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*Full Length Research Paper*

# Variation in physico-chemical properties of seed of selected improved varieties of Cowpea as it relates to industrial utilization of the crop

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**Cowpea is an important food, cash and fodder crop in Sub-Saharan Africa and has potential of becoming an industrial crop. A trial was conducted to evaluate selected improved and popular varieties of cowpea for physicochemical characteristics that can help to promote commercial production and industrial use. Variations in content were found among varieties for protein (21.3 - 26.9%), carbohydrate (63.37 - 69.56%), fat (1.2 to 1.80%), crude fibre (0.43 to 1.03%), and tannin (0.87 - 1.51 mg/g), also in water binding capacity (91.77 - 108.35%) and gelatinization temperature (79.13 - 84.83°C). High positive correlations (0.86) were observed between the content of fat and crude fibre, ash and protein (0.78), carbohydrate and viscosity of cowpea flour (0.76), and between ash and tannin (0.61) content of cowpea seed, negative correlations were observed between the content of crude protein and carbohydrate (-0.98), ash and fat (-0.78), crude protein and viscosity (-0.76) of cowpea flour, fat and water binding capacity of cowpea flour (-0.72) and carbohydrate and tannin (-0.54) in cowpea seed. Seed coat colour plays no significant role in the chemical content of the seed. The physicochemical properties evaluated generally had high broad sense heritability (56 - 99%). Cowpea varieties (IT97K-1101-5 and IT89KD-288) with high protein content could be selected for formulating infant feeds, varieties with lower carbohydrate, low fat and high crude fibre (IT90K-277-2) would be desirable in making meals for diabetic patients.**

**Key words:** Industrial crop, seed physicochemical content, *Vigna unduiculata*.

## INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.], is the most important source of vegetable protein in rural and urban diets across West and Central Africa and in parts of East and Southern Africa (Bressani, 1985; Singh et al., 1997). It is consumed in many forms. Young leaves, green pods, and seeds are eaten as vegetables and dry seeds are used in various food preparations (Nielsen et al., 1997). Varieties are selected based on yield potential, pest resistance, seed quality, maturity period, suitability for use as grain for food and fodder for livestock, taste and cooking properties (Singh and Ntare, 1985; Singh, 2001).

Varietal differences from region to region depend on the seed characteristics (IITA, 1983). The crude protein content ranges from 22 to 30% in the grain and leaves on a dry weight basis (Omueti and Singh, 1987; Nielsen et al, 1997). As the bulk of the diet of rural and urban poor especially in Africa, consists of starchy food made from cassava, yam, plantain and banana, millet, sorghum and maize, the addition of even a small amount of cowpea ensures nutritional balance. It enhances the quality by the synergistic effect of high protein and high lysine from cowpea and high methionine and high energy from the starchy food (Singh et al., 2003). Because of its high protein, vitamins and minerals contents, it impacts positively on the health of women and children. A study was conducted to evaluate the contributions of cowpea

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**Table 1.** Physical characteristics of selected cowpea varieties.

| Variety | Texture | Seed coat colour | 100 seed weight (g) | Seed vol. (ml) | | Dry seed density (g ml$^{-1}$) | Swelling ratio | Water uptake (ml) | Hardness (kg) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | dry | wet | | | | |
| IT97K-1101 – 5 | Smooth | Black | 18.87 | 19.00 | 51.75 | 1.05 | 2.72 | 31.75 | 4.30 |
| IT89KD-288 | Rough | White | 17.4 | 16.50 | 46.00 | 1.21 | 2.79 | 26.50 | 5.60 |
| IT97K-569–18 | Rough | Brown | 15.10 | 16.75 | 46.00 | 1.19 | 2.75 | 26.00 | 5.00 |
| IT98K-131 – 2 | Rough | Brown | 13.03 | 16.75 | 46.00 | 1.19 | 2.75 | 27.50 | 4.35 |
| IT89KD 391 | Rough | Brown | 15.68 | 16.50 | 47.25 | 1.21 | 2.87 | 27.25 | 4.95 |
| IT97K-499 – 35 | Rough | White | 13.2 | 17.00 | 44.50 | 1.18 | 2.62 | 26.50 | 4.50 |
| IT90K-277 – 2 | Rough | White | 16.27 | 17.00 | 42.75 | 1.18 | 2.51 | 23.50 | 6.60 |
| IT93K-452 – 1 | Rough | White | 14.95 | 15.25 | 44.25 | 1.31 | 2.90 | 26.50 | 5.95 |
| IT90K-76 | Rough | Brown | 16.05 | 16.00 | 48.00 | 1.25 | 3.00 | 29.50 | 5.15 |
| Mean | | | 15.62 | 16.75 | 46.28 | 1.2 | 2.77 | 27.22 | 5.16 |
| LSD (5%) | | | 1.66 | 0.88 | 1.995 | 0.066 | 0.164 | 1.35 | 1.272 |

and other legumes to the food intake of pre-school children and pregnant women in the rural areas of northern Anambra State, Nigeria, during the wet and dry seasons (King et al., 1986). This showed that for children 2 - 5 year old, in the wet season, cowpea and other legumes together contributed 35% of thiamine intake, 31% of protein, 24% of iron, 21% of niacin, 16% of energy and riboflavin and 13% of calcium. Among the pregnant women, cowpea and other legumes together contributed 27% of thiamin intake, 25% of protein, 20% of iron, 16% of niacin, 14% of riboflavin, 13% of energy and 10% of calcium.

The high protein content with hardly any anti-nutritive factor represents a major advantage in the use of cowpea in nutritional products for infant and children's food and cowpea could be a good source of protein for industrial product manufacturing. The major constraints to the industrial use by food companies in Africa include the lack of reliable statistics on production, strong price fluctuations during the year and the problem of the availability of raw material of acceptable quality and quantity (Lambot, 2002). Only limited studies have been done to draw the relationship between seed type and it physical properties and their effect on other attributes (Fery, 1985; Fery and Singh, 1997) and relation ship between different seed types and their physical properties (Singh, 2001). However, there are no known reports on the relationship between the seed types, physical properties and their chemical properties. The determination of the nutritive quality would benefit the producers and consumers of cowpea products. There is a need to evaluate varieties for their physico-chemical properties and the relationship among these properties. This would help breeders, other researchers and processors to note which varieties are suitable for what purposes, in terms of their innate characteristics for various needs: general purpose use, processing into flour, and other industrial uses for infant formula and diabetic patients. The present study was conducted to evaluate selected improved and popular cowpea varieties for characteristics which will help to promote selected varieties for commercial production and industrial use.

## MATERIALS AND METHODS

### Physical properties

Nine improved cowpea varieties were used for the assessment (Table 1). The cowpea varieties included three varieties (IT90K-76, IT90K-277-2 and IT93K-452-1 ) that have been released in Nigeria, two that have been recommended for release (IT97K-499-35 and IT89KD-288) and four (IT89KD-391, IT97K-569-18, IT97K-1101-1 and IT98K-131-2) that are in advance stages of evaluation and are likely to be released. They were also selected to reflect the wide range of seed types accepted in the country. Physical properties were estimated for each of the nine varieties using the following methods.

**Seed size:** One hundred seeds for each variety were randomly picked and weighed.

**Dry seed density:** 20 g of seed of each variety were placed in a 100 ml measuring cylinder filled with 50 ml water. The rise in water level after through shaking to remove air bubble was recorded as dry seed volume. Dry seed density was estimated by dividing 20 g with the dry seed volume.

**Wet seed volume:** The 20 g seeds of each variety were allowed o stay overnight in the measuring cylinder with 50 ml of water. The water level in the cylinder was noted in the morning as total volume of the wet seeds and unabsorbed water. The excess water was then saved in another measuring cylinder. The difference between the total volume and excess water was recorded as the wet seed volume.

**Swelling ratio:** The wet seed volume was divided by the dry seed volume to obtain swelling ratio.

**Table 2.** Chemical properties of seed of selected cowpea varieties.

| Variety | %Protein | %Ash | %CHO | %Fat | % WBC | Viscosity | Gel temp | % CF | Tannin |
|---|---|---|---|---|---|---|---|---|---|
| IT 97K 1101 – 5 | 26.85 | 4.59 | 63.37 | 1.2 | 108.35 | 154.09 | 79.88 | 0.61 | 1.45 |
| IT 89KD 288 | 26.06 | 3.79 | 64.86 | 1.72 | 91.82 | 188.78 | 83.18 | 0.89 | 1.51 |
| IT 97K 569 – 18 | 23.64 | 4 | 67.51 | 1.32 | 103.67 | 231.43 | 83.88 | 0.49 | 1.48 |
| IT 98K 131 – 2 | 23.05 | 3.47 | 68.67 | 1.4 | 103.67 | 194.84 | 84.83 | 0.43 | 0.96 |
| IT 89 KD 391 | 22.57 | 3.93 | 68.31 | 1.57 | 95.61 | 208.66 | 82.33 | 0.64 | 1.28 |
| IT 97K 499 – 35 | 22.49 | 3.43 | 68.83 | 1.73 | 96.11 | 214.82 | 82.48 | 0.89 | 1.11 |
| IT 90K 277 – 2 | 21.84 | 3.37 | 69.42 | 1.8 | 99.47 | 201.29 | 82.33 | 1.03 | 1.12 |
| IT 93K 452 – 1 | 21.36 | 3.45 | 68.98 | 1.73 | 91.77 | 215.16 | 79.13 | 0.84 | 0.87 |
| IT 90K 76 | 21.29 | 3.53 | 69.56 | 1.66 | 105.46 | 250.18 | 82.43 | 0.91 | 1.49 |
| **Mean** | 23.24 | 3.727 | 67.72 | 1.57 | 99.55 | 206.582 | 82.2694 | 0.748 | 1.2512 |
| **LSD (5%)** | 1.761 | 0.6838 | 1.962 | 0.2759 | 4.073 | 0.6262 | 0.08153 | 0.1037 | 0.07372 |
| **Heritability** | 0.86 | 0.56 | 0.86 | 0.73 | 0.92 | 0.99 | 0.99 | 0.96 | 0.98 |

Ash = % ash; Moisture = % moisture; CP= %crude protein; Fat= % fat; CHO= % carbohydrate; CF = % crude fibre; Tannin = Tannin mg $g^{-1}$; WBC = water binding capacity; Viscosity = final viscosity RVA; Gel. Temp = pasting time temperature ($^oC$).

**Water absorbed:** The excess water removed after overnight soaking was subtracted from 50 ml and the difference was recorded as water absorbed.

**Seed hardness:** The crushing strength of individual seed was measured in using a Hardness Tester Model No. 174886 made by M/S KIYA SEISAKUSHO Ltd, Tokyo, Japan.

### Chemical properties

The seed were manually de-hulled and dried using a cabinet drier at 60℃ for 24 h. The dried de-hulled samples were milled, using a hammer mill (model A1, Nigeria Tech. Co, Lagos). The milled flour was sieved through a 250 micro-mesh sieve. The flour obtained from the each variety was then divided into three parts to give three replications for each variety for subsequent analysis. Chemical determinations were made of flour samples from each variety: Moisture content, crude protein, ash, carbohydrate and crude fibre using AACC (1981) and AOAC (1975) methods. The flour hydration capacities were measured using the method of Yasunaga et al. (1968). The hydration capacity was calculated using the following formula:

Hydration capacity (%) = [Uptake of water (g) / Flour dry matter content] × 100

The viscosity and pasting properties of the flour were determined using the rapid visco-analyzer (RVA) at the International Institute of Tropical Agriculture, Ibadan. The design was a completely randomise design with four replication for the physical properties and two replication for the chemical properties. The data were then subjected to statistical analysis using computer package GenStat Discovery Edition2[7] (2005). Least Significant Difference (LSD) among means was calculated at 5% significant level. Correlation co-efficient was used to determine the degree of association between different parameters. Broad sense heritability was estimated from the ANOVA table as follows:

Variety MS = $\delta^2 v = \delta^2 e + r\delta^2 g$

Error MS = $\delta^2 e$

Genotype variance = $\delta^2 g = (\delta^2 v - \delta^2 e)/r$

Replication = r

Broad sense heritability = $\delta^2 g/(\delta^2 e + \delta^2 g)$

## RESULTS

The physical characteristics of the 9 selected cowpea varieties are given in Table 1. Seed coat colours were white (4), brown (4) and black (1). Eight varieties had a rough seed coat and one was smooth seeded. Significant differences (5%) were observed among the cowpea varieties for all the physical properties. The 100 seed weight ranged from 13.1 g in IT90K-76 to 24.2 g in IT97K-1101-5. Dry seed volume was lowest for IT93K-452-1 (15.25) and highest for IT97K-1101-5 (19.0), while IT90K-277-2 (42.75) had the lowest wet volume and IT97K-1101-5 (51.75) had the highest wet volume. IT97K-1101-5, which had the highest volume (wet and dry), however had the lowest density (1.05) and IT93K-452-1 (1.31) had the highest density. Swelling ratio ranged from 2.51 in IT90K-277-2 to 3.00 in IT90K-76. IT90K-277-2 (6.6 kg) had the highest hardness and IT98K-131-2 had the lowest hardness. Broad sense heritability was above 75% for all the physical characteristics evaluated except hardness which was 35%.

The chemical constituents of the seed of the selected cowpea varieties are given in Table 2. There were significant differences among the varieties for percentage crude protein content that ranged from 21.3% in IT90K-76 to 26.5% in IT97K-1101-5. The highest protein content was found in IT97K-1101-5 (black seeded) and IT89KD-288 (white seeded) and the lowest of 21.3% in IT93K-452-1 (white seeded) and IT90K-76 (brown seeded) va-

**Table 3.** Correlation coefficient among different physico-chemical* properties of cowpea seed.

| Variable | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 | V13 | V14 | V15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | 1.00 | | | | | | | | | | | | | | |
| V2 | 0.77 | 1.00 | | | | | | | | | | | | | |
| V3 | 0.49 | 0.60 | 1.00 | | | | | | | | | | | | |
| V4 | -0.75 | -1.00 | -0.59 | 1.00 | | | | | | | | | | | |
| V5 | -0.37 | -0.52 | 0.37 | 0.53 | 1.00 | | | | | | | | | | |
| V6 | 0.31 | 0.46 | 0.94 | -0.43 | 0.47 | 1.00 | | | | | | | | | |
| V7 | 0.02 | -0.48 | -0.64 | 0.49 | -0.14 | -0.68 | 1.00 | | | | | | | | |
| V8 | 0.73 | 0.71 | 0.61 | -0.71 | -0.18 | 0.45 | -0.38 | 1.00 | | | | | | | |
| V9 | 0.73 | 0.71 | 0.84 | -0.70 | 0.07 | 0.65 | -0.46 | 0.78 | 1.00 | | | | | | |
| V10 | -0.78 | -0.68 | -0.67 | 0.67 | 0.07 | -0.52 | 0.32 | -0.98 | -0.84 | 1.00 | | | | | |
| V11 | -0.36 | -0.63 | -0.73 | 0.64 | -0.05 | -0.61 | 0.69 | -0.56 | -0.78 | 0.54 | 1.00 | | | | |
| V12 | 0.21 | 0.59 | 0.61 | -0.60 | -0.04 | 0.57 | -0.48 | 0.20 | 0.44 | -0.17 | -0.72 | 1.00 | | | |
| V13 | -0.84 | -0.73 | -0.39 | 0.71 | 0.42 | -0.30 | 0.21 | -0.76 | -0.55 | 0.76 | 0.39 | -0.09 | 1.00 | | |
| V14 | -0.42 | -0.07 | -0.23 | -0.02 | -0.17 | -0.32 | -0.22 | -0.02 | -0.26 | 0.21 | -0.08 | 0.16 | 0.26 | 1.00 | |
| V15 | 0.00 | -0.28 | -0.43 | 0.31 | -0.14 | -0.35 | 0.68 | -0.32 | -0.48 | 0.26 | 0.86 | -0.44 | 0.20 | -0.33 | 1.00 |
| V16 | 0.33 | 0.35 | 0.58 | -0.37 | 0.21 | 0.39 | -0.17 | 0.54 | 0.61 | -0.55 | -0.32 | 0.36 | 0.01 | 0.17 | -0.03 |

*V1 = Seed wt, V2 = dry seed vol., V3 = wet seedvol., V4 = dry seed density, V5 = swelling ratio, V6 = water uptake, V7 = seed hardness, V8 = crude protein, V9 = %ash, V10 = % carbohydrate, V11 = %Fat, V12 = water binding capacity, V13 = Viscosity, V14 = pasting time temperatureGel, V15 = %crude fibre and V16 = Tanin.

riety. Broad sense heritability of protein content was 86%. The results from the analysis showed that, apart from IT97K-1101–5 with ash content of 4.59% which was significantly higher than ash content of 6 other varieties, the ash contents of the remaining cowpea varieties did not vary significantly among themselves and had broad sense heritability of 56%. The varieties can be grouped into two on the basis of carbohydrate content of seed. The first group (7 varieties) had a carbohydrate content of 67 to 69.56 %; in the second group, carbohydrate content was 63.37% for IT97K-1101–5, and 64.86% for IT89KD-288. These two varieties with the lowest carbohydrate however had the highest crude protein content. Significant differences were recorded for fat content as IT90K-277– 2 had the highest amount of fat (1.7%), IT97-K-1101–5 had the least (1.20%). Significant differences were also observed among the selected varieties for crude fibre content that ranged from 0.43% in IT98K-131-2 to 1.03% in IT90K-277-2. Significant differences were also observed for tannin content that ranged from 0.87 mg $g^{-1}$ in IT93K-452-1 to 1.51 mg $g^{-1}$ in IT89KD-288. IT93K 452–1 (91.77%) had the least water binding capacity, while IT97K-1101–5 (108.35%), had the highest. The potential for cowpea to go into slurry/become viscous quickly vary significantly among the varieties. IT90K-76 attained a maximum peak viscosity of 250.18, which significantly varied from the others; IT97K-1101–5 attained the least peak viscosity of 154.09. The integrity of starch molecules in cowpea varieties differs significantly. From the results, the gelatinization temperature, i.e. the temperature at which starch molecules rupture was highest with IT98K-131–2 (84.82°C), and lowest in IT97K-452–1 (79.13°C). Broad sense heritability was 73, 86, 92, 96 and 98% for fat content, carbohydrate and crude protein, water binding capa-city, crude fibre, and tannin content, respectively, and 99% for final viscosity and pasting time temperature.

The correlation coefficients among the various physico-chemical properties of cowpea seed are given in Table 3. The following properties had positive and significant correlation coefficient: one hundred seed weight vs dry and wet seed volume (r = 0.77 and 0.49 respectively), one hundred seed weight vs crude protein and % ash content (0.73). Dry seed volume vs wet seed volume (0.60), crude protein and ash content (0.71) and water binding capacity (0.59), wet seed volume vs water uptake (0.94), crude protein (0.61), ash content (0.84), water binding capacity (0.61) and tannin content (0.58). Dry seed density vs swelling ratio (0.53), carbohydrate content (0.67), fat content (0.64) and final viscosity (0.71). Swelling ratio vs water uptake (0.47) and final viscosity (0.42), while water uptake had positive and significant correlation coefficient with crude protein (0.45) and ash content (0.65), and with water binding capacity (0.57). Seed hardness was also positively correlated with fat content (0.69) and crude fibre (0.68). Crude protein was positively correlated with ash content (0.78) and tannin content (0.54), and ash with tannin content (0.61), carbohydrate with fat (0.54), and 0.76 with final viscosity, while fat content was also positively correlated with crude fibre content (0.86).

The following properties had negative and significant correlation coefficient: Seed weight with dry seed density (r = -0.75), % carbohydrate (-0.78) and final viscosity (-0.84); dry seed volume with dry seed density (-1), swelling ratio (-0.52), seed hardness (-0.48), carbohydrate (-0.68), fat (-0.63) and final viscosity (-0.73); wet seed volume with dry seed density (-0.59), seed hardness (-0.64), % carbohydrate (-0.67) and % fat content (-0.73); dry seed density with crude protein (-0.71), ash content (-0.70), and water binding capacity (-0.60); water uptake with hardness (-0.68), carbohydrate (-0.52), fat (-0.61) contents; seed hardness with ash (-0.46), and water binding capacity (-0.48); crude protein content with carbohydrate (-0.98), fat (-0.56), and final viscosity (-0.76); ash content with carbohydrate (-0.84), fat (-0.78), final viscosity (-0.55) and crude fibre (-0.48); carbohydrate with tannin content (-0.55) and fat with water binding capacity (-0.72).

## DISCUSSION

Whereas the highest protein content was found in IT97K-1101–5 (black seeded) and IT 89KD 288 (white seeded) and the lowest in IT93K-452–1 (white seeded) and IT 90K-76 (brown seeded) with 21.36 and 21.30%, respectively. Seed coat does not appear to play a significant role in determining the protein content, as the white and brown seeded varieties were distributed evenly in the protein range. Significant genetic differences were observed for all the physical and chemical properties evaluated in this trial. Heritability for the physical properties recorded in this trial were high, ranging from 78 to 93% and are similar to that recorded by Singh, (2001), except for seed hardness which was low (35%), Singh (2001) observed 92% for seed hardness. Varieties with high protein content (IT97K-1101–5 and IT 89KD 288) would be suitable in formulating infant feeds, while those with the lower protein content would be suitable for general purposes and adult consumption. The range of protein content recorded was similar to that obtained by other authors (Bliss, 1975; Omueti and Singh 1987; Nielsen et al., 1993). Cowpea is rich in lysine, but deficient in sulfurous amino acids (Lambot 2002), and to a lesser extent isoleucine, however levels of essential amino acids are at least as high as those in soybean (Lambot 2002). Cowpea contains a higher level of flatulent sugars than that found in soybean but its raffinose content (most flatulent sugar) is lower than that in soybean (Lambot, 2002). These characteristics present a major advantage in the use of cowpea in nutritional products, for infant’s and children’s food. Ash content of cowpea seed was comparatively stable among the selected varieties compared to other chemical characters studied; however variations existed for carbohydrate content. The carbohydrate content (63.37 to 69.56%) found in this study was similar to that (59.7 - 71.6%) reported by Nielsen et al. (1993). As with other studies (Nielsen et al., 1993), protein content was positively correlated with ash and negatively correlated with fat and carbohydrate content indicating that selection for high protein will decrease carbohydrate content and increase ash content which will make the improved line nutritional superior. In formulating cowpea diets for diabetic patients, varieties with low carbohydrate could be selected since diabetic patients may need a reduced consumption of carbohydrate rich foods. Varieties with less fat may be most suited for formulating food/meals for diabetic patients. Carbohydrate was positively correlated with fat content making these varieties excellent for this purpose. In using cowpea flour in products, the water binding capacity would be important. Here again, significant differences were observed. The variety with highest water binding capacity (IT97K-1101–5) would absorb more water in formulating any product. Varieties with high peak viscosities flow better when re-constituted in water, and thus make a better paste. Usually, varieties with a high gelatinization temperature take longer to cook, because of the hard and strong chemical bonding binding the nutrients in the grain structure of starch composition in the grain. A high positive correlation observed between ash and protein implies varieties with these characters would be suitable for infant formulae that can be fortified with high energy cereals.

### Conclusions

The present study has shown that significant variations exist among cowpea lines for most of the physico-chemical constituents of cowpea grain with high heritability. Suitable parents could therefore be selected for further improvement of any of the characters. Varieties also exist that can be used for specialized industrial products like infants formula etc. Cowpea varieties (IT97K-1101-5 and IT89KD-288) with high protein content could be selected for formulating infant feeds, varieties with lower carbohydrate, low fat and high crude fibre (IT90K-277-2) would be desirable in making meals for diabetic patients.

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