Physical, Functional and Cooking Characteristics of Six Newly Released Cowpea (*Vignaunguiculata*[L]Walp) varieties in Ghana

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Abstract
As part of the innovative platform in varietal development and biodiversity, the CSIR - Crops Research Institute has released four cowpea varieties (Hans Adua, Nketewade, Zamzam and Agyenkwa). For consumer and end-use indices there is the need therefore to evaluate these newly released cowpea varieties alongside two previously released varieties(Asomdwee and Hewale), for their proximate composition, horticultural characteristics, bulk densities, hydration behavior and cooking characteristics to elicit data to support its broadened utilization. Approved methods of the AAAC, (2000) were used in determining percent crude protein, moisture, ether extract, crude ash, and carbohydrate content which ranged from 22.41 - 25.46, 7.41 - 11.37, 1.54 - 2.44, 2.71 - 3.07 and 57.61 - 63.17 % respectively. Total energy ranged between 337.54 and 350.98 kcal. Cooking time, Water UptakeRatio, Volume Expansion Ratio, Gruel solid loss, hydration capacity and Index, Swelling capacity ranged from 25.00 - 42.50 min, 1.14 - 1.32, 2.07 - 2.29, 0.27 - 0.78 g, 0.12 - 0.17 g/seed, 0.83 - 1.01, 0.270.35 mL/seed respectively.Flours' bulk densities, true densities and porosities ranged from 0.67 0.72 g/cm3, 0.37 0.47 g/cm3 and 98.03 98.93 % respectively.Horticultural characteristics seed shapes were described as kidney, ovoid and rhomboid. Seed coat texture were smooth; seed coat colour were whitish; seed sizes ranged between 123.30 - 301.86 mm3.From the results, these cowpeavarietiescould serve as a good template and a potential functional ingredient for a lot of aqueous and non-aqueous food formulations both in food and non-food utilization.

Keywords: physico-chemical, horticultural, gruel solid loss, water uptake, bulk density.

Résumé
Dans le cadre de la plate-forme d'innovation dans le développement des variétés et de la biodiversité, le CSIR - Crops Research Institute a homologué quatre variétés de niébé (Hans - Adua, Nketewade, Zamzam et Agyenkwa). Pour les consommateurs et l'utilisation finale des indices il est nécessaire donc d'évaluer ces variétés de niébé nouvellement homologués aux côtés de deux variétés précédemment homologuées (Asomdwee et Hewale), pour leur composition immédiate, caractéristiques horticoles, les densités en vrac, le comportement d'hydratation et les caractéristiques de cuisson pour obtenir des données soutenir son utilisation élargie. Pourcentage de protéines brutes, l'humidité, extrait à l'éther, cendres brutes, et la teneur en hydrates de carbone variaient de 22,41 à 25,46, 7,41 à 11,37, 1,54 à

2,44, 2,71 à 3,07 et de 57,61 à 63,17%, respectivement. L'énergie totale se situait entre 337,54 et 350,98 kcals. Le temps de cuisson, Ratio d'absorption d'eau, Ratio d'expansion du volume, Gruau perte solide, capacité d'hydratation et de l'indice, la capacité gonflement variaient de 25,00 à 42,50 min, 1,14 à 1,32, 2,07 à 2,29, 0,27 à 0,78 g, 0,12 à 0,17 g/semences, 0,83 - 1,01, 0,27 à 0,35 ml /semences respectivement. Densités en vrac, véritables densités et porosités de farines variaient de 0,67 à 0.72 g/cm3, 0,37 à 0,47 g/cm3 et de 98,03 à 98,93%, respectivement. Caractéristiques horticoles - formes de semences ont été décrits comme les reins, ovoïde et rhomboïde. Le texture manteau de graine étaient lisses; la couleur du pelage des semences étaient blanchâtres; tailles de semences variaient entre 123,30 à 301,86 mm3.A partir des résultats, ces variétés de niébé pourraient servir comme un bon modèle et un ingrédient fonctionnel potentiel pour un grand nombre de formulations alimentaires aqueuses et non aqueuses tant dans les aliments et l'utilisation non-alimentaire.

Mots-clés: physico-chimique, l'horticulture, du gruau perte solide, absorption d'eau, expansion du volume, la densité en vrac.

Introduction

Ghana, a country located on Latitude 4° 44'N and 11° 11'N, and Longitude 3° 11'W and 1°11'E, with a population of over 25 million people and land area of 238,500 square km, has a total of 13.6 million hectares of available Agricultural Land. Out of this over 7.9 million hectares has been cultivated. Cowpea cultivation in 2003 alone covered about 190,400 hectares of this but had been reduced to 163,700 by 2010 (MoFA, SRID, 2011).

In dietary terms, food legumes complement cereal crops as a source of protein and minerals, while agronomically; they serve as rotation crop with cereals; reducing soil pathogens and supplying nitrogen to cereal crops (Beebe and Steve, 2010). Cowpea (*Vigna unguiculata* [L.] Walp), also known as Southern pea, China pea, Black-eye bean or Cow gram in the United States (Olalekan and Bosede, 2010; Appiah *et al.,* 2011) is an important versatile food legume indigenous to Africa, and belongs to the family Fabaceae. Though African by origin, (both tropical and sub-tropical), cowpea is adapted and cultivated between 35°N to 30°S of the equator; covering Asia and Oceania, the Middle East, Southern Europe, Africa, Southern USA, and Central and South America (Appiah *et al.,* 2011; Chinma *et al.,* 2008). Unlike other legumes such as soybeans and groundnuts, which are oil-protein seeds, cowpea is starch-protein seed offering a wider pattern of utilization than any other legume in West Africa (Henshaw, 2000).

For consumer and end-use indices there is the need therefore to evaluate these newly released cowpea varieties alongside two previously released varieties(Asomdwee and Hewale), for their proximate composition, horticultural characteristics, bulk densities, hydration behavior and cooking characteristics to elicit data to support its broadened utilization.

Processing of cowpea into value added products is influenced by both physical and chemical properties. According to the World Cowpea Conference in 2010, for proper processing and industrial application of any material, knowledge of the physical and functional properties of such material is imperative. Such knowledge can help in formulation, packaging and even designing for use, certain equipment in processing and planting. In cowpeas, physical properties such as seed texture affect hydration behaviour while chemical composition affects cooking properties of the seed (Sefa-Dedeh and Stanley, 1979). Chemical composition such as carbohydrates and protein contents, influence seeds' cooking time (Henshaw *et al.,* 2003; Henshaw, 2000). According to Langyintuo *et al.* (2003) consumer acceptable factors considered to influence production and preference in the cowpea value chain are the ease in cooking, horticultural characteristics, grain appearance and palatability of the bean. Silva *et al.* (2009) also reported that grain acceptability for human consumption depends not only on its nutritional quality, but also on its cooking and hydration characteristics. They as well indicated that thermal treatment of leguminous grains has nutritional implications in that it develops adequate flavor and texture for consumption, and inactivates heat labile anti-nutritional factors, thus improving protein digestibility. Carbonell *et al.* (2003) also alluded that the most important bean characteristics for consumers are: shorter cooking time, fast hydration capacity, teguments that do not break during hydration and cooking, and high volume expansion after cooking. Bressani, (1993) reported that, besides the shorter cooking time and fast hydration, cooked grains should have good grain size and color, grain color stability, thick sauce, good taste, good texture, moderately cracked grains and thin husk. Prolonged cooking time causes minerals, vitamins and proteins loss. Bourne (1982), reported that cooking renders food crops including legumes edible and good cooking ensures their acceptable sensory integrity.

In cowpeas, cooking brings to bear certain physico-chemical changes in the textural integrity of the bean. These changes include gelatinization of starch, denaturation of proteins, solubilization of some of the polysaccharides, and softening and breakdown of the middle lamella of the cotyledon (Vindiola *et al.,* 1986). Cooking also reduces the levels and sometimes inactivates heat-labile anti-nutrients such as trypsin inhibitors and flatulence-causing oligosaccharides (verbascose, mannose and stachyose), (Addo, 2004) resulting in improved nutritional quality, consumption, acceptability and improved digestibility (Wang *et al.,* 2008; Ayyagari *et al.* 1989; Jood *et al.,* 1985). Though, cooking renders legumes edible (Bourne, 1982), prolonged cooking time is associated with some negative effects such as breakdown and loss of structural integrity of the cooked grains, reduction in protein nutritive value, thus limiting their preference as high protein source, (Chandrashaker *et al.,* 1981), and increased consumption of energy/fuel and time. Cooking timeis one of the most important factors responsible for consumers' choice for a particular food. Besides cooking time, the assessment of texture and maintenance of structural integrity after cooking are also critical in the determination of cooking quality and plays an important role in determining consumer acceptance of cooked legumes (Stanley *et al.,* 1989). The objective of the present study was to determine cowpeas' physicochemical properties,assess theirhydration behavior in relation to cooking and evaluate cooking characteristics of four newly released cowpea varieties by the CSIR - Crops Research Institute (CSIR-CRI), Ghana, as well as assess their comparative advantage to two other already released varieties, thus generating data to assist in their broadened utilization.

Materials and Methods

Materials

True-to-type cowpea grains of the newly released varieties namely, Hans-Adua, Nketewade, Zamzam and Agyenkwa,and two already released varieties; Asomdwee and Hewalewere obtained from the Oil Seeds and Legumes Improvement Breeding Programme of the CSIR-CRI in Kumasi, Ghana. Grains received were subjected to laboratory screening, cleaned of foreign matter and damaged grains, sampled and ground into respective flours using a Cyclone Sample Mill (Model 3010 08IP) with a mesh size of 45 µm. Flours were then packed in zip-lock whirl-pac sample bags and stored in a freezer until further usage. All reagents used in this study were of analytical grade.

Methods

Proximate composition

Percent crude protein (CP) was determined by the Kjeldahl AOAC method with the Kjeltec Auto FOSS 8012 analyzerand calculated as (% CP = % N X 6.25), Percent Ether Extract (EE) was determined by Soxhlet extraction, percent ash (% mineral) by incinerating samples in a muffle furnace at 600 ^{o}C for eight hours, and moisture contents using convection oven. All determinations were according to the American Association of Cereal Chemist standard methods (AAAC, 2000). Percent carbohydrate content was obtained by difference. Total Energy in kcal was calculated by formula.

% Carbohydrate = [100 (% protein + % fat + % ash + % fiber + % moisture)].

Total Energy (kcal) = [(Protein x 4) + (Fat x 9) + (Carbohydrate x 3.75)]

Thousand seed weight

Thousand (1000) seed weight was determined by counting one thousand cowpea seeds manually and weighing using an analytical weighing balance.

Horticultural properties

Horticultural properties of cowpea seeds namely, seed shape, seed coat colour and hilum colour were described by visual examination. Seed shapes were classified using descriptors for cowpea seeds as described by Ogle *et al.* (1987).

Bulk density and true density

Bulk density was determined according to the method of Wani *et al.* (2013a) and expressed as g/L and True density according to the method of Mohsenin (1980).

Porosity

The porosity (ε) of the bulk of cowpea is the ratio of spaces in the bulk to its bulk volume and was determined by the following equation (Mohsenin, 1980).

$$\% \varepsilon = 100 [(1 \quad (Pb/Pk)]$$

where ε is the porosity in percentage; Pb is bulk density in g/mL and Pk is seed density in g/mL.

Cooking characteristics and hydration behaviour

Cooking time (CT)

Cooking time was determined according to the method of Wani *et al.* (2013b).

Gruel solid loss (GSL)

Grains (5 g) were cooked in 100 mL deionized water for minimum cooking time. The gruel was transferred into 250 mL beaker and then evaporated till completely dried in a hot air convection oven (Model: OSK 9500 C, Ogawa Seiki) at 110 oC. The solids were subsequently weighed and gruel solid loss was calculated as percentage.

Water uptake ratio (WUR)

Twenty grams (20 g) of grains were placed in a pre-weighed wire basket and lowered into a 1000 mL beaker containing 640 mL boiling deionized water and cooked for a minimum cooking time at reduced heat. The cooked grains were then removed; drained and surface water on samples removed using filter paper. The wire basket and dried samples were reweighed and the water uptake ratio was calculated as the ratio of weight gained after cooking to weight before cooking. (Wani *et al,* 2013b)

Volume expansion ratio (VER)

Twenty grams (20 g) of grains was placed in a small graduated measuring cylinder and the height of the raw samples measured to the nearest milliliter. The samples were then placed in a wire basket and immersed into a 1000 mL beaker containing 640 mL boiling deionized water and cooked for minimum cooking time at reduced heat. The cooked samples were then removed; drained and surface water on samples removed using filter paper. The samples were placed in the measuring cylinder and the height of sample measured. Volume expansion ratio was calculated as Height of sample after cooking to height of sample before cooking. (Wani *et al,* 2013b)

Hydration capacity (HC) and hydration index (HI)

Grains (5 g) were soaked in 50 mL de-ionised water in a beaker and covered with aluminum foil. Seeds were left to soak for 24 h at ambient temperature (28± 2°C); drained and excess water removed using tissue paper. The weight of the swollen seeds was measured. Hydration capacity and hydration index were calculated as below (Adebowale *et al.* 2005).

$$\text{Hydration capacity} = \frac{\text{Water after soaking - Weight before soaking}}{\text{Number of seed}}$$

$$\text{Swelling index} = \frac{\text{Hydration capacity of seed}}{\text{Weight of one seed}}$$

Swelling capacity and swelling index

The volume of 5 g of grains was predetermined using a graduated measuring cylinder. Grains were subsequently soaked overnight in de-ionised water at ambient temperature (28±2°C). The volume of the seeds after soaking was then measured. Swelling capacity and swelling index were determined using the method of Adebowale *et al.* (2005);

$$\text{Swelling capacity} = \frac{\text{Volume after soaking - Volume before soaking}}{\text{Number of seed}}$$

$$\text{Swelling index} = \frac{\text{Swelling capacity of seed}}{\text{Number of seed}}$$

Mineral determination

The method of Hunter *et al.* (1984) and Benton *et al.* (1990) was used for mineral analysis. Flour sample (0.480.52 g) was weighed into a clean ceramic crucible. Blank crucible was added. Samples were incinerated in a muffle furnace at 600 °C for 8 hours. Ashed sample was transferred into 50 mL centrifuge tube and the crucible was subsequently rinsed with 5 mL distilled water and 5 mL (3 times) of "aqua regia" solution. The sample was vortexed and centrifuged at 3000 rpm for 10 min. The supernatant was decanted into micro-vials. Macro and Micro minerals composition was determined using flame atomic absorption spectrophotometer (Model: Buck 205 from Buck Scientific, USA).

Statistical analysis

GenStat Discovery, Edition 3 was used for the statistical analyses (http://www.vsni.co.uk).

Results and Discussions

Varieties assessed had varied horticultural properties. Apart from Hans-Adua and Zamzam which had tan brown hilum colour, all varieties under study had black hilum colour (Table 1). Seed coat texture described as either smooth or wrinkled were smooth-rough for Nketewade and Hewale but smooth for the other varieties (Table 1). Seed coat texture has been shown to affect cooking and moisture absorption properties. According to Sefa-Dedeh *et al.* (1978) and Sefa-Dedeh and Stanley, (1979), cowpea seeds with smooth seed coat texture tend to absorb less water than seeds with wrinkled seed coat. Seed coat texture could be an important selection index when processing cowpea seeds into flour. Seed shape could be described as kidney, globose, ovoid and rhomboid shapes. Nketewade, Zamzam and Hewaleare rhomboid in shape as compared to ovoidal shape of Agyenkwa, kidney of Hans-Adua and globose of Asomdwee (Table 1). Seed coat colour is an important property which influence consumer acceptance of cowpea varieties. Ghanaians are known to prefer cream/whitish seeded cowpea (Quaye *et al.,* 2009) unlike Nigerian's who prefer the brown coloured seeds to cream/white for cooking by boiling because they provide a sensory appeal by their colour. Cream/white coloured varieties are mainly used in products requiring de-hulling such as cowpea paste and flours in Nigeria (Quaye *et al.,* 2009).All varieties under study were whitish in colour (Table 1).Thousand (1000) seed weight ranged between 123.30 and 231.70g (Table 1). These results were in agreement though higher than that reported by Hamid *et al.,* (2014) for Red cowpea (130.78 g) and Black cowpea (98.82 g). Appiah *et al.* (2011) also reported 1000 seed weight of 131.6 - 151.6 g for three cowpea cultivars. Sobukola and Abayomi (2011) have reported 1000 seed mass for certain cowpea seeds in the range between 140.44 g and 192.81 g. The dimensions of cowpea beans and their 1000-seed weight give indication of the space their flours would occupy as well as their bulkiness.

Apart from percent crude protein, significant ($p<0.001$) differences were observed across varieties for percent (moisture, ether extract, ash and carbohydrate) contents (Table 2). Percent crude protein content was in the range of 22.41 % (Agyenkwa) and 25.46 % (Zamzam). This is in agreement with early reports by Appiah *et al.,* (2011) who reported protein content of 26.53, 26.55 and 29.00 % for Adom, Tona and Nhyira respectively; and Hamid *et al.* (2014); Red cowpea (21.29 %) and Black cowpea (23.90 %). Moisture content ranged between 7.41 % (Hewale) to 11.37 % (Zamzam). This implies that in terms of spoilage and storage life, Hewale would be more resilient or irrepressible than Zamzam. Percent ether extract ranged from 1.54% to 2.44% confirming that cowpea is a low fat legume compared to soybean and groundnut. Significant ($p<0.001$) difference was observed in percent crude ash (a reflection of mineral status, even though contamination can indicate a high concentration in a sample) ranging between 2.71 % and 3.07%. Carbohydrate content was in the range of 57.61 % and 63.17 %. Total energy ranged between 337.54 kcal and 350.98 kcal indicating that cowpea is a high energy legume (Table 2).

Cooking is the combination of hydration and heating regimes. Cooking characteristics of cowpea seeds were studied by measuring cooking time, water uptake ratio, gruel solid

Table 1: Horticultural characteristics of cowpea varieties

Horticultural characteristic					
Varieties	*Seed Coat Texture*	*Seed Shape*	*Hilum Colour*	*Seed Coat Colour*	*1000 Seed Weight (g*
Nketewade	Smooth-rough	Rhomboid	Black	Whitish	172.23
Hans-Adua	Smooth	Kidney	Tan Brown	Whitish	189.67
Zamzam	Smooth	Rhomboid	Tan Brown	Whitish	201.90
Agyenkwa	Smooth	Ovoid	Black	Whitish	188.70
Asomdwee	Smooth	Globose	Brown	Whitish	231.70
Hewale	Smooth-rough	Rhomboid	Black	Whitish	123.30

loss, and volume elongation ratio (VER) (Table 3). Cooking time ranged between 25.00 min to 42.50 min. Nketewade, Hans Adua and Zamzam had significantly (p ?0.001) lower cooking time compared to Agyenkwa, Hewale and Asomdwee. These results indicate that the former three varieties would be the first preference for consumers as it would involve lesser energy/fuel and time for cooking. These results are in agreement with results of Appiah *et al.,* (2011) and Hamid *et al.,* (2014) who have reported cooking times of 57 min, 65 min and 84 min for three cowpea varieties viz. Nhyira, Tona and Adom, respectively and 64.67 and 29.77 min for Red and Black cowpea respectively. No significant difference was observed in WUR for all varieties under this study. This is so because no significant ($p>0.001$) differences was observed in their respective bulk densities. Volume expansion Ratio or cooked elongation ratio and percent gruel solid loss during cooking did not vary significantly (Table 3). Gruel solid loss was in the range of 0.27 g and 0.78 g. This is indicative of the fact that in cooking a lot of solids would be retained in cowpeas under study and is in agreement with earlier work reported by Hamid *et al.* (2014) for Red cowpea (0.44 g) and Black cowpea (0.48 g) solid loss.

Hydration capacity and hydration index ranged between 0.12 and 0.17 g/seed and 0.83 to 1.01 respectively (Table 3). No significant difference was observed. This might be due to the indifference in bulk densities. Tresina and Mohan (2012) have reported hydration capacity of 0.03 g/seed and hydration index of 0.9 for cowpea. Significant ($p<0.001$) difference was observed in swelling capacity which ranged between 0.270.35 mL/seed but no difference was observed for swelling index which recorded 0.01 for cowpea varieties (Table 3). Tresina and Mohan (2012) have reported swelling capacity and swelling index values as 0.053 mL/seed and 0.001 mL/seed, respectively for Red and Black cowpea cultivars.

The bulk density (heaviness) of flours is determined by particle density which in turn is determined by solid density and particle internal porosity, and also by spatial arrangement of the particles in its containment.

Table 2. Table of mean determinations of proximate composition of released cowpea

Cowpea Varieties	*Moisture Content*	*Total Proteins*	*Ether Extract*	*Ash Content*	*Total Carbohydrate*	*Total Energy (kcal)*
Nketewade	9.70 (0.53)	24.29 (0.01)	2.44 (0.13)	2.82 (0.04)	60.44 (0.53)	345.02
Hans-Adua	10.32 (0.52)	24.23 (0.25)	1.75 (0.04)	2.75 (0.02)	60.48 (0.52)	339.61
Zamzam	11.37 (0.04)	25.46 (1.63)	1.74 (0.04)	2.71 (0.02)	57.61 (0.04)	337.54
Agyenkwa	11.21 (0.17)	22.41 (2.68)	2.07 (0.11)	2.71 (0.04)	59.94 (0.03)	339.88
Asomdwee	8.50 (0.13)	25.12 (0.01)	1.54 (0.06)	2.83 (0.01)	62.15 (0.17)	347.02
Hewale	7.41 (0.38)	24.22 (0.01)	1.96 (0.08)	3.07 (0.07)	63.17 (0.15)	350.98
Max	11.37	25.46	2.44	3.07	63.17	350.98
Min	7.41	22.41	1.54	2.71	57.61	337.54
Average	9.75	24.28	1.92	2.81	60.63	343.34

Figures in brackets are standard deviations

Table 3.Hydration behavior and cooking characteristics of cowpea varieties

Parameter	*Cowpea Varieties*								
	Nketewade	*Hans-Adua*	*Zamzam*	*Agyenkwa*	*Asomdwee*	*Hewale*	*Mean*	*Max*	*Min*
WUR	1.15±0.02	1.14±0.08	1.15±0.13	1.14±0.04	1.19±0.05	1.13±0.02	1.18	1.32	1.14
VER	2.07±0.05	2.11±0.18	2.13±0.06	2.13±0.00	2.25±0.04	2.29±0.04	2.16	2.29	2.07
HC	0.12±0.02	0.14±0.00	0.17±0.00	0.14±0.00	0.13±0.00	0.12±0.00	0.14	0.17	0.12
HI	0.83±0.24	1.01±0.00	0.95±0.15	0.98±0.06	0.92±0.01	0.97±0.00	0.94	1.01	0.83
SC	0.27±0.02	0.31±0.03	0.35±0.01	0.30±0.01	0.28±0.02	0.30±0.00	0.30	0.35	0.27
SI	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01	0.01	0.01
GSL	0.27±0.03	0.31±0.03	0.27±0.03	0.32±0.03	0.78±0.08	0.35±0.02	0.38	0.78	0.27
CT(min)	25.00±1.41	25.00±0.00	29.00±1.14	42.50±0.71	40.50±0.71	34.50±0.71	32.75	42.50	25.00

FWUR = Water Uptake Ratio; VER = Volume Expansion Ratio; HC = Hydration Capacity;
HI = Hydration Index; GSL = Gruel Solid Loss; SC = Swelling Capacity; SI = Swelling Index;
CT = Cooking Time

Table 4. Physical properties of cowpea seeds

Parameter	*Cowpea Varieties*								
	Nketewade	*Hans-Adua*	*Zamzam*	*Agyenkwa*	*Asomdwee*	*Hewale*	*Mean*	*Max*	*Min*
BD (g/cm^3)	0.68 (0.01)	0.68 (0.00)	0.67 (0.01)	0.69 (0.01)	0.72 (0.01)	0.72 (0.01)	0.69	0.72	0.67
TD (g/cm^3)	0.39 (0.06)	0.39 (0.00)	0.45 (0.00)	0.37 (0.00)	0.43 (0.01)	0.47 (0.00)	0.42	0.47	0.37
Por. (?) %	98.70 (0.45)	98.78 (0.02)	98.15 (0).04	98.93 (0.02)	98.70 (0.04)	98.03 (0.02)	098.55	98.93	98.03

BD = Bulk Density, TD = True Density, Por. = Porosity and AR = Angle of Repose.
Figures in brackets are standard deviations

Significant difference ($p<0.001$) was observed in bulk densities of cowpea. The values for bulk density, true density and porosity are show in Table 4. Bulk density ranged between 0.67 - 0.72 g/cm^3. Bulk densities of 0.69 - 0.80 g/cm^3 were reported for three cowpea varieties by Appiah *et al.* (2011). Hamid *et al.* (2014) also reported bulk density values of 0.82 g/mL for Black cowpea and 0.72 g/mL for Red cowpea. Values for porosity were in agreement with previously reported work by Hamid *et al.* (2014) for Red cowpea (94.24 %) and Black cowpea (93.60 %). Porosity of seeds is very important in water uptake, as seeds with low porosity may find it difficult to take up water easily compared to seeds with high porosity (Saguy *et al.,* 2005; Marabi and Saguy, 2004). This may have implications on cooking time of cowpeas.

Mineral deficiency is a major health issue especially micronutrients which can lead to several health consequences. Researchers aim at investigating the mineral levels in commonly consumed foods for possible improvement.

Phosphorus (P) is found in most foods because it is a critical component of all living organisms. A range of 0.33% to 0.36 % P was obtained for the cowpea varieties under study (Table 5). Calcium contents varied between 0.12 % and 0.16 % with a mean of 0.15 %

Table 5. Macro Mineral Composition of Cowpea Varieties

Cowpea Varieties	*Mineral Composition (%)*				
	Ca	*Mg*	*K*	*Ca*	*P*
Nketewade	0.16	0.21	0.84	0.87	0.35
Hans-Adua	0.16	0.19	0.61	0.66	0.33
Zamzam	0.16	0.17	0.34	0.48	0.37
Agyenkwa	0.12	0.19	0.32	0.54	0.36
Asomdwee	0.16	0.17	0.53	0.48	0.36
Hewale	0.12	0.23	0.65	0.72	0.40
Grand Mean	0.15	0.17	0.55	0.63	0.36
Maximum	0.16	0.23	0.84	0.87	0.40
Minimum	0.12	0.17	0.32	0.48	0.33

Ca = Calcium; Mg = Magnesium; K = Potassium; Na = Sodium; P = Phosphorus

Table 6. Micro Mineral Composition of Cowpea Varieties

Cowpea Varieties	*Mineral Composition (mg/kg)*			
	Fe	*Mn*	*Cu*	*Zn*
Nketewade	211.92	2.40	9.88	11.52
Hans-Adua	154.32	2.56	9.96	11.28
Zamzam	323.76	1.16	9.64	10.00
Agyenkwa	280.32	2.88	8.52	10.84
Asomdwee	288.24	0.76	8.16	9.72
Hewale	252.48	3.28	9.04	12.64
Grand Mean	251.84	1.87	9.22	10.69
Maximum	323.76	3.28	9.96	11.52
Minimum	154.32	0.76	8.16	9.72

Fe = Iron; Mn = Manganese; Cu = Copper; Zn = Zinc

(Table 5). The Recommended Daily Average (RDA) for calcium is about 0.8 -1.2 % for adults. It is vital for the development of healthy bones, teeth, muscle contraction, heartbeat regulation as well as formation of blood clots. A long-term shortage of calcium can lead to osteoporosis, when the bones become brittle and break easily. Daily intake of potassium (K) between 1.875 % and 5.625 % is considered adequate and safe, however, too much can be harmful. K content in cowpea varieties under study ranged from 0.32 % to 0.84 %; appreciably good K content in these varieties.The proper balance of potassium in the body depends on sodium (Na). Na is important for the control of water balance in the body, helps with normal nerve impulse regulation and muscle contraction. Sodium levels in cowpea varieties under study ranged from 0.48 % and 0.87 %. A good potassium-sodium balance in these cowpeas gives assurance that when taken could provide protection for the human body against osteoporosis and heart diseases (Walsh, 2003). Magnesium content ranged between 0.17 % and 0.23 % with a mean of 0.17 %. The RDA of Mg is set at 0.3 % for women and 0.35 % for men. From the results, cowpeas could be very good source of Mg.

Billions of people in developing countries suffer from micronutrient malnutrition, also known as "hidden hunger," that is caused by insufficient micronutrients i.e. Vitamin A, Zinc (Zn), and Iron (Fe) in the diet. Cowpea varieties studied had manganese (Mn) content ranging from 0.76 to 3.28 mg/kg (Table 6). High levels of Iron (Fe) concentration were observed within cowpea varieties ranging between 154.32 mg/kg and 323.76 mg/kg (Table 6). The content of Copper (Cu) ranged between 8.16 and 9.96 mg/kg for cowpea flour. Contents of Zinc (Zn) ranged between 9.72 and 11.52 mg/kg (Table 6). With this range of zinc content of cowpea flour, cowpea could be recommended for diet formulations for hypertensive patients. Zn helps to regulate many of the human body's processes and is essential for survival. Deficiency has serious consequences for health (Brown and Wuehler, 2000). The results indicate that these released cowpea varieties are a good source of both macro- and micro- minerals for its consumers. However, further studies could be done on bioavailability of the minerals.

Conclusion

The findings of this study showed that these cowpeavarieties are rich in proteins, minerals and carbohydrates with good hydration properties and could serve as a good template and a potential functional ingredient for a lot of aqueous and non-aqueous food formulations both in food and non-food utilization. Also differences in 1000-seed weight of the varieties suggest that equal quantity of each cultivar would occupy unequal space and the cost of packaging and transportation would be different (if based on space occupied). The shorter cooking time, comparatively higher protein and fat contents would make them more acceptable by the consumers since the main attraction would be high protein content with shorter cooking time.

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