Effect of Domestic Processing on the Levels of Some Functional Parameters in Black Turtle Bean (*Phaseolus vulgaris* L)

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Abstract

There are useful constituents that are present in legume seeds but their utilization has been ignored because it has been established that there are compounds or substances which act to reduce nutrient intake, digestion and absorption. It was on these premises that effect of domestic processing methods (boiling, cooking, roasting, sprouting and fermenting) were investigated on some functional parameters for black turtle bean (*Phaseolus vulgaris* L.) flour. The functional parameters (oil absorption, oil emulsion, water and foaming capacities: OAC, OEC, WAC, FC; foaming and oil emulsion stabilities: FS, OES; bulk density: BD; least gelation capacity: LGC; protein solubility: PS) of raw and processed black turtle bean flour were all determined using standard analytical techniques. The results showed that WAC, OAC, FC, LGC and BD were all enhanced by different processing methods while FS was reduced by the same methods. Emulsion capacity and stability were either enhanced or reduced by these methods. Processing significantly ($p \leq 0.05$) affected the content of some functional parameters in black turtle bean flour. The protein solubility studies of the raw and processed samples were found to have minimum solubility at pH 4.0 which corresponds to the isoelectric point where protein isolates might be recovered from the samples. The food properties of WAC, OAC, FC, FS, EC, ES, LGC and BD in the raw and processed black turtle bean (*Phaseolus vulgaris* L.) are much better than most literature samples thereby making black turtle bean potentially useful in some food formulations.

Keywords: Food properties, processing methods, black turtle bean

1. Introduction

The black turtle bean (*Phaseolus vulgaris* L.) is often called simply the black bean although this can cause confusion with other black beans, as such given the name black turtle. The black turtle has a dense, meaty texture and flavor reminiscent of mushroom, which makes it popular in vegetarian dishes (Davendra, 1995). It is a very popular bean in various regions of Brazil, and is used in the national dish. It is also main ingredient of *Moroscon Cristaianos* in Cuba, and is served in almost all of Latin American dishes as well as many Hispanic enclaves in the United States. The black turtle bean is also very popular for making into soups, which are often eaten with Cuban crackers. It has recently been reported that black turtle is an extremely good source of nutritional antioxidant (Choung *et al.,* 2003).

The abundance of anti–nutritional factors and toxic influences in plants used as human foods and animal feeds calls for concern. Nutritional quality is affected by these factors that interact with the intestinal tract such as phytate, tannins and oxalates which reduce protein digestibility and amino acid absorption (Nowacki, 1980). Liener (1994) has emphasized that unless these substances are destroyed by heat or some other treatments, they can exert adverse physiological effects when ingested by man and animals. The domestic processing methods such as soaking, cooking, germinating, roasting, fermenting and boiling have been used to improve nutritional quality of legumes (Trugo *et al.,* 1993; Barampana & Simard, 1994; Aremu *et al.,* 2006; Aremu *et al.,* 2010; Audu & Aremu, 2011). Therefore, it is desirable to reduce these anti–nutritional factors in the legumes if they must be effectively exploited as inexpensive source of protein (Philips & Abbeyi, 1989; Aremu *et al.,* 2009).

This research was conducted to investigate the effect of domestic processing (boiling, cooking, roasting, sprouting and fermenting) on the levels of some functional parameters in black turtle bean (*Phaseolus vulgaris* L.) flour. This will provide useful information on the potentiality of the seed flour as a functional ingredient in food system.

2. Materials and Methods

2.1 Collection of the sample

The mature seeds of black turtle beans (*Phaseolus vulgaris* L.) were purchased from a market in Bokkos town of Plateau State, Nigeria. The seeds were sorted to remove stones and bad ones while the god ones were thoroughly cleaned with distilled water. The processing methods employed were boiling, cooking, roasting, sprouting and fermenting while raw sample served as control.

2.2 Preparation of processed black turtle beans seed flour

2.2.1 Raw sample

Cold water was added on 500 g of black turtle bean seeds, left for 5 h and dehuled. The dehulled seeds were dried in the oven at 45^{o}C for 36 h.

2.2.2 Boiling

The dehulled raw black turtle beans (500 g) were boiled in distilled water at 100^{o}C at the ratio of 1:10 $^{wt}/_{v}$ for 55 min, after which they were drained and oven–dried at 50^{o}C for 36 h.

2.2.3 Cooking

The cooking was done in an aluminium pot using one part of the dehulled raw seeds (500 g) to 15 parts of distilled water on a Gallenkamp thermostat hot plate. The black turtle bean seeds were considered cooked when they became soft to touch when pressed between the thumb and fingers. At the end of the cooking time, the boiling water was drained and seeds were sun–dried.

2.2.4 Roasting

Dehulled raw seeds (500 g) were roasted in fine sand and stirred using the Gallenkamp thermostat hot plate 85^{o}C until a characteristic brownish coloured seed was obtained after 1 h 15 min, which indicated complete roasting. Then the seeds were cleaned and cooled.

2.2.5 Sprouting

Black turtle bean seeds (500 g) were germinated using sawdust in a locally woven reed basket. The seeds were arranged on the layers of sawdust, wetted daily and observed for sprouting. Seeds with sprouts about 1 cm long (3 – 4 days) were picked, washed, dehulled, sliced and dried at 45^{o}C.

2.2.6 Fermenting

The dehulled raw seeds (500 g) were wrapped in blanched banana leaves and allowed to ferment for 4 days. Fermented seeds were picked, washed, sliced and dried at 45^{o}C.

After all the processing treatments were completed, all the raw and processed seed samples were ground into fine flour with a small sample mill (DIETZ, 7311 Dettingentech, West Germany). They were kept in airtight container and put in a deep freezer (–4^{o}C) prior to chemical analysis.

2.3 Determination of functional properties

Water and oil absorption capacities were measured by the Benchat (1977) procedure. Foaming capacity and foaming stabilities were determined by the method described by Coffman and Garcia (1977). Full experimental details have been reported by Aremu *et al.* (2007). Oil emulsion capacity and stability were determined by the procedure of Benchat (1977) as modified by Adeyeye *et al.,* (1994). Lowest gelation concentration was determined by employing the method of Coffman and Garcia (1977) with slight modification as described by Aremu and Ekunode (2008). Bulk density was determined using the procedure of Chou and Morr (1979) as modified by Akpapunam and Markakis (1981); Narayana and Narasinga Rao (1984).

3. Results and Discussion

The functional properties of black turtle bean flour are shown in Table 1. The water absorption capacity ranged from 94.0% in the raw to 147.0% in the fermented sample. The reported value of the WAC of black turtle bean flour in this work is comparable to reported values of sun flower (107%) and soybean (130%) (Lin *et al*., 1974) and various lima bean (130 – 142%) (Oshodi & Ekperigin, 1989). So the black turtle bean flour could be useful replacement in viscous food formulations such as soups or baked products. The oil absorption capacity 172.0% for the raw sample is higher than values for *Gymarchus niloticus* fish (148.9%) (Adeyeye & Adamu, 2005), pigeon pea flour (89.7%) (Oshodi & Ekperigin, 1989), wheat (84.2%) and soy flour (84.4%) (Lin *et al*., 1974). Oil absorption is important as oil acts as a flavor retainer and improves the mouth feel of foods (Kinsella, 1979) so black turtle product would be a good sample in this regard. Foaming capacity ranged from 17.7% in the raw sample to 28.7% in the sprouted sample. The values are higher than reported values for *P.africana* (3.92%) (Aremu *et al*., 2007b), selected sea foods (6–14%) (Ogunlade *et al*., 2005) but compared with benniseed (18.0%) (Oshodi *et al*., 1999). Foaming stability recorded after 1 h ranged from 43.4% in the cooked sample to 51.3% in the raw sample. The 53.1% (1 h) recorded for the raw black turtle bean flour is lower than reported value for *P. africana* (96.2%, 12 h) (Aremu *et al.,* 2006b).

The emulsion capacity (11.4 mL/g) for the raw black turtle bean flour is lower than value reported for *P. africana* (30.0 mL/g) but compared to reported value for pigeon peas (7–11%) (Oshodi & Ekperigin, 1989), soy bean (18%) (Lin *et al*., 1974). This indicates that the black turtle bean flour might be useful in the production of sausages, soups and cakes (Kinsella, 1979). The oil emulsion stability (OES) is also presented in Table 1. The values ranged from 26.4 mL/g in fermented sample to 33.1 mL/g in the sprouted sample. The emulsion stability (31.4 mL/g) for the raw sample is higher than values reported for *Clarias lazera* (19.5%) but close to values reported for P. *africana* (38.4 mL/g), pear millet (34.0%) (Oshodi *et al*., 1999; Aremu *et al.,* 2006b). The least gelation for the raw sample 12.0% is higher than reported values for pigeon pea (10.0%), cowpea (10.0%) (Oshodi & Ekperigin, 1989). This indicates that the black turtle bean flour can be useful in food application and in new product development, thereby providing an added dimension to protein functionality (Padmashree *et al.*, 1987). The bulk density was 0.2400 g/cm^3 for the raw. The value is lower than values for *P. africana* (0.5268 g/ml) (Aremu *et al*., 2006b).

Table 1: Functional properties of black turtle bean

Properties	Raw I	Boiled II	Cooked III	Roasted IV	Sprouted V	Fermented VI	Mean	SD	CV%
WAC %	94	129	143	125	126	147	127.33	18.76	14.73
OAC %	172	256	218	198	198	222	210.66	83.65	39.73
Foaming Capacity %	17.7	23.5	25.9	25.8	28.7	24.2	24.30	3.70	15.22
Foaming Stability %	53.1	48.8	43.4	48.6	48.5	50.3	48.80	3.16	6.47
Emulsion Capacity mL/g	11.4	10.8	12.5	12.6	12.3	10.4	11.66	0.93	7.97
Emulsion Stability mL/g	31.4	33.6	32.1	31.2	33.10	26.4	31.30	2.59	8.27
Least Gelation Capacity %	12.00	14.00	16.00	12.00	14.00	14.00	13.70	1.02	8.03
Bulk Density g/cm^3	0.2400	0.5400	0.4400	0.5600	0.5900	0.6100	0.49	0.13	26.53

The effect of processing on the functional properties of black turtle bean is presented in Table 2. All the processing methods used in the present study enhanced WAC of the black turtle bean seed flours. The water absorption capacity (WAC) increased by 37.23, 51.06, 32.98, 34.04 and 56.38%, respectively when compared to the raw dry seed of black turtle bean. This suggests that the black turtle bean seed flour can serve as a thickner in food system. Boiling, cooking, roasting, sprouting and fermented affected the OAC by increasing it. The increase was by 48.84, 26.74, 15.12 and 29.07%, respectively. This suggests that black turtle bean seed flour could give better palatability and better flour retention. Foaming capacity of the black turtle bean seed was also enhanced by all the processing methods. The foaming capacity increased by 32.77, 46.33, 45.76, 62.15 and 36.72%, respectively. All the processing methods reduced foaming stability. The foaming stability decreased by 8.10, 18.27, 8.47, 8.47 and 5.27% (boiling, cooking, roasting, sprouting and fermenting). Cooking, roasting and sprouting increased emulsion capacity by 1.1, 1.2 and 0.9 mL/g while boiling and fermenting reduced it by 0.6 mL/g and 1.0 mL/g. Boiling, cooking and sprouting increased emulsion stability (2.2, 0.7 and 1.7 mL/g) while roasting, and fermenting reduced the foaming stability (0.2 and 5.0 mL/g). Processing (boiling, cooking, roasting, sprouting and fermenting) increased the least gelatinous capacity of the black turtle bean seed flours. The LGC increased by 16.67, 33.33, 0.0, 16.67 and 16.67%, respectively. Processing significantly ($p \leq 0.05$) affected the bulk density of the black turtle bean seed flours. Boiling, cooking, roasting, sprouting and fermented increased the bulk density by 125, 83.33, 133.33, 145.83, and 154.17%, respectively.

Table 2: Difference in the functional properties of raw and processed black turtle bean

Properties	I–II	I–III	I–IV	I–V	I–VI	Mean	SD	CV%
WAC %	–35.0 (–37.23%)	–48.0 (–51.06%)	–31.0 (–32.98)	–32.0 (–34.04)	–53.0 (–56.38)	40.00	10.24	25.60
OAC %	–84.0 (–48.84%)	–46.0 (–26.74%)	–26.0 (–15.12%)	–26.0 (–15.12%)	–50.0 (–29.07%)	37.29	25.84	69.29
Foaming Capacity %	–5.8 (–32.77%)	–8.2 (–46.33%)	–8.1 (–45.76%)	–11.0 (62.15%)	–6.5 (–36.72%)	7.92	2.00	25.20
Foaming Stability %	4.3 (8.10%)	9.7 (18.27%)	4.5 (8.47%)	4.5 (8.47%)	2.8 (5.27%)	5.16	2.63	50.96
Emulsion Capacity mL/g	0.6 (5.26%)	–1.1 (–9.65%)	–1.2 (–10.53%)	–0.9 (–7.89%)	1.0 (8.77%)	0.96	0.23	23.95
Emulsion Stability mL/g	–2.2 (–7.01%)	–0.7 (–2.23%)	0.2 (0.64%)	–1.7 (–5.41%)	5.0 (15.92%)	1.96	1.77	90.30
Least Gelation. Capacity %	–2.0 (–16.67%)	–4.0 (–33.33%)	0.0 (0%)	–2.0 (–16.67%)	–2.0 (–16.67%)	2.40	1.44	47.50
Bulk Density g/cm^3	–0.3 (–125%)	–0.2 (–83.33%)	–0.32 (–133.33%)	–0.35 (–145.83%)	–0.37 (154.17%)	0.33	0.07	23.30

I = Raw; **II** = Boiled; **III** = Cooked; **IV** = Roasted; **V** = Sprouted; **VI** = Fermented

Figure 1 presents the protein solubility of black turtle bean flours (raw and processed). The minimum protein solubility was observed at pH 4 for raw and the processed black turtle bean flours. The maximum protein solubility was observed at pH 9 for both the raw and processed turtle bean. At the either side of pH 4, there was an increase in protein solubility. The pH 4 may be the isoelectric point (IEP) of black turtle bean flours, which is the minimum point at which the protein solubilized. Black turtle seed flour irrespective of the processing techniques showed similar minimum protein solubility at pH 4 as the case with vegetable proteins (Chau & Cheung, 1998). Cooking, roasting and sprouting reduced the protein solubility while boiling and fermenting improved it. Raw, boiled and fermented black turtle bean flours may be useful in vegetable milk production.

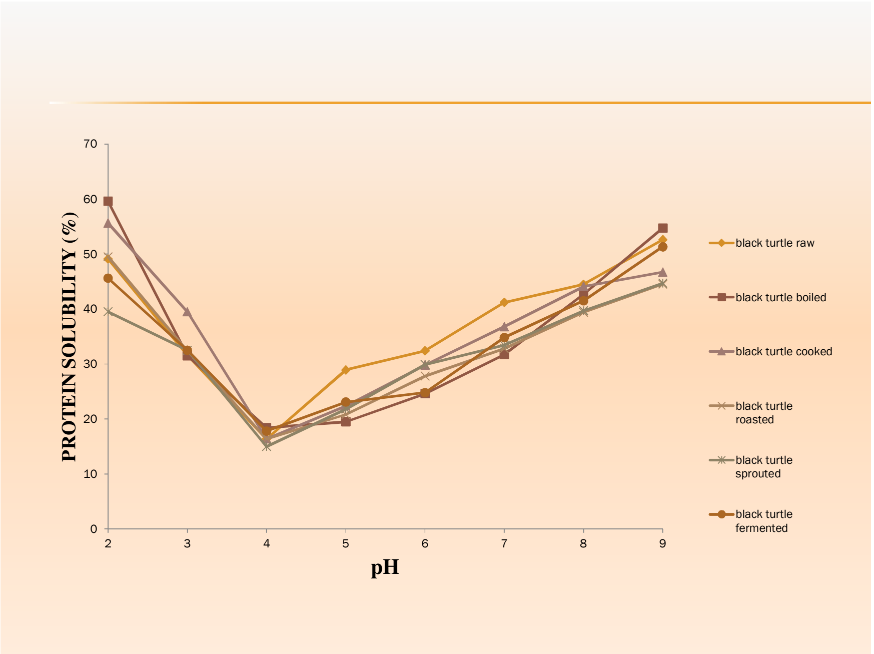

Fig. 1: Protein solubility of black turtle bean flour

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