilization in Donut Cake

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ABSTRACT

Utilization of the black bean legume is still limited. The effects of cooking conditions were examined on black bean flour production and the physical, chemical and functional properties of black bean flour were studied. The quality of donut cake made entirely of black bean flour was also investigated. Three cooking methods were investigated: boiling, steaming and pressure cooking. Raw bean flour contained slightly higher protein ($29.42 \pm 1.03\%$) and fiber ($2.19 \pm 0.10\%$) contents than the flours made of cooked beans. Cooking the beans altered the functional properties of the flour, while the beany flavor was largely eliminated. The hardness of donut cakes increased from 33.32 ± 0.52 to 114.27 ± 10.38 N when raw and cooked bean flour was used, respectively, as did the gumminess (20.08 ± 0.33 to 56.26 ± 2.82) and chewiness (17.86 ± 0.68 to 44.08 ± 4.21). Donut cakes made from black bean flour provided considerable protein ($12.31 \pm 0.44\%$) and fiber ($1.21 \pm 0.01\%$) contents compared to those produced from wheat flour comprising $7.54 \pm 0.12\%$ protein and only $0.03 \pm 0.03\%$ fiber. The chemical and functional properties of the black bean flour were not significantly different among the cooking methods. Black bean flour could be used to improve the hardness, gumminess and chewiness of donut cake. Its utilization may be increased through the value adding of protein-rich flour.

Keywords: black bean, legume flour, cooked bean flour, donut cake, beany flavor

INTRODUCTION

Legumes are an important part of the diet in many countries because of their protein and soluble fiber content (Kabagambe *et al.*, 2005). Beside these nutritional benefits, beans are free of gluten, a structural protein in products made from wheat contributing to elasticity in products (Minarro *et al.*, 2012). Therefore, foodstuffs made from bean flour provide alternatives to wheat-flour-based products (Siddiq *et al.*, 2013). Black bean is a high protein legume containing anthocyanin in the seed coat and it is also rich in fiber and other

minerals (Takeoka *et al.*, 1997). The consumption of black beans could reduce the risk of heart disease (Kabagambe *et al.*, 2005). Compared with cereals, tubers and unripe fruits, raw and processed legumes contain high levels of resistant starch and the starch digestion rate of legumes is lower than other cereal products resulting in a low release of glucose into the blood stream and the reduction of glycemic and insulinemic response (Torres *et al.*, 2004).

Several techniques have been employed for processing legume flour such as fermentation, heat treatment and extrusion and these processes

can be used to supplement the benefits of legume in other products (Baik and Han, 2012). Applications of legume flour have been studied in many foods. For example, navy and pinto bean flour from low-temperature extrusion was used to produce cookies, which were well-accepted by consumers (Siddiq *et al.*, 2013). The mixture of rice and black bean extruded flour was reported to increase the protein content of cookies and results of “slightly like” on appearance and “overall liking” were obtained from sensory analysis (Bassinello *et al.*, 2011). At present, there are limited studies on the physicochemical properties of cooked bean flour from different cooking methods. Therefore, the objectives of the present study were to investigate the chemical, physical and functional properties of various black bean flours produced using different methods and to evaluate the chemical, physical and sensory quality of donut cakes prepared using these flours compared with wheat flour.

MATERIALS AND METHODS

Production of raw black bean flour and cooked black bean flour

Black beans were purchased from a local market in Bangkok, Thailand and stored at room temperature until processed. After cleaning and removing broken seeds, the black beans were soaked at room temperature for 12 hr. The beans were subjected to different cooking methods: boiling (100 °C for 40 min), steaming (100 °C for 75 min) and pressure cooking (121 °C for 15 min at 103.42 kPa). Cooked beans were then dried at 60 °C for 12 hr using a tray dryer (model BWS; Frecon; Bangkok, Thailand). The dried beans were finely ground using a food grinder (HK-20B; Jinan Sensi Industries Co. Ltd.; Jinan, China) until the flour passed through a 100 mesh, stainless steel sieve. The flour samples were stored in aluminum foil pouches at 4 °C until used for analyses. Raw black bean flour was prepared by drying the soaked beans at 60 °C for 12 hr before milling into flour.

Production of donut cake

Donut cakes prepared from raw black bean and cooked black bean flours were compared with wheat flour. Donut cakes were made using the following formulation: all purpose wheat flour (26.21%), whole egg (20.97%), sugar (18.86%), unsweetened evaporated milk (18.86%), baking powder (8.18%), soybean oil (6.71%) and salt (0.21%). The black bean flours produced from different cooking methods were used to completely replace the wheat flour.

Quality analysis of black bean flours

Proximate analysis of black bean flours

The flour samples from the different cooking methods and raw black bean flour were estimated for their moisture, ash, fat, protein and crude fiber contents employing the standard methods of analysis (Association of Official Analytical Chemists, 2006).

Physical properties of black bean flours

Color

The color of the flour samples was measured using a spectrophotometer (CM-3500d; Konica Minolta Inc.; Tokyo, Japan). Black bean flour was placed in the sample cup and color was recorded as lightness (L^*), redness (a^*) and yellowness (b^*) according to the CIE system (Hunter and Harold, 1987).

Bulk density and water activity

The bulk density of each black bean flour sample was determined according to the method of Okaka and Potter (1977). A 50 g sample was placed in a 100 mL graduated measuring cylinder. The cylinder was tapped gently several times on a laboratory bench to a constant volume. The results for bulk density were reported as grams per milliliter. The water activity of the legume flours was determined (AquaLab, Series 3 TE; Decagon Devices, Inc.; Pullman, WA, USA.)

Pasting properties

The pasting properties of the legume flours were determined using a Rapid Visco

Analyzer (RVA, Newport Scientific; Manasquan NJ, USA.) according to American Association of Cereal Chemists (1995). A bean flour sample was weighed into an aluminum canister and mixed with water. After putting a stirring paddle into the canister, the canister was placed into a heating chamber. A programmed heating-cooling cycle was used, where the sample was equilibrated at 25 °C for 2 min, heated to 95 °C at a rate of 9 °C.min⁻¹, held at 95 °C for 2.5 min and cooled to 25 °C at the same rate. The stirring speed was 160 rpm throughout the sample period.

Functional properties of legume flours

Water absorption capacity

The water absorption capacity (WAC) of the legume flours was measured using the centrifugation method reported by Kaur and Singh (2006). Each sample (3.0 g) was dissolved in 25 mL of distilled water and placed in a 50 mL pre-weighed centrifuge tube. The mixture was stirred at 5 min intervals and held for 30 min, followed by centrifugation for 30 min at 3,000×g. The supernatant was decanted and the excess moisture was removed at 50 °C for 25 min and the sample was reweighed.

Water absorption index and water solubility index

The water absorption index (WAI) and water solubility index (WSI) of the legume flours were determined by referring to the methods reported by Kaur and Singh (2006). A legume flour sample (3 g) was dissolved in 30 mL distilled water and heated in a water bath at 90 °C for 15 min. Then, the cooked paste was cooled to room temperature, transferred to pre-weighed centrifuge tubes, and centrifuged at 3,000×g for 10 min. The supernatant was decanted into a pre-weighed evaporating dish to determine its solid content and the sediment was weighed. The weight of dry solids was recovered by evaporating the supernatant overnight at 105 °C. The WAI and WSI were calculated using Equations 1 and 2:

$$\text{WAI} = \frac{\text{Weight of sediment}}{\text{Weight of flour sample}} \quad (1)$$

$$\text{WSI} = \frac{\text{Weight of dissolved solids in supernatant}}{\text{Weight of flour sample}} \quad (2)$$

Foaming properties

Foaming properties were determined according to the method of Okaka and Potter (1977). A sample of 1 g of flour was dispersed in 50 mL of distilled water in a capped test tube by shaking vigorously for 5 min followed by intermediate pouring into a 250 mL graduated cylinder. The volume of the foam formed and the volume of the suspension were recorded. A final observation was made after 60 min. The foaming capacity (FC) and foaming stability (FS) were calculated using Equations 3 and 4:

$$\text{FC} = \frac{V_2 - V_1}{V_1} \times 100\% \quad (3)$$

$$\text{FS} = \frac{V_2 - V_3}{V_2} \times 100\% \quad (4)$$

where FC is the foaming capacity, FS is the foaming stability, V_1 is the volume of the suspension, V_2 is the volume of suspension and foam formed and V_3 is the volume of the foam formed after it is allowed to stand for 60 min, all volumes measured in milliliters.

Quality analysis of donut cakes

Proximate analysis of donut cake

Donut cakes from legume flour and wheat flour were estimated for their moisture, ash, fat, protein and crude fiber contents employing the standard methods of analysis (Association of Official Analytical Chemists, 2006).

Physical properties

Color

The color of the donut cakes was measured using the same procedure and equipment as for the black bean flour samples described above.

Texture measurement

A modified texture profile analysis (TPA) method was used to determine the donut cake properties (Melito and Farkas, 2013) using a texture analyzer (TAXT plus; Stable Micro-System Ltd.; Godalming, U.K.) fitted with a 5 kg load cell. In this method, a whole donut cake sample was placed on the center of the stand plate and a 51 mm diameter probe was compressed on the center of each donut cake. A two-cycle compression test was performed to 40% strain during each cycle at 2 mm.s⁻¹ test speed.

Water activity

The water activity of donut cake was determined using the same equipment as for the black bean flour samples described above.

Sensory evaluation of donut cakes

The sensory evaluation of the donut cakes made of black bean flours was carried out for color, odor, flavor, texture and overall liking using a nine-point hedonic scale (1 = extremely dislike, through to 9 = extremely like) with 50 untrained panelists.

Statistical analysis

Data were analyzed using a one-way analysis of variance using the SPSS software package (version 13; SPSS Inc.; Chicago, IL, USA). Significant differences were tested using Duncan's multiple range test and statistical significance was defined as $P < 0.05$.

RESULTS AND DISCUSSION

Legume flour properties

Proximate analysis

The moisture content of black bean flours from various processes was significantly different, ranging from 6.94 ± 0.02 to $8.79 \pm 0.02\%$ (Table 1). The fat content of the legume flours was not statistically different. A decrease in the protein, crude fiber and ash contents was observed in the cooked legume flour with the cooking method of the black beans prior to flour production. Proximate analysis (on a dry basis) of raw black bean flour was $55.25 \pm 1.29\%$, $29.42 \pm 1.03\%$, $8.79 \pm 0.02\%$, $2.72 \pm 0.21\%$, $2.19 \pm 0.10\%$ and $1.63 \pm 0.11\%$ for carbohydrate, protein, moisture, ash, crude fiber and fat, respectively. The protein content of the cooked legume flour was lower than that of raw flour due to protein denaturation by heat as Baik and Han (2012) stated that protein solubility decreased when chickpeas, lentils, peas and soybeans were cooked or roasted. However, cooking could improve *in vitro* digestibility, as the protein is digested more easily.

Physical properties

Color

The cooking method significantly affected the color of the black bean flours by decreasing the lightness (L*) of the flour. Pressure-

Table 1 Proximate chemical properties (on a dry basis) of black bean flours from different cooking methods compared to raw legume flour.

Flour source	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)
Raw legume	8.79 ± 0.02^a	29.42 ± 1.03^a	1.63 ± 0.11^a	2.19 ± 0.10^a	2.72 ± 0.21^a	55.25 ± 1.29^c
Boiled legume	6.94 ± 0.02^d	27.06 ± 0.23^b	1.66 ± 0.11^a	1.53 ± 0.29^b	1.87 ± 0.03^b	60.94 ± 0.41^a
Steamed legume	7.65 ± 0.06^c	27.95 ± 0.24^b	1.74 ± 0.03^a	1.60 ± 0.09^b	2.15 ± 0.26^b	58.91 ± 0.69^b
Pressure-cooked legume	8.18 ± 0.04^b	27.82 ± 0.31^b	1.64 ± 0.03^a	1.51 ± 0.02^b	2.07 ± 0.04^b	58.78 ± 0.35^b

a - d = Means \pm SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

cooked bean flour provided the highest redness ($a^* = 5.17 \pm 0.02$) and steam-cooked flour had the least lightness ($L^* = 57.62 \pm 0.05$), compared to the other flours (Table 2). Redness (a^*) and yellowness (b^*) increased when legume flours were made from the cooked beans. The a^* and b^* values increased because the bean absorbed the pigment from the seed coat while being heated. The color of the black bean flour when used in products would turn the product dark brown, which could be a unique property when properly formulated.

Bulk density and water activity

The bulk density of all legume flours was not significantly different (0.75 ± 0.01 to 0.76 ± 0.02 g.mL⁻¹). The bulk density results were similar to Du *et al.* (2014), who reported the bulk density of black bean flour as 0.76 ± 0.01 g.mL⁻¹. Flours produced from legumes such as pinto, lima, lentil, chickpea and mung bean generally had higher bulk density than wheat flour, ranging from 0.54 to 0.86 g.mL⁻¹ (Du *et al.*, 2014). All-purpose wheat flour had a bulk density of 0.62 g.mL⁻¹ (Siddiq *et al.*, 2009). The water activity of all the legume flours ranged from 0.256 ± 0.010 to 0.406 ± 0.010 (Table 3).

Pasting properties

The RVA showed that the peak viscosity of the raw legume flour was significantly higher than for the other cooked legume flours. A high temperature treatment (95 °C for 30 min) could complete the gelatinization of the starch in bean flour (Siddiq *et al.*, 2013). The cooking methods used in the current study were considered as severe thermal treatments, thus rendering the complete gelatinization of starch. The black bean flour contained approximately 20% starch content and 25% amylose content, with the gelatinization temperature of black bean starch being 64 °C (Hoover and Ratnayake, 2002). Gelatinization of most starchy products is usually observed at 60 to 65 °C (Whalen and Bason, 1997). All the cooked legume flours had a final viscosity of approximately 9.5 RVU, whereas the peak viscosities were from 1.47 ± 0.17 to 5.36 ± 0.12 RVU (Table 4).

Functional properties

Water absorption capacity

The WAC is an important functional property of flour because this property has an effect on the functional and sensory properties

Table 2 Effect of cooking methods on color properties of black bean flours.

Flour source	L*	a*	b*
Raw legume	75.56±0.01 ^a	0.68±0.05 ^d	8.36±0.05 ^d
Boiled legume	63.09±0.02 ^b	2.85±0.03 ^c	9.57±0.09 ^b
Steamed legume	57.62±0.05 ^d	4.22±0.01 ^b	8.93±0.09 ^c
Pressure-cooked legume	58.18±0.04 ^c	5.17±0.02 ^a	9.89±0.13 ^a

a – d = Means ± SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

L* = Lightness, a* = redness b* = yellowness according to the CIE system (Hunter and Harold, 1987).

Table 3 Effect of cooking methods on water activity (a_w) and bulk density of black bean flours.

Flour source	a_w	Bulk density (g.mL ⁻¹)
Raw legume	0.406±0.010 ^a	0.75±0.01 ^a
Boiled legume	0.256±0.010 ^d	0.76±0.02 ^a
Steamed legume	0.355±0.010 ^b	0.76±0.01 ^a
Pressure-cooked legume	0.340±0.010 ^c	0.76±0.01 ^a

a – d = Means ± SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

of the final product (Du *et al.*, 2014). The values of the WAC increased in cooked legume flours compared to raw legume flour (Table 5). This was probably due to the protein unfolding upon heating and hydration sites that were previously buried could be exposed, thereby making them interact with water (Maruatona *et al.*, 2010). A similar improvement in the WAC of heat-treated cowpea flour ($3.4 \pm 0.3 \text{ g.g}^{-1}$) compared to unheated cowpea flour ($2.6 \pm 0.1 \text{ g.g}^{-1}$) was reported by Miami (1993).

Water absorption index and water solubility index

The WAI determines the absorption and retention of water and its effect on various processing conditions (Siddiq *et al.*, 2013). Raw legume flour ($7.75 \pm 0.95 \text{ g.g}^{-1}$) had a significantly higher WAI than cooked legume flours (5.34 ± 0.39) as shown in Table 5. The WAI is related to the hydrophilicity and gelation capacity of biomacromolecules, such as starch and protein that are present in flour (Du *et al.*, 2014). The WSI increased with an increase in starch depolymerization resulting in a consequent

reduction in the length of the amylose and amylopectin chains (Siddiq *et al.*, 2013). Cooked legume flours had significantly higher WSI values than raw legume flour. The heating effect from cooking may have degraded the starch and produced more soluble molecules (Siddiq *et al.*, 2013), thus increasing the solubility of the cooked bean flour.

Foaming properties

Foaming capacity and foaming stability generally depend on the interfacial film formed by proteins, which maintains the air bubbles in suspension and slows down the rate of coalescence (Du *et al.*, 2014). The foaming capacity of raw legume flour was $41.99 \pm 4.96\%$ and the values decreased in cooked legume flour (Table 5). An application of heat treatment during the cooking process led to protein denaturation, thus lowering the foaming capacity of the cooked legume flours. The high foaming stability of raw black bean flour ($98.44 \pm 1.56\%$) allows it to be used as a substitute for foam food protein (Du *et al.*, 2014). The foaming properties are important when developing the formulation of bakery products.

Table 4 Effect of cooking methods on pasting properties of black bean flours.

Flour source	Peak viscosity (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)
Raw legume	147.41±6.00 ^a	16.82±3.20 ^a	186.93±3.05 ^a	56.08±0.72 ^a
Boiled legume	4.47±0.17 ^b	1.00±0.14 ^b	9.41±0.46 ^b	5.94±0.24 ^b
Steamed legume	1.47±0.17 ^b	0.94±0.19 ^b	9.30±0.25 ^b	5.69±0.17 ^b
Pressure-cooked legume	5.36±0.12 ^b	1.02±0.17 ^b	9.50±0.25 ^b	5.16±0.22 ^b

a – b = Means ± SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

RVU = Rapid Visco Units.

Table 5 Effect of cooking methods on functional properties (on a dry basis) of black bean flours.

Flour source	WAC (g.g ⁻¹)	WAI (g.g ⁻¹)	WSI (g per 100 g)	Foaming capacity (%)
Raw legume	1.88±0.10 ^c	7.75±0.95 ^a	0.26±0.04 ^c	41.99±4.96 ^a
Boiled legume	3.34±0.10 ^b	5.79±0.12 ^b	6.21±0.24 ^b	3.84±0.20 ^c
Steamed legume	3.32±0.08 ^b	5.13±0.30 ^b	7.57±1.48 ^b	7.90±0.37 ^b
Pressure-cooked legume	3.81±0.01 ^a	5.10±0.10 ^b	10.11±0.29 ^a	7.69±0.20 ^b

a – d = Means ± SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

WAC = Water absorption capacity; WAI = Water absorption index; WSI = Water solubility index.

Quality of donut cake

Proximate analysis

The moisture content of donut cake ranged from 28.72 ± 0.37 to $39.79 \pm 0.04\%$ (Table 6). The protein and crude fiber content of donut cake significantly increased because of the high nutritional values of the black bean flours, especially of the protein and fiber (Table 1). Donut cake made of raw legume flour was higher in protein than donut cake made from cooked legume flours (Table 6). The fat content of all donut cakes was not significantly different and the ash content ranged from 2.63 ± 0.01 to $3.76 \pm 0.01\%$.

Physical properties

Color

Donut cakes made from legume flours were darker than those from wheat flour. The redness (a^*) of the donut cake was found to be slightly different among all flours (14.17 ± 1.06 to 16.39 ± 0.21). A decrease in the yellowness (b^*) was observed when cooked black bean flours were used as replacements for wheat flour in donut cake (Table 7). A significant difference between raw legume flour and cooked legume flour was observed in all color parameters. However, legume flours made from steamed beans and pressure-cooked beans yielded a similar color of donut cake.

Table 6 Proximate chemical properties on a dry basic of donut cake made from black bean flours using different cooking methods.

Flour type	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)
Wheat *	30.98 ± 0.36^d	7.54 ± 0.12^c	11.15 ± 0.11^a	0.03 ± 0.03^b	3.43 ± 0.01^b	46.87 ± 0.27^a
Raw legume	28.72 ± 0.37^e	12.98 ± 0.09^a	11.19 ± 0.97^a	1.21 ± 0.20^a	2.77 ± 0.02^c	42.22 ± 0.75^b
Boiled legume	39.79 ± 0.04^a	12.08 ± 0.13^b	11.15 ± 0.51^a	1.19 ± 0.14^a	3.76 ± 0.01^a	32.03 ± 0.61^d
Steamed legume	31.84 ± 0.34^c	12.13 ± 0.18^b	10.88 ± 0.24^a	1.21 ± 0.08^a	2.63 ± 0.01^e	41.31 ± 0.66^c
Pressure-cooked legume	33.64 ± 0.52^b	12.05 ± 0.11^b	11.26 ± 0.37^a	1.23 ± 0.10^a	2.72 ± 0.01^d	39.10 ± 0.39^c

a – e = Means \pm SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

* = Donut cake made from wheat flour was used as the control.

Table 7 Color properties of donut cake made from black bean flours using different cooking methods.

Flour type	L*	a*	b*
Wheat *	48.47 ± 0.26^a	14.17 ± 1.06^b	33.38 ± 1.44^a
Raw legume	38.40 ± 0.24^b	14.54 ± 0.37^b	24.24 ± 0.89^c
Boiled legume	34.41 ± 0.63^c	16.39 ± 0.21^a	26.54 ± 0.52^b
Steamed legume	28.48 ± 0.26^d	14.79 ± 0.11^{ab}	19.39 ± 1.43^d
Pressure-cooked legume	28.80 ± 0.39^d	14.26 ± 0.21^b	20.55 ± 1.63^d

a – d = Means \pm SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

L* = Lightness, a* = redness b* = yellowness according to the CIE system (Hunter and Harold, 1987).

* = Donut cake made from wheat flour was used as the control.

Texture and water activity

Hardness was largely increased in donut cake made from cooked legume flour when compared with raw legume flour and wheat flour (Table 8). Similar trends were also observed in the gumminess and chewiness. An increase in the hardness, gumminess and chewiness of donut cake resulted from the high WAC of the cooked bean flours. Therefore, limited water was available in the donut cake batter. Kaur and Singh (2006) stated that the gumminess and chewiness were correlated and less energy was needed for gelatinizing a product with a high WSI. The water activity of all donut cakes was approximately 0.915 ± 0.009 (Table 8).

Sensory evaluation

Sensory analysis of donut cake made from black bean flours showed that all attributes had liking scores in the range of 5 to 6, representing “neither like nor dislike” and “slightly like”, respectively. The color scores were not significantly different regardless of the cooking methods used to produce the black bean flour (Figure 1). The color score of the donut cake made from raw flour (6.6 ± 1.6) was comparable to those from cooked flours (6.3 ± 0.1). Donut cakes made from all cooked bean flours had higher liking scores on odor and flavor than those made from raw legumes flour. Cooking by heat could predominately reduce the beany flavor in legume flours (Siddiq *et al.*, 2013).

Table 8 Texture and water activity (a_w) of donut cake made from black bean flours using different cooking methods.

Flour type	Hardness (N)	Springiness	Gumminess	Chewiness	a_w
Wheat *	22.43±0.37 ^d	0.92±0.03 ^a	15.39±0.23 ^c	14.29±0.17 ^c	0.908±0.005 ^b
Raw legume	33.32±0.52 ^c	0.85±0.01 ^b	20.80±0.33 ^b	17.86±0.68 ^c	0.908±0.011 ^b
Boiled legume	105.55±4.83 ^b	0.82±0.01 ^c	59.32±2.07 ^a	48.92±1.92 ^a	0.924±0.007 ^a
Steamed legume	111.95±10.38 ^b	0.76±0.01 ^d	53.75±9.26 ^a	41.26±4.32 ^b	0.918±0.004 ^{ab}
Pressure-cooked legume	125.29±6.71 ^a	0.75±0.01 ^d	55.71±2.61 ^a	42.04±2.39 ^b	0.916±0.005 ^{ab}

a – d = Means ± SD with different lowercase superscript letters within a column are significantly different ($P < 0.05$).

* = Donut cake made from wheat flour was used as the control.

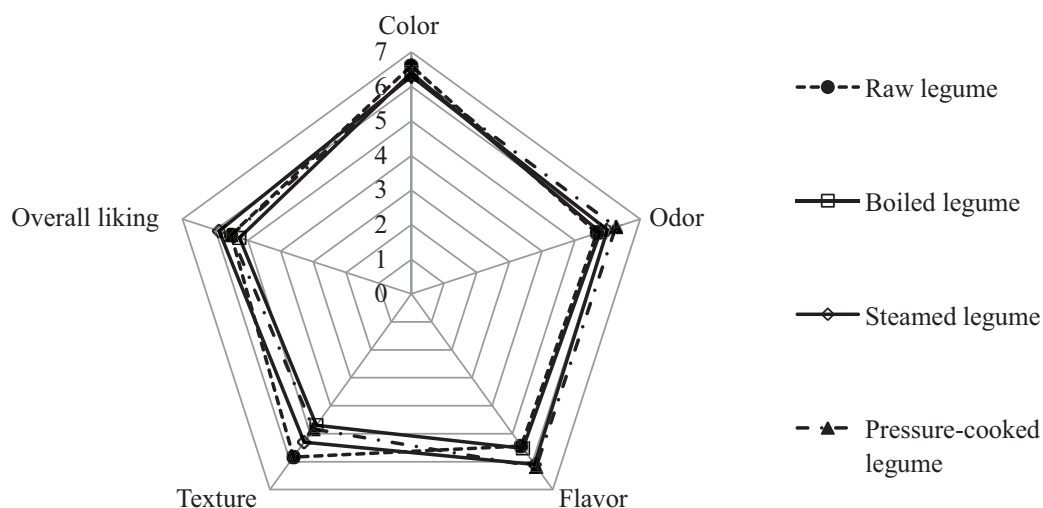


Figure 1 Sensory score of donut cake made from black bean flours using different cooking methods.

Liking scores on the texture of donut cakes from cooked bean flours were less preferred than those from raw bean flour as a result of the increase in hardness (Table 8). Donut cakes consisting of steamed black bean flour received the highest overall liking score (5.9 ± 1.5).

CONCLUSION

The differences in the cooking processes used in bean flour production provided similar characteristics in the cooked bean flour. The proximate composition of the cooked legume flours was slightly diminished compared to raw black bean flour. Changes in functional properties such as the WAC and WSI affected the quality of final products. Among the cooking methods studied, not all of the flour properties were different. When wheat flour was completely replaced with cooked bean flour, a firm and rigid texture of donut cakes was obtained, leading to substantial hardness. It is recommended that the pressure cooking method should be used to produce cooked black bean flour due to its short processing time. Cooked legume flour may be used to produce wheat-alternative products with the benefits of being highly nutritious in protein and fiber while the beany flavor is largely reduced.

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