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Functionality of plantain- cowpea blends for extruded snacks

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Abstract Influence of functional and proximate properties of flour and blends of plantain and cowpea flour were determined to assess their suitability for making extruded snacks. The proximate and functional characteristics (water absorption index, water solubility index and pasting) of the flour were determined. The rheological properties, protein, crude fiber and fat contents of blends of 90:10, 80:20, 70:30, 60:40 and 50:50 from the plantain and cowpea flours were determined. The influence of drying and extrusion on the functional properties of dried plantain and cowpea flours from different varieties was determined, along with their suitability for making extruded snacks. The varieties were: plantain (*Apantu* and *Apem*) and cowpea (*Nhyira* and *Asetenapa*), and there were significant differences (P<0.05) in both product varieties. The proximate composition, functional uniqueness, and rheological properties of dried plantain and cowpea blends (plantain: cowpea) 90:10, 80:20, 70:30, 60:40 and 50:50 were evaluated with the Brabender amylograph before extrusion cooking. For example, the rheological property peak paste viscosity in Brabender Units (BU) decreased from 595.5 BU for plantain, to 281.5 BU for plantain and cowpea (75:25%). Cowpea peak paste values were *Nhyira* 6 BU and *Asetenapa* 13BU. As the amount of cowpea in the plantain blends increased, the BU decreased. The extruded snacks were formulated from the plantain and cowpea flours at ratios of, plantains (75 to 100%), cowpea (0 to 25%), and oat fiber (0 to 25%) and extruded through a ZSK 30 twin-screw extruder at temperatures of 90 to 140 °C into half- and expanded- products. Pasting properties of the extruded blends determined with a Rotovisco Analyzer (RVA) were significantly different (P<0.05) among varieties. The peak viscosity for the extruded plantain was 6719.5 cP, blending with cowpea at 25 wt% reduced peak paste viscosity values to 4511.0 cP. Differences in rheological properties depended on plantain and cowpea varieties, and the paste property of extruded products was affected by the level of cowpea

Key words: Crude protein, fibre, rheological properties

Materials and Methods

Raw material. Thirty kilogrammes of two varieties of unripe (green) plantains (*Musa paradisiacal normalis)* namely *Apantu* (False Horn) and *Apem* (French horn) were obtained directly from *Agbloloshie* market in Accra, Ghana. The fruits were chosen of grade 1 maturity stage (unripe) and with acceptable appearance for consumption (Dadzie & Orchard, 1997).

Twenty kilogrammes of cowpea varieties: CSIR-Asetenapa and CSIR-Nhyira were obtained from the CSIR-Crops Research Institute, Fumesua, Kumasi Ghana.

Production of unripe plantain flour. Plantains were cleaned, peeled with a stainless steel knife and rinsed with 150 ml of potable water. Plantains (400 kg) were manually sliced 0.5-1'' thick and 200 kg were mechanically sliced with a slicer (Fold-up electric Food Slicer mod.CFE 1954, Philips Atlantis.) into 2-5 mm thick, to be used in the production of flours. The sliced plantain chips were dried in a mechanical dryer (Apex Royce Ross, UK) at 60 p C for 7 hours. The dried chips were milled with a laboratory Hammer mill (Milomat Laboratory mill, Pfeuffer) and sifted with a 250micron sieve. The flour obtained was stored at 27 ±3 ºC and relative humidity of 79 ±2% in a hermetic glass container, until analysis (Barbosa-Canovas & Vega-Mercado, 1996; Singh & Heldman, 2001).

Production of cowpea flour. The cowpeas (350 kg) were also processed into flour by first, soaking for 36 hr, dehulling, washing the cotyledons, blanching for 6 min. at 100 °C, drying at 60 °C in mechanical dryer(Apex Royce Rolls, UK) for 8 hr, milling with a laboratory Hammer mill (Milomat Laboratory mill, Pfeuffer), and sifted with 250 micron sieve. The cowpea flours were packaged in air-tight polyethylene bags and stored at room temperature for further analysis.

Proximate composition and chemical characteristics. The moisture content, protein (N×6.25), crude fiber, fat, ash, of the fresh edible portions of the plantains (5 kg) and the cowpea varieties (4 kg) and 2 kg each of flours from cowpea and plantain were analysed following methods in AOAC (2000). Total crude fiber was determined using the methodology described by Pearson's Composition and Analysis of Foods. Energy was determined using the Atwater Factor and total carbohydrate was determined by difference.

Water adsorption index and Water solubility index. The water adsorption index (WAI) and water solubility index (WSI) were performed according to Jin *et al*. (1995), with minor modifications. Ground sample (5 g) of plantain flours (*Apantu* and *Apem*) and cowpea flours (5 g) (Asetenapa and *Nhyira*) that passed through a 250 mesh screen was

combined with 30 ml of distilled water in a tarred centrifuge tube. The mixture was sealed, vortex, and allowed to hydrate for 10 min. The sealed tube was inverted 3 times at both 5 and 10 min to ensure proper mixing. After 10 min, samples were centrifuged for 15 min at 3000 rpm using a Sorvall RC-5B fixed angle rotor (DuPont Instruments, Wilmington, Del., U.S.A.) and the supernatant was decanted into a pre-weighed aluminum dish. The tube was inverted for 5 min over the dish to catch residual moisture. The dish was allowed to dry overnight in a drying oven (BS Gallenkamp, England) at 70 °C and the centrifuge tube was reweighed to determine the weight of the sediment. WAI was calculated by dividing the sediment weight by the dry sample weight while WSI was calculated by dividing the dried supernatant weight by the dry sample weight (Jin *et al.*, 1995).

Rheological characteristics. The gelatinisation profiles of the 40 kg each of flours (*Apantu* and *Apem* flour and the CSIR-*Asetenapa* and CSIR-*Nhyira* cowpea flour) were evaluated using the Brabender Amylograph (Viscograph E), according to method 76-10 in AACC (2000). Slurry of 8% concentration (on dry matter basis) of each sample was made with distilled water (40 ml). The slurry was then poured into the amylograph bowl and heated uniformly from 25 to 95 ^{0}C. The suspension was heated at a rate of 1.5 ^{0}Cmin^{-1} by means of a thermoregulator. When the suspension reached 95 ^{0}C, it was held constant for 15mins (first holding period), while being continuously stirred. Initial pasting temperature, range of pasting temperature, peak viscosity, viscosity at 95 °C, viscosity at 50 °C, breakdown and setback were the points analysed from the Amylograph curve (Zhuo *et al*., 1998).

Pre-extrusion. Five kilogrammes each of plantain flours and cowpea flours from *Apantu* and *Apem* plantains and *Asetanapa* and *Nhyira* cowpea respectively was sent to the United States Department of Agriculture -Eastern Regional Research Center at Philadelphia. Moisture determination and rheological studies were conducted on these samples. They could not be used for extrusion studies because their quantity was less than the 10 kg the twin-screw Extruder ZSK-30 was supposed to take. To simulate extrusion processing at Eastern Regional Research Institute, USA, 100 kg of commercially processed plantain flour obtained from (Raymond-Hadley Corp. Spencer, NY 14883), white bean flour (Bob's Red Mill Natural Foods, INC.), and oat fiber (Sun Opta Ingredient Group) were obtained from a commercial distributor.

Formulation of blends. The following blends were formulated, 100% plantain, 100% white bean flour, 75% plantain + 25% white bean flour, 75%plantain + 25% oat fiber and 50% plantain + 25% white bean flour +25% oat fiber.

Data analysis. The data generated were analysed using Statistical Analysis Systems version 9.1 SAS (2003) software package. Significance of treatment means was tested at 5% probability level using Duncan's New Multiple Range Test.

Results and Discussion

Proximate composition of plantain and cowpea and their flour. Table 1 shows the proximate composition of the two varieties of plantains and cowpeas. The *Apantu* plantain recorded a moisture content of 57.24 ± 3.88 g^{-1}100 g while the *Apem* plantain gave a moisture content of 57.9 ± 0.30 g^{-1}100 g. Akomolafe & Aborisade (2007), however reported a moisture content of 55.8 g^{-1}100g. The fat content for the plantains was 0.02 ± 0.01 and 0.04 g^{-1}100 g compared to 0.08 g^{-1}100 g reported by Akomolafe & Aborisade (2007).

The cowpea protein content was 31.07 ± 0.17 and 28.25 ± 0.13g^{-1}100 g respectively for the *Nhyira* and *Asetenapa* cowpeas which is above the literature range of 24.1- 25.4g^{-1}100 g (Bressani, 1985) reported that cowpea contained 24% protein. The cowpeas recorded the same fat content of 1.9 g^{-1}100 g, compared to literature range of 1.3 g^{-1}100 g reported by Deshpande & Damodaran, (1990). According to Deshpande & Damodaran (1990), the ash content for cowpeas range from 3.4-3.9 g^{-1}100g, *Nhyira* and *Asetanapa* cowpeas gave values of 3.2 ± 0.04 and 2.7 ± 0.16 g^{-1}100 g respectively which is comparable to the literature range.

The plantain flours gave similar moisture content values of 8.2 ± 0.21 and 8.7± 0.01 g^{-1}100 g (Table 2) compared 11.75 g^{-1}100 g which was recorded by Pacheco-Delahaye *et al*. (2008). The ash content for the *Apantu* and *Apem* plantain flours were (2.12 and 1.62 g^{-1}100 g) respectively which is comparable with the 2.02 g^{-1}100 g value recorded by Pacheco-Delahaye *et al*. (2008). For the protein content of the plantain flour, Pacheco-Delahaye *et al*. (2008) recorded a value of 3.08 g^{-1}100 g compared to 1.69 and 2.55 g^{-1}100 g recorded by the *Apantu* and *Apem*

Table 1. Proximate composition of plantain tuber and cowpea seeds.

Product	Moisture (g^{-1}100 g)	Ash (g^{-1}100 g)	Fat (g^{-1}100 g)	Protein (g^{-1}100 g)	Carbohydrate (g^{-1}100 g)	Crude fiber (g^{-1}100 g)	Energy (Kcal^{-1}100 g)
Apantu	57.24 ± 3.88	1.03 ± 0.04	0.02 ± 0.01	1.28 ± 0.12	38	0.6 ± 0.09	157.3
Plantain							
Apem	57.9 ± 0.30	0.9 ± 0.01	0.04	1.45 ± 0.12	39.71	0.2	165± 0.02
Nhyira	13.7 ± 0.10	3.2 ± 0.04	1.9 ± 0.23	31.07 ± 0.17	58.6	3.7	341.9± 0.26
Cowpea							
Asetenapa	13.8 ± 0.01	2.7 ± 0.16	1.9 ± 0.01	28.25 ± 0.13	60.4	3.9343.5	±0.04

plantain flours. The fat content of the plantain flours was 1.7± 0.45 and 2.1 ± 0.05 g^{-1}100 g compared to 0.31 g^{-1}100 g reported by Pacheco-Delahaye *et al*. (2008). According to Morton (1987), the protein content of plantain ranges from 1.16- 1.47 g^{-1}100 g, for the *Apantu* and *Apem* plantains, the protein content was 1.69 and 2.55 g^{-1}100 g which is in the literature range. The *Nhyira* and *Asetenapa* cowpea flour recorded moisture contents of 6.1 ± 0.06 g^{-1}100 g and 7.8 ± 0.22 g^{-1}100 g.

Brabender viscoamylograph. The *Apantu* plantain flour recorded the highest peak viscosity of 629 ± 1.41BU at a pasting temperature of 73.55 ± 0.07 °C compared to a peak viscosity of 595.5 ± 3.54 at a pasting temperature of 74.85 ± 0.07 °C for the *Apem* plantain flour (Table 3). This means that the starch granules of the *Apantu* plantain flour had a greater pasting ability than that of the *Apem* plantain flour. For the cowpea flours, the *Asetenapa* cowpea flour recorded peak viscosity value of 13 ± 1.41BU at a pasting temperature of 94.25 ± 0.64 °C compared to the value of 50.2BU at a pasting temperature of 6 ± 1.41. This meant that the starch granules in the cowpea flours possessed low pasting ability. However, the starch granules of the *Nhyira* cowpea flour swelled highly when heated at relatively low temperatures. Generally, the *Apantu* plantain flour recorded higher rheological properties (viscosity at 95 °C, viscosity at 50 °C, viscosity at 95 °C after 15minutes, pasting stability at 50 °C, setback and breakdown) than the *Apem* plantain flour. *Asetenapa* cowpea flour gave high visco-graphic parameters than the *Nhyira* cowpea flour (Table 3). Significant differences ($p<0.05$) existed between and within all the rheological parameters measured for both plantain and cowpea samples.

Table 2. Proximate composition of plantain and cowpea flour.

Flours	Moisture (g^{-1}100 g)	Ash (g^{-1}100 g)	Fat (g^{-1}100 g)	Protein (g^{-1}100 g)	Carbohydrate (g^{-1}100 g)	Crude fiber (g^{-1}100 g)	Energy ($Kcal^{-1}$100 g)
Apantu	8.2±0.21	2.12	1.7±0.45	1.69	85.69	0.6	364.8
Plantain							
Apem	8.7±0.01	1.62±0.04	2.1± 0.05	2.55	84.43	0.6	366.8
Nhyira	6.1±0.06	1.26±0.02	4.0 ±0.14	22.74± 0.02	65.2	0.7	387.8
Cowpea							
Asetenapa	7.8±0.22	1.55	3.5 ±0.18	23.43±0.29	62.32	1.4	374.5

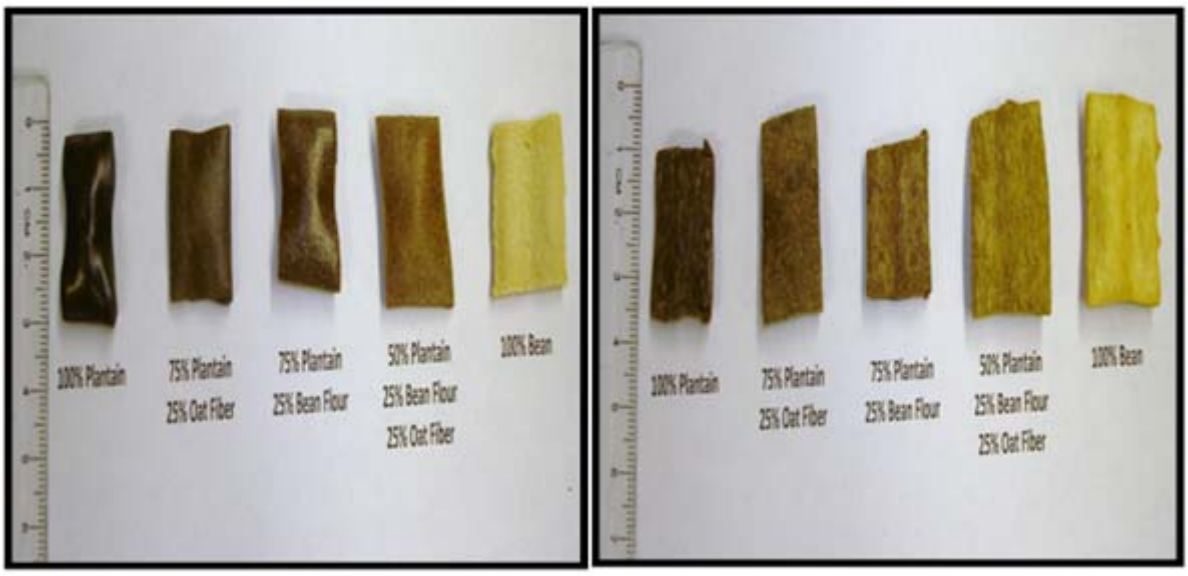

Figure 1. Pictures showing extruded and baked half-products from plantain, white bean flour and oat fiber.

Table 3. Brabender analysis of plantain and cowpea flour.

Flours	Pasting Temp (°C)	Peak Viscosity (BU)	Viscosity at 95°C (BU)	Viscosity after 15 min (BU)	Viscosity at 50°C (BU)	Pasting stability at 50°C (BU)	Breakdown (BU)	Setback (BU)
Apantu	73.55 ± 0.07d	629 ± 1.41d	607.5 ± 2.12c	515 ± 9.89b	776.±7.78c	750 ± 15.56	115 ± 10.62 d	252c
Plantain								
Apem	74.85 ± 0.07c	595.5 ± 3.54c	591 ± 2.83b	509 ± 4.24b	764.5 ± 0.71c	747 ± 1.41	86.5 ± 0.71 c	252.5± 4.95b
Nhyira	50.2a	6 ± 1.41a	2.5 ± 0.71a	6 ± 1.41a	19.5 ± 3.54a	18 ± 2.83	0	13.5 ± 2.12a
Cowpea								
Asetenapa	94.25 ± 0.64b	13 ± 1.41b	6.5± 0.71a	12.5 ± 0.71a	351.41b	32.5 ±2.12	0.5 ± 0.71b	22.5 ± 0.71a

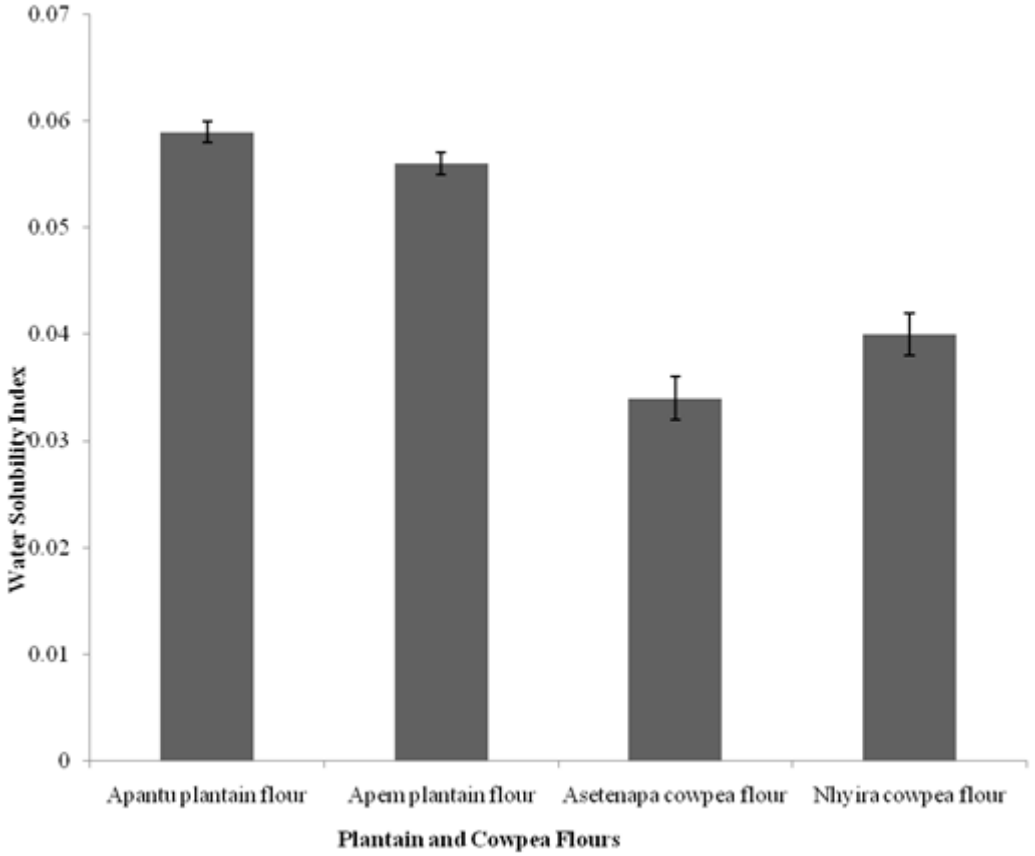

Figure 2. Water solubility index of plantain and cowpea flour.

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