ASSESSMENT OF FUNCTIONAL PROPERTIES AND NUTRITIONAL COMPOSITION OF SOME COWPEA (*Vigna unguiculata* L.) GENOTYPES IN GHANA

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ABSTRACT

Cowpea (*Vigna unguiculata*) is a widely consumed food crop and largely cultivated in the dry savanna region of Northern Ghana. However one of the major constraints to cowpea production in Ghana is parasitism by *Striga gesnerioides* given rise to poor yield, hence to solve this problem *Striga*-resistance cowpea recombinant inbred lines have been developed from IT97K-499-35 (*Striga*-resistant parent) x Apagbaala (susceptible parent). The current study determined the functional properties and nutritional compositions of seeds of four advanced genotypes (F_8 progenies) derived from the cross and compared to the parental lines and a local check (GH3684) to assess their potential use in food and nutrition based on standard chemical analytical methods. There were significant differences ($P \leq 0.05$) in the nutritional and functional properties among the new cowpea genotypes and their parents compared to the local check, GH3684. Water absorption capacities, oil absorption capacities, foaming capacities and swelling power of the new breeds varied between 1.57-1.67 g/g, 0.86-0.97 g/g, 17.89-21.68 ml and 2.77-3.23 g/g, respectively. There were high values for ash, fiber and carbohydrate with ranges 4.47-4.72%, 1.56-2.55% and 54.78-59.03%, respectively. Fat content varied between 1.17-1.36%. Moisture and protein content ranged between 11.81-13.24% and 21.63-25.28%, respectively. The results indicate that the four new breeds of cowpea have appreciable nutritional composition and functional properties and therefore have great potential use in the food industry.

Keywords: cowpea, nutritional composition, functional properties.

INTRODUCTION

Cowpea (*Vigna unguiculata*) is a leguminous plant which belongs to the family *Fabaceae*. It is widely grown all over the world though it is perceived to have originated from Africa (Davis *et al*., 1991). It is a major staple food crop in sub-Saharan Africa, especially in the dry savanna regions of West Africa. The seeds are a major source of plant proteins and vitamins for man, feed for animals, and also a source of cash income. The young leaves and immature pods are eaten as vegetables (Dugje *et al*., 2009). The cowpea plant has the ability to tolerate drought and fix atmospheric nitrogen in the soil enhanced by the *Rhizobium* symbiont. Cowpea also suppresses weed because of its quick growth and establishment and control soil erosion to some extent. The economic uses of cowpea makes it a choice crop for serving food security needs of societies (Appiah *et al*., 2009). Some health benefits of cowpea include, toning the spleen, stomach and pancreas, helps induce urination and relieves damp conditions like leucorrhoea (Imrie, 2004).

Cowpea is rich in potassium with good amount of calcium, magnesium and phosphorus. It also has small amount of iron, sodium, zinc, copper, manganese and selenium. Cowpea is rich in vitamin A and C and also has appreciable amount of thiamin, riboflavin, niacin, vitamin B_6 and pantothenic acid as well as small amount of foliate (IITA, 2009). These nutrients provided by cowpea makes it extremely valuable especially where many people cannot afford animal proteins such as meat and fish (Appiah *et al*., 2011).

In Ghana cowpea is generally prepared and eaten as a whole or as part of a meal. It is the main raw material in meals like 'koose' (cowpea fritters) and 'gari' and beans (roasted graded fermented cassava and cooked beans). It is also used for preparing soup and stew (Appiah *et al*., 2011) but in developed world it is processed into flours and used as protein concentrate and isolates and animal feed formulation (Chinma *et al*., 2008). Variations in nutritional and functional properties in cowpea could influence potential use of the crop. The main objective of this work was to evaluate nutritional composition and functional properties of some recombinant inbred lines of cowpea to establish potential usage.

MATERIALS AND METHOD

Four advanced lines ($F_{8)}$ of cowpea; UC-96-446, UC-96-473, UC-96-390 and UC-96-513, a local cowpea accession (GH3684) and two parents (Apagbaala and IT97K-499-35) were used in this study.

Sample preparation

The samples were sundried two hours daily for 5 days. All foreign materials such as dust, stones, chaff, immature and broken seeds as well as bad seeds were removed by picking. The samples were then ground using the heavy duty blender and then packaged for analysis in the laboratory.

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DETERMINATION OF FUNCTIONAL PROPERTIES

Determination of water and oil absorption capacities

The method by Appiah *et al.* (2011) was used to determine water and oil absorption capacities of the cowpea genotypes. 1.0 g of the sample was mixed with 10 ml of distilled water in 20 ml centrifuge tube. The slurry was agitated for 2 minutes and allowed to stand at 28°C for 30 minutes and then centrifuged at 500 rpm for 20 minutes. The clear supernatant was decanted and discarded. The adhering drops of water or oil in the centrifuge tube were removed with cotton wool and the tubes were weighed. The weight of water or oil absorbed by 1 g of cowpea flour was calculated and expressed using the formula:

$$\frac{\text{Weight of water or oil absorbed (g)}}{\text{Weight of dry flour (g)}} \times 100$$

Determination of foaming capacity

Approximately 1.0 g of cowpea flour was weighed and whipped vigorously with 100 ml distilled water in a graduated cylinder for 5 minutes. The volume of foam at 30 seconds after whipping was expressed as the foam capacity using the formula:

Foam capacity = volume of foam (ml) / Mass of sample (g) (Appiah *et al*., 2011).

Determination of swelling power

Approximately 1.0 g of cowpea flour was weighed and mixed with 10 ml distilled water in a centrifuged tube and heated in a hot water bath at 80°C for 30 minutes while continuously shaking the tube. After heating, it was centrifuged at 1000 rpm for 15 minutes. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated using the formula: Swelling power = Weight of paste (g) / Weight of dry flour (g) (Appiah *et al*., 2011).

DETERMINATION OF NUTRITIONAL COMPOSITION

The cowpea samples were analyzed for moisture, protein, fat, ash, crude fibre and carbohydrate using standard procedures of AOAC, 2000.

RESULTS AND DISCUSSIONS

The results of the functional properties and nutritional compositions of the cowpea flours are shown on Figures 1 and 2, respectively.

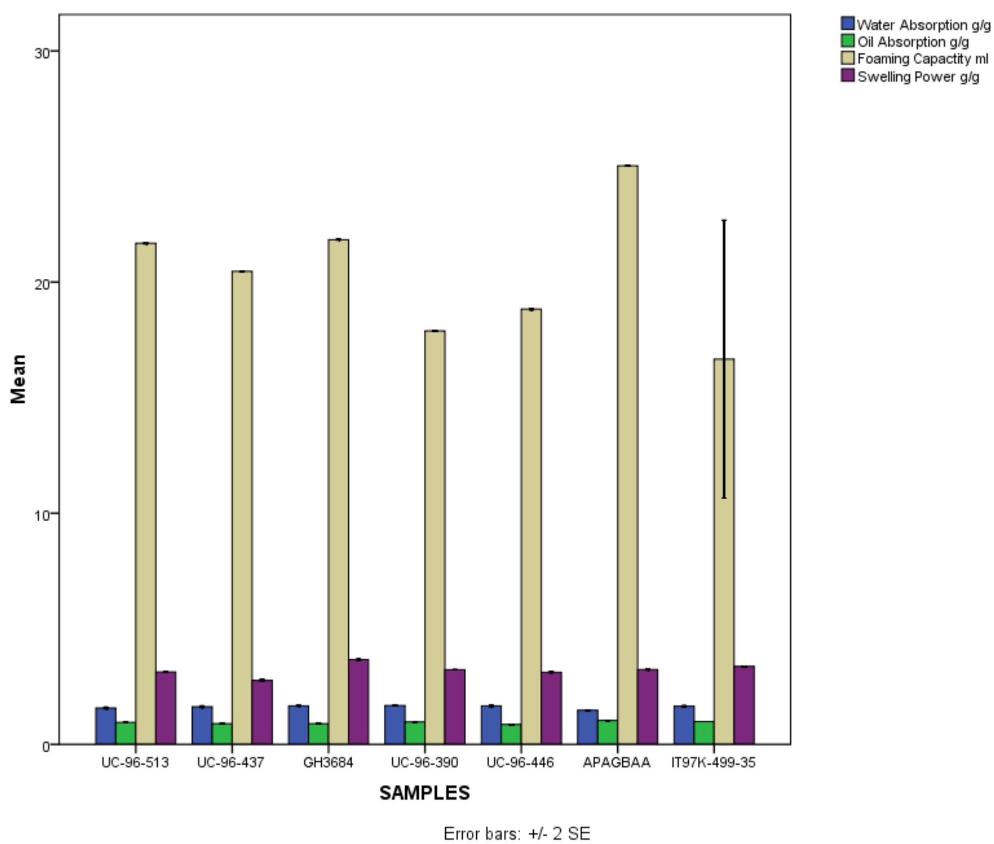

Figure-1. Functional properties of the cowpea samples.

Functional properties of cowpea flours

There were significant differences ($P \leq 0.05$) in water absorption capacities among the cowpea genotypes. The water absorption capacity of the cowpea genotypes ranged between 1.47-1.67 g/g (Figure-1). UC-96-390, a *Striga*-resistant and susceptible recombinant inbred cowpea genotype (RILs) had the highest water absorption capacity comparable to that of GH3684 (local *Striga*-resistant cowpea accession). In addition, significant difference ($P \leq 0.05$) in water absorption capacity existed between UC-96-513, UC-96-473 and the local accession GH3684. Similarly, significant difference ($P \leq 0.05$) in water absorption capacity was observed between sample UC-96-513 and 1T97K-499-35. On the whole the water absorption capacities (1.57- 1.67 g/g) among the RILs were significantly ($P \leq 0.05$) higher than that of the *Striga*-susceptible parent APAGBAALA (1.47 g/g). Appiah *et al.* (2011) reported 1.89 g/g-2.13 g/g water absorption capacities of three varieties of cowpea in Ghana which were higher compared to that of the results. This may be due to differences in protein concentrations, their degree of interaction with water and their conformational characteristics (Butt and Batool, 2011). According to Adejuyitan (2009), carbohydrates have been reported to influence water absorption capacities in foods. So the low level of water absorption capacities may be as a result of the high carbohydrate contents. It may also be due to less availability of polar amino acids in flours (Kuntz, 1971). However all but sample UC-96-513 of the new varieties conform to the work done by Chinma *et al*. (2008); for some cowpea varieties in Nigeria who reported water absorption capacities range of 1.60 g/g-1.94 g/g. So the moderate water absorption capacities of samples suggest that they may have useful functional ingredients in bakery products.

The oil absorption capacity of the samples ranged between 0.87-1.03 g/g (Figure-1). There were significant differences ($P \leq 0.05$) in oil absorption capacities between all the new breeds except between sample UC-96-513 and UC-96-390. There were also significant differences in oil absorption capacity between the parental genotypes and the RILs. The work done by Chinma *et al*., 2008) on cowpeas in Nigeria reported range of 0.39-0.53 g/g. The differences in oil absorption capacities may be due to differences in protein content Appiah *et al*. (2011). However, the moderate oil absorption capacities of the novel genotypes of cowpea could make them useful in food systems where oil imbibitions is desired; food such as sausage production and also suitable in facilitating enhancement in flavor and mouth feel when used in food preparations. The genotypes UC-96-513 and UC-96-390 could therefore be preferable to others since they have significantly higher oil absorption capacities.

The foaming capacity of the cowpea samples ranged between 17.89-25.03 ml (Figure-1). There were significant differences ($P \leq 0.05$) in foaming capacities among the cowpea genotypes. There was also significant difference between the local breed and all the RILs. Foaming capacities of the RILs were all lower than that of the local breed. Also there were significant differences ($P \leq 0.05$) between the parents and the RILs. While one parent Apagbaala has foaming capacity higher than all the RILs, the *Striga*-resistant parent IT97K-499-35 has a foaming capacity higher than samples UC-96-390 and UC-96-446 but lower than those of UC-96-473 and UC-96-573. This result compares favorably with the work done by Appiah *et al.* (2011) on three cowpea varieties in Ghana; who reported foaming capacity range of 17.0 ml-21.0 ml. The higher foaming capacities of the new breeds may be due to highly hydrated foams (Mwasaru *et al*., 1999). The high levels of foaming capacities of the new breeds are indication that their flours may be useful as foam enhancer in food systems. This means that their flours will be useful as aerating agents in food such as 'koose' (cowpea fritters) which require the production of stable foam volume when whipped. Sample UC-96-513 may be most preferred because of its high foaming capacity.

The swelling power of the cowpea samples ranged between 2.77-5.67 g/g (Figure-1). The swelling power differ significantly ($P \leq 0.05$) among the cowpea genotypes. There were high levels of swelling powers in all the RILs compared to the work done by Appiah *et al.* (2011) who reported a range of swelling power of 2.66-2.68 g/g. The difference in the swelling power ranges may be due to varietal factors. The high swelling powers of the cowpea genotypes considered in this work suggests that flour of the RILs could be useful in food systems where swelling is required with preference to samples UC-96-446 and UC-96-390.

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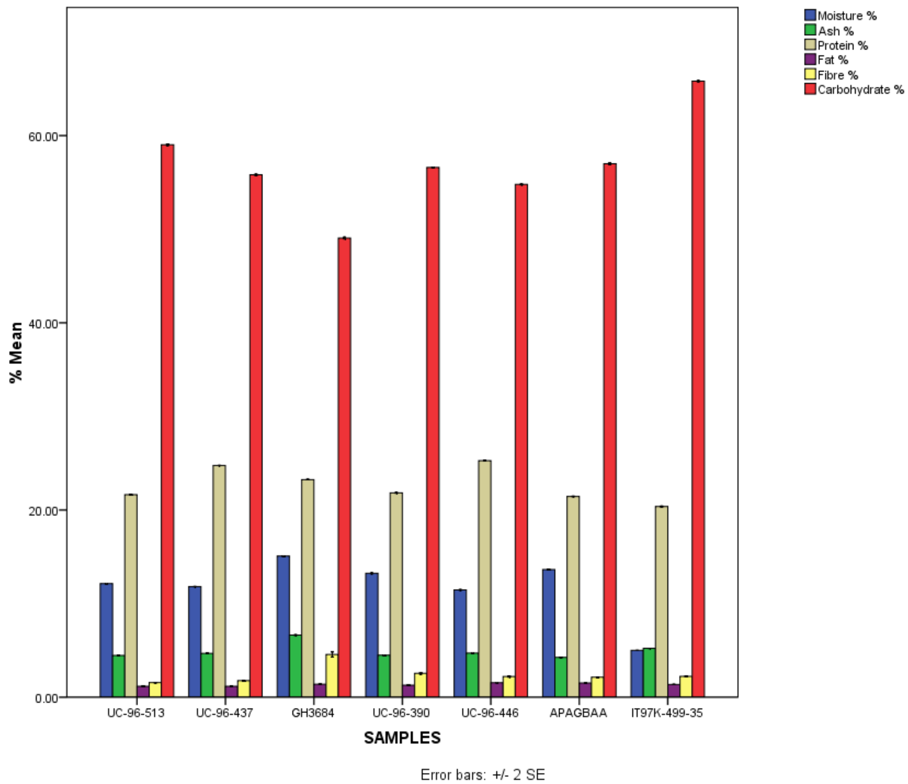

Figure-2. Nutritional composition of cowpea samples.

Nutritional composition of cowpea

According to Appiah *et al.* (2011) compositional differences in cowpea could be attributed to type of soil, cultural practices, environmental and genetic factors. Since the cowpea genotypes were grown under similar conditions the differences in proximate compositions could be mainly genetic. The ash content of the samples varied significantly ($P \le 0.05$) between 4.26-6.64% (Figure-2). There was significant difference ($P \le 0.05$) between the new breeds and the local accession GH3684. Also there was significant difference ($P \le 0.05$) between the parents and the new breeds. Chinma *et al*. (2011) observed that ash content varied from 2.72% - 3.73% for four varieties of cowpea in Nigeria and also Appiah *et al*. (2011) reported on three cowpea varieties in Ghana with ash content of 2.95% - 3.22%. The difference in ash content ranges could be attributed to type of soil, cultural practices, environmental and genetic factors Appiah *et al*. (2011). This high ash content indicates that the new breeds could be important source of minerals (Musood and Batool (2011). UC-96-446 will be the most preferred because of its high carbohydrate content.

The fat content of the cowpea sample varied between 1.18% - 1.56% (Figure-2). There were significant differences ($P \le 0.05$) between the fat content of the new breeds except for UC-96-473 and UC-96-513. There were also significant difference ($P \le 0.05$) between the new breeds and the parents. This work compares favorably to the work done by Chinma *et al.* (2008) on four cowpea varieties in Nigeria with fat content ranging from 0.79% - 2.4%. Similarly, the work done by Masood and Batool (2011) on some promising legume protein isolates in Pakistan indicated that fat content in cowpea is around 1.27%. The fairly high fat content of the new varieties ranging from 1.17% to1.56% suggested that the flours could be useful in improving palatability of foods in which they are incorporated (Appiah *et al*., 2011) with preference to UC-96- 446 due to its high fat content.

The moisture content of the sample ranged from 5.0% - 15.09% (Figure-2). There were significant differences ($P \le 0.05$) of moisture content among the new breeds. There were also significant difference ($P \le 0.05$) among the new breeds and between the local breed parent genotypes. Apart IT97K-499-35 the rest of the results compares favorably with the works of Appiah *et al.* (2011) and Chinma *et al.* (2008) where moisture content values ranges from 9.15% to 9.83% and 9.25% to 10.07% respectively. The difference in moisture content ranges could be attributed to type of soil, cultural practices, environmental and genetic factors. This high level of moisture means major part of the cowpea bean is made of water and can interact with protein and other chemical components and have good enzymatic reactions (Adebiyi *et al*., 2011).

The protein content of the cowpea sample ranged between 20.37% - 25.28% (Figure-2). There were significant difference ($P \le 0.05$) in protein content between the new breeds and the local GH3684. Whiles protein contents of the resistant new breeds are lesser than that of the local breed, that of the susceptible ones are higher than the local breed. There was also significant difference ($P \leq 0.05$) between the parents and the new breeds. All the new breeds have protein content higher than that of the parents. Masood and Batool (2010) reported that protein content of cowpea is around 27.88% and Appiah *et al.* (2011) reported protein content range from 26.53% to 29.00% on 3 cowpea varieties in Ghana. The difference in protein content range may be due to genetic factors and edaphic. But sample UC-96-446 has moderately high protein content of 25.28% indicating that it will be preferred in improving nutrition and therefore could help reduce protein deficiency conditions such as Kwashiorkor.

The fiber content of the samples ranged between 1.56% - 4.47% (Figure-2). There were significant differences ($P \leq 0.05$) in the fiber content of the new varieties. There were also significant differences ($P \leq 0.05$) between the new breeds and the local cowpea accession (GH3654). However there was no significant difference ($P \geq 0.05$) between UC-96-446 and the parent in relation to crude fiber content. Sample UC-96-390 has fiber content higher than that of both parents but samples UC-96-513 and UC-96-473 have fiber content less than that of the parental genotypes. Chinma *et al.* (2008) reported on four cowpea varieties in Nigeria which varies from 1.92%-3.37%. Samples UC-96-513 and UC-96-473 have fiber contents lower than this range but samples UC-96-446 and UC-96-390 have fiber contents which fall within this range. The differences in fiber content may be due to genetic and environmental factors. Although the crude fiber contents of the novel genotypes were relatively low, UC-96-390 and UC-96-446 could be useful in providing bulk to foods to relieve constipation.

The carbohydrate content of the cowpea genotypes varied significantly ($P \leq 0.05$) between 49.06%-65.81% (Figure-2). All the four new genotypes had carbohydrate content higher than that of the local cowpea accession (GH3684). There was also significant difference ($P \leq 0.05$) between the parents and the new varieties. This result compares favorably to the work done by Appiah *et al*., on four cowpea varieties in Ghana which ranges from 50.55% to 53.98%. Similar work done by Chinma *et al.* (2008) on four cowpea varieties in Nigeria reported range of 53.56% to 57.36%. The differences in carbohydrate content ranges may be due to genetic factors. They could be important source of energy to consumers Appiah *et al*. (2011).

CONCLUSIONS

The study showed that the four new cowpea genotypes (UC-96-390 and UC-96-513 which has resistance to *Striga gesnerioides* and samples UC-96-446 and UC-96-473 which are susceptible to *Striga gesnerioides*) are rich in carbohydrate and have good nutritional composition which could be exploited for food formulation and nutrition. The good functional properties will make them useful in foods such as sauces, sausage, 'koose', 'waakye', soup and stews where they could play functional roles. The flours of these new cowpea genotypes could be used to fortify conventional flours which are low in protein especially UC-96-446 and when consumed will help alleviate protein malnutrition. They are good to be used in general food systems

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