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Processing Effects on Chemical, Functional and Pasting Properties of Cowpea Flour from Different Varieties

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ABSTRACT

Cowpea varieties (IT88D-867-11, IT89KD-288 and MALA) were boiled, roasted, dehulled and later milled into powder. The proximate composition, functional and pasting properties as well as anti-nutritional contents (Tannin) of the product was subsequently determined. The result of the study revealed significant increase ($P < 0.05$) in the crude protein, crude ash, swelling power and water absorption capacity. Conversely, significant decrease ($P < 0.05$) was observed in crude fat, starch content, moisture content, solubility and peak viscosity. Boiled samples have significantly higher ($P < 0.05$) crude protein, swelling power, water absorption capacity, with concomitantly lower solubility and tannin content. Crude ash, moisture, solubility and tannin content of dehulled samples decreased significantly with an increase in protein, swelling power and water absorption capacity. However, IT89KD-288 has the highest protein content irrespective of the processing used. But raw IT89KD-288 showed highest percentage of swelling power, solubility, water absorption capacity and Tannin content. The result revealed that both boiling and dehulling will greatly reduce tannin content of cowpea.

Keywords: Cowpea, boiling, dehulling, proximate, tannin.

Introduction

Cowpeas are leguminous seeds that are widely produced in Africa under marginal production systems. Cowpeas perform well even when produced in marginal soils due to their ability to fix substantial nitrogen in the soil (Hall *et al*., 2003). Cowpea is of vital importance to the livelihood of millions of people in west and central Africa. From its production, rural families derive food, animal feed and cash income.

It provides a nutritious (gain) and an inexpensive source of protein for both rural and urban consumers, as cowpea contains about 25% proteins and 64% carbohydrate (Henshaw *et al*., 1996). It has a tremendous potential to alleviate malnutrition among poor farmers.

In addition, cowpeas contribute to the sustainability of cropping systems and soil fertility improvements in lands by providing ground cover and plant residues, fixing nitrogen and suppressing weed. The wider utilization of dry whole cowpea seeds, however, is limited due to factors of long cooking time and limited variety in cowpea-based products, among others. The cooking time of cowpeas, which ranges from 35 min to l20 min or more, depending on variety and type of cooking water that is used (Olapade *et al*., 2002), is a great challenge for both urban and rural consumers due to time and energy requirements. Changing lifestyles in urban areas has placed convenience as a crucial factor in food choices. About 8 million ha (hectare) of cowpea (fields) are grown in the west and central Africa, where the most important producers are Nigeria, (4 million ha), Niger (3 million ha), Mali, Burkina Faso and Senegal (FAOSTAT, 2008). Several factors account for these impressive increases. Over the

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last two decades, the International Institute of Tropical Agriculture (IITA) has made significant advances in improving the productivity of cowpea in sub-Saharan Africa. A number of varieties have been developed combining diverse plant types, different maturity periods and resistance to several diseases; insect pests' and parasitic weeds and possessing other good agronomic trait (Oligbinde and Akeyele, 1983).

In Nigeria cowpea can be eaten in various ways, either alone or mixed with maize, rice, fish or *gari*. Bean flour is made into fried or boiled cakes. Cowpeas are eaten in various forms by more than one half of the population and this makes a large contribution to the protein and energy content available to the population than any other foods. The traditional methods of processing these foods as well as limitations in digestive capacities greatly reduce their value (Henshaw *et al*., 1996). Cowpea proteins are usually deficient in methionine and cystine and the mature seeds may contain several anti-nutritional factors which limit protein quality. It was therefore necessary to carry out a research on the effect of processing and varieties on proximate, functional, pasting and some anti-nutritional factors in cowpea (*Vigna unguiculata*).

Materials and Methodology

Materials

Three varieties of cowpeas – IT 88D-867-11, IT 89KD-288, and MALA were purchased from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Processing

The methods used for this research were boiling, roasting, dehulling and oven drying. The seeds were thoroughly cleaned and sorted to remove extraneous matters. Cowpea seeds from each variety were divided into three portions. One portion was subjected to boiling, another portion to roasting and the third portion was soaked at room temperature in cold water and later dehulled manually and cooked.

Preparation of boiled cowpea flour: A portion containing 125 g of the whole seeds were boiled in 470 ml of distilled water at 100°C for 40 min after which they were drained and oven dried at 60°C for 180 min. The dried seeds were milled into flour and sealed in a polythene bag.

Preparation of roasted cowpea flour: The cowpea sample was roasted in the laboratory in an aluminum frying pan using a 1000 W electric hot plate (Guangzhou D.G.H. Electrical Appliances Co. Ltd. Guangdong, China) as the heat source. The pan was allowed to warm to a temperature of between 60°C and 70°C. Approximately 125 g of cowpea sample was added at each time and heating continued with stirring until the temperature reached 120°C to 130°C. The time required to roast was about 50 min, after which the seeds were milled into powdered form and kept in an airtight polythene bag (Ayatse *et al*., 1983).

Preparation of dehulled cowpea flour: A portion containing 125 g of the raw seeds was soaked in 230 ml water for 5 min at room temperature and dehulled manually. Dehulled seeds were boiled in 240 ml of water at 100 oC for 20 min, oven dried at 60 oC for 180 min, milled into flour and packed in a polythene bag.

Nutrients and anti-nutrient contents determination

The nutrient composition (ash, fat, protein, moisture) of the processed cowpea was determined using standard AOAC (2004) methods. Tannin content was determined using the Vanillin-HCL method as described by Kirk and Sawyer (1998). Starch and sugar contents were determined by the method of Dubois *et al*. (1956). This involves weighing of 0.02 g of the sample into a centrifuge tube with 1 ml ethanol, 2 ml distilled water and 10 ml hot ethanol. The mixture was vortexed and centrifuged at 2000 rpm for 10 min. The supernatant was decanted and used for determining sugar content while the sediment was hydrolyzed with perchloric acid and used to estimate starch content. Phenol-sulfuric acid reagent was used for colour development and

glucose standards were used for estimation of sugar. The absorbance was read with a spectrophotometer (Milton Roy Spectronic 601, USA) at 490 nm. Sugar content = [Absorbance % I (0.0044)]/ (Sample wt × 0.55). Starch = [(Absorbance % 0.0044)4]/(Sample wt × 0.55). Amylose content was determined by the iodine binding method described by Williams *et al.* (1970). Water absorption capacity (WAC) was determined using the method described by Sosulski (1962). Swelling power and solubility were determined by the method of Leach *et al.* (1959). Pasting properties were determined with a Rapid Visco Analyser 3 C (RVA, Newport Scientific PTY Ltd, Sydney) (Ross *et al.* 1987; Walker *et al.*, 1988).

Statistical analysis

Each analytical determination was carried out in three replicates. Data were subjected to analysis of variance (ANOVA) using SAS version 8e software (SAS Institute Inc., Cary, NC, USA) at $p < 0.05$. Means were separated using Duncan's Multiple Range Test.

Results and Discussion

The proximate analysis of the cowpea varieties obtained from IITA and Kuto market is shown in Table 1. The moisture content of the sample ranged from 1.40 % to 7.53 %. The lowest value was recorded in roasted IT 89KD-288 while the highest value was recorded in raw IT88D-867-11 which is close to the value recorded by Ene-Obong and Carnovale (1992). The ash content ranged between 2.91% and 3.93%.

The lowest value was recorded in boiled IT88D-867-11 cowpea while the highest value was recorded in roasted MALA cowpea. Crude fat content ranged between 1.40% and 2.44%, the lowest was recorded by roasted IT89KD-288 cowpea while the highest value was recorded in dehulled IT89KD-288 cowpea, which were in agreement with previous report by (Ene-Obong and Carnovale, 1992).

The crude protein content ranged between 20.02 % and 23.29%. The highest value was recorded in roasted IT89KD-288 cowpea while the lowest value was recorded in raw IT88D-867-11 cowpea. The protein content of roasted cowpea varieties compared favourably with that reported by Ene-Obong and Carnovale (1992). Dehulling and boiling reduced the protein content of the cowpea varieties; this may be due to the leached soluble nutrients in the water used for boiling. Amylose content ranged between 16.32% and 19.19%; the lowest was recorded in raw IT89KD-288 while the highest was recorded in raw MALA. Sugar content ranged between 8.51% and 12.12%, the highest value was recorded in boiled IT88D-867-11 while the lowest value was recorded in boiled IT89KD-288. Starch content ranged from 52.12% to 74.16 %, the lowest value was recorded in dehulled IT89KD-288 while the highest value was recorded in raw IT88D-867-11.

Tannin content was very low, ranging between 0.13 mg/100 g to 1.85 mg/100 g. The lowest value was recorded in the dehulled IT88D-67-I while the highest was recorded in roasted IT89KD-288. High values of tannins observed in roasted cowpea may be due to improvement in the assayable tannins brought about by the reduction in tannin-protein interaction as a result of thermal destruction of the seed protein (Plahar *et al.*, 1997). The swelling power was very low, which ranged from 3.29% to 7.44%; the highest was recorded in roasted IT88D-867-II while the lowest value was recorded in MALA. Solubility index ranged between 10.12% and 23.42%: the lowest was recorded in roasted IT88D-867-II while the highest was recorded in raw IT89KD-288. The water binding capacity was very high, ranging between 76.86% and 265.82, the highest was recorded in dehulled IT88D-867-II and the lowest value was recorded in raw MALA.

Pasting characteristics

Pasting temperature is the temperature where viscosities first increase by at least 2 RVU over a 20 sec period. It gives an indication of temperature required to cook the starch in the cowpeas beyond their gelatinization point (Olkku and Rha, 1978; Appelqvist and Debet, 1997). Similar pasting temperatures (Table 3) were observed for all the treatments and cultivars, except for raw cowpea flour that has slightly higher temperature.

Table 1: Proximate and chemical composition of cowpea varieties

Processing variables	Cowpea varieties	Moisture %	Ash %	Fat %	Protein %	Amylose %	Sugar %	Starch %	Tannin (mg/100 g)
Raw	IT89KD-288	7.09^{b}	3.42^{e}	1.88^{e}	21.27^{f}	16.32^{g}	8.69^{i}	67.76^{c}	1.54^{b}
	IT88D-867-II	7.53^{a}	3.34^{f}	2.10^{c}	20.02^{h}	16.35^{g}	10.57^{d}	74.16^{a}	0.64^{f}
	MALA	5.70^{c}	3.63^{c}	1.60^{g}	21.01^{g}	19.19^{a}	10.88^{c}	55.38^{i}	0.77^{e}
Boiled	IT89KD-288	3.90^{d}	3.52^{d}	2.14^{b}	22.75^{b}	17.79^{cd}	8.51^{d}	55.79^{hi}	0.67^{f}
	IT88D-867-II	5.82^{c}	2.91^{h}	2.08^{d}	21.03^{fg}	17.44^{e}	12.12^{a}	73.35^{a}	0.19^{i}
	MALA	3.04^{f}	3.80^{b}	2.12c	21.93^{de}	17.53^{de}	10.43^{e}	69.83^{b}	0.30^{g}
Dehulled	IT89KD288	3.66^{de}	3.31^{f}	2.44^{a}	23.11^{a}	18.01^{c}	11.48^{b}	52.12^{j}	0.22^{hi}
	IT88D-867 II	3.55^{ef}	3.09^{g}	1.82^{f}	21.79^{e}	16.93^{f}	9.97^{g}	58.58^{g}	0.13^{g}
	MALA	2.97^{f}	3.49^{d}	2.14^{e}	22.76^{c}	16.93^{f}	10.24^{f}	56.74^{h}	0.24^{h}
	IT89KD-288	1.40^{h}	3.75^{b}	1.40^{h}	23.29^{a}	18.59^{b}	10.20^{f}	60.54^{f}	1.85^{b}
Roasted	IT88D-867-II	2.54^{g}	3.67^{c}	1.61^{g}	22.15^{a}	17.82^{cd}	8.63^{id}	66.43^{d}	1.14^{cb}
	MALA	2.21^{g}	3.93^{a}	1.88^{e}	22.41^{i}	17.88^{c}	8.94^{h}	14.78^{d}	1.20^{b}

Peak viscosity is the maximum viscosity developed during or soon after the heating portion of the test. Viscosity increased markedly after gelatinization causing further disintegration of the granules at elevated temperature. A drop in viscosity is characterized by the peak in the viscosity temperature curve (Dengate, 1984). The significant decreases in peak viscosities observed in treated samples are indicative of various degrees of starch gelatinization. However, while there were remnant ungelatinized starches in the roasted sample (9.67 to 67.88 RVU), starch granules of other treatments were completely gelatinized and therefore exhibited negative viscosity values. This is because maximum viscosity of starch suspension heated in an excess of water occurred after most of the granule swelling had ceased any further increase in viscosity would be caused mainly by exudates released from the granules which may appear as a filamentous network among them (Miller, *et al.,* 1973; Adebowale, *et al.*, 2008).

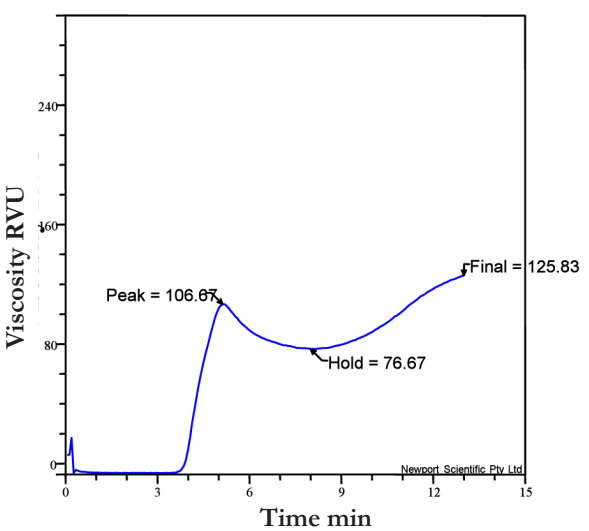

Fig. 1: RVA of raw cowpea (IT89KD-288)

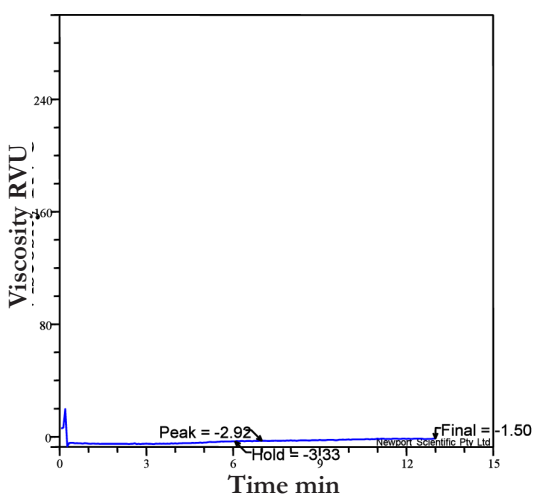

Fig. 2: RVA of boiled cowpea (IT88D-867-II)

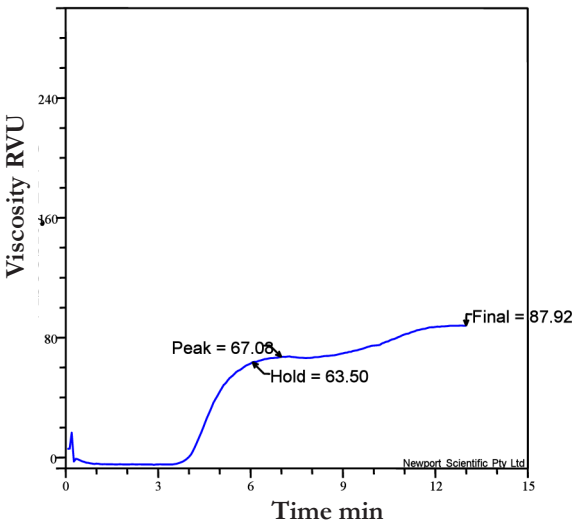

Fig. 3: RVA of roasted cowpea (IT89KD-288)

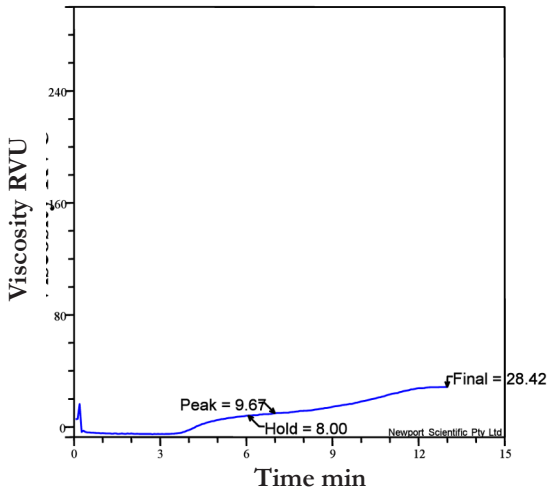

Fig. 4: RVA of roasted MALA

Trough (holding strength) is the minimum viscosity after the peak, normally occurring around the commencement of sample cooling. It is the ability of the granules to remain undisrupted when the flour paste is subjected to a hold period of constant high temperature (95°C for 2 min 30 sec) and mechanical shear stress. The holding period is often accompanied by breakdown in viscosity also referred to as shear-thinning, hot paste viscosity, paste stability or trough. It is regarded as a measure of the degree of disintegration of the granules or of 'Paste stability' (Olkku and Rha, 1978). Expectedly, roasted samples had significantly lower breakdown viscosity values (1.58 to 3.46 RVU) than untreated sample, but had better hot paste stability which was similar to previous observations (Plahar and Annan, 1997; Henshaw *et al.*, 1996). Final viscosity is the viscosity at the end of the test. As gelatinized dispersion of starch is cooled, a loose paste or gel is formed depending on starch concentration. At concentrations above the critical concentration, a three-dimensional network is established, where the swollen granules become embodied into a continuous matrix of entangled amylose molecules (Ring, 1985). Such a complex polymer matrix set as a viscoelastic gel in which the molecular associations involving hydrogen bonding between chains, are mainly physical rather than covalent cross links (Applqvist and Debet, 1997). The formation of such gel that is indicated by increase in viscosity is known as the final viscosity in paste gel curve. Final viscosities of roasted samples (17.54 to 88.42 RVU) were significantly lower than those of the untreated samples (122.54 to 146.71 RVU) but were higher than those of other processing treatments.

Setback viscosity is measured as the difference between the final viscosity and the trough. It is the phase of the pasting curve after cooling the starches to 50°C. This stage involves re-association, retrogradation or reordering of starch molecules. It shows the tendency of the starch to associate and retrograde. The setback viscosity of flours has been correlated with texture of various products (Adeyemi and Idowu, 1990; Mkhiyo *et al.*, 2004). High setback is also associated with syneresis or weeping. High setback viscosities in raw cowpea samples are indicative of greater tendencies towards retrogradation compared to samples from other treatments, particularly boiled samples (-1.88 to 1.46). This therefore has implication for use of cowpea in specific products. Peak time is the time at which the peak viscosity occurred in minutes, it is also indicative of the ease of cooking the product. Treated samples generally had significantly higher peak time than untreated cowpea.

Table 2: Functional properties of processed cowpea varieties

Processing variables	Cowpea varieties	Swelling power %	Solubility %	Water absorption capacity %
Raw	IT89KD-288	3.65[d]	23.42[a]	78.74[e]
	IT88D-867-II	3.45[d]	22.15[a]	77.76[e]
	MALA	3.29[d]	21.24[b]	76.86[e]
Boiled	IT89KD-288	4.92[bc]	14.34[cd]	237.92[b]
	IT88D-867-II	5.48[b]	11.55ef	244.21[ab]
	MALA	4.84[c]	15.68[c]	253.60[ab]
Dehulled	IT89KD-288	4.46[c]	14.43[cd]	242.31[cd]
	IT88D-867-II	4.83[c]	14.36[cd]	265.82[c]
	MALA	5.46[b]	12.93[de]	209.29[c]
Roasted	IT89KD-288	7.10[a]	11.53[ef]	141.99[d]
	IT88D-867-II	7.44[a]	10.12[ef]	141.99[d]
	MALA	6.93[a]	13.17[de]	140.26[c]

Table 3: Pasting properties of processed cowpea varieties

Processing variables	Cowpea varieties	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback Back (RVU)	Peak Time (min)	Pasting Temp (°c)
Raw	IT89KD-288	103.33[b]	75.67[b]	27.67[a]	122.54[c]	46.88[c]	52.3[a]	61.93[ab]
	IT88D-867-II	101.42[b]	77.58[b]	23.83[a]	130.7[b]	53.13[b]	5.23[d]	61.90[ad]
	MALA	114.71[e]	88.71[a]	26.00[a]	146.71[a]	58.00[a]	5.27[d]	62.40[a]
Boiled	IT89KD-288	–3.17[e]	–3.63[f]	0.46[b]	–2.17[g]	1.46[g]	6.77[ab]	61.90[ab]
	IT88D-867-II	–2.88[e]	–3.25[f]	0.38[b]	–1.38[g]	–1.88[g]	6.77[ab]	61.93[ab]
	MALA	–3.78[e]	–4.08[f]	0.29[b]	–2.79[g]	1.29[g]	6.27c	61.95[ab]
Dehulled	IT89KD-288	–4.00[e]	–4.46[f]	0.46[b]	–3.04[g]	1.42[g]	6.87[a]	61.88[ab]
	IT88D-867-II	–1.79[e]	–2.33[f]	0.54[b]	0.08[g]	2.42[g]	6.47[ab]	61.95[ab]
	MALA	–2.67[e]	–3.04[f]	0.38[b]	–1.54[a]	1.80[g]	7.00[a]	62.03[ab]
Roasted	IT89KD-288	67.88[c]	64.42[c]	3.46[b]	88.42[b]	24.00[d]	7.00[a]	61.93[ab]
	IT88D-867-II	5.80[d]	3.88[c]	1.63[b]	17.54[f]	13.67[f]	6.97[a]	61.98[ab]
	MALA	9.67[d]	8.88[d]	1.58[b]	28.29e	20.21[e]	7.00[a]	61.88[b]

Conclusion

Cowpea cultivars are similar in pasting properties, swelling power and water absorption but are significantly different in solubility characteristic. There were also significant differences in proximate and chemical composition of cultivars. Various processing treatments to which the samples were subjected resulted in significant differences between samples; tannin contents of the samples decreased significantly as a result of the treatments.

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