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FULL LENGTH ARTICLE

Physical and cooking characteristics of two cowpea cultivars grown in temperate Indian climate

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Abstract Two local cowpea cultivars (Red cowpea and Black cowpea) were studied for various physical, cooking and textural properties. The moisture, crude protein, fat, ash and carbohydrate content of seeds ranged from 10.0% to 10.1%, 21.29–23.90%, 0.49–1.94%, 19.8–2.81%, and 60.53–62.45%, respectively. Sphericity, 1000-seed weight and surface area were significantly higher for Red cowpea than Black cowpea. However bulk density was found significantly higher for Black cowpea than Red cowpea. Black cowpea had significantly shorter cooking time (29.77 min) than Red cowpea (64.67 min). Water uptake ratio, hydration capacity and swelling capacity were significantly higher for Red cowpea than Black cowpea. Hardness was higher for soaked Red cowpea seeds (16.37 kg) than soaked Black cowpea (7.62 kg). Adhesiveness values were observed significantly higher for soaked Black cowpea seeds (1.26 kg s) than soaked Red cowpea (0.004 kg s). Chewiness was also significantly higher for Red cowpea. Cooked seeds did not show a significant difference for the textural parameters between the two cultivars.

1. Introduction

Cowpea (*Vigna unguiculata*/*Vigna sinensis*) also known as Southern pea, China pea, Black-eye bean or Cow gram in the United States (Olalekan and Bosede, 2010) is an edible legume belonging to the family Fabaceae. It represents an important source of proteins and carbohydrates. It is well known to be of African native and is widely cultivated and consumed in tropical and sub-tropical areas of Africa, Latin America, Southeast Asia and in the Southern United States (Appiah et al., 2011). The crop was first introduced to India during the Neolithic period, and therefore India seems to be a secondary centre of genetic diversity (Pant et al., 1982). Cowpea is a rich source of protein for people who cannot afford proteins from animal sources such as meat and fish (Akpapunam and Sefa-Dedeh, 1997) and are often referred to as poor man's meat. They represent one of the dietary staples in many parts of the world (Odedeji and Oyeleke, 2011).

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It has been estimated that worldwide area of production of cowpeas is approximately 10.1 million hectares with annual global grain production being approximately 4.99 million tons. The largest areas under cultivation are in Central and West Africa. In India cowpea is grown on an area of 3.9 million hectares with a production of 2.21 million tonnes with the national productivity of 683 kg per ha (Singh et al., 2012).

Cowpea due to its nutrient and functional benefits has also gained industrial importance for being used as a potential ingredient in food formulations. However, its processing in industries requires a number of equipment and the design of such equipment. World Cowpea Conference (2010) demands understanding of the physical properties of the seed. For instance, the knowledge of dimensions is very useful in determining aperture sizes in the design of grain handling machineries. Similarly knowledge of geometric surface would help in deciding the clearance between the abrasive surfaces for dehulling and would also help in designing the grader, cleaner and separator for the seeds (Tchiagam et al., 2011).

Cooking time that gives an indication of cooking quality is one of the most important factors responsible for consumer's choice for a particular food. Of the major limitations that make cowpea like other legumes uneconomical and unacceptable to consumers is its longer cooking time. Cooking renders legumes edible and ensures their acceptable sensory properties (Bourne, 1982). The process involves certain physicochemical changes including gelatinization of starch, denaturation of proteins, solubilization of some of the polysaccharides, and softening and breakdown of the middle lamella, a cementing material found in the cotyledon (Vindiola et al., 1986; Stanley and Aguilera, 1985). Cooking also inactivates or reduces the levels of anti-nutrients such as trypsin inhibitors and flatulence-causing oligosaccharides, resulting in improved nutritional quality (Wang et al., 2008; Ayyagari et al., 1989; Jood et al., 1985). Though cooking renders legumes edible, longer cooking time is associated with some negative effects such as reduction in nutritive value of proteins (Chandrashaker et al., 1981), increased energy and time consumption, thus limiting their preference as protein source. Besides cooking time, the assessment of texture is also critical to the determination of cooking quality and plays an important role in determining consumer acceptance of cooked legumes (Stanley et al., 1989). The aim of the present study was to evaluate two locally available cowpea cultivars for physical, cooking and textural characteristics.

2. Materials and methods

2.1. Materials

The certified seeds of two cowpea cultivars (Red cowpea and Black cowpea) were procured from the local market of Srinagar J&K, India. Seeds were cleaned of the dirt, and foreign matter and damaged ones were removed. The seeds of both the cultivars were ground in a common household grinder to obtain respective flours. The flours were then packed in air tight polythene bags and stored until further use at 20 °C. All the reagents used in the study were of analytical grade.

2.2. Methods

2.2.1. Proximate composition of seed

Protein (method 960.10), fat (method 920.85), ash (method 923.03), moisture (method 925.10) contents were determined according to standard methods (AOAC, 1990). Carbohydrate content was obtained from the difference (100 – %protein + %fat + %ash + % moisture).

2.2.2. Colour

The surface colour of seeds was measured using a portable Hunter Lab Spectrocolorimeter (Miniscan XETM, Hunter Associates Laboratory Inc., Reston, Virginia, USA) according to the method of Sharma and Gujral (2014). Colour measurement was done in the values of Hunter L (lightness), a (redness to greenness) and b (yellowness to blueness) values.

2.3. Physical properties of seeds

2.3.1. Seed dimensions

Hundred randomly selected seeds were used to measure length (L), breadth (B) and thickness (T), three principal dimensions which are in the three mutually perpendicular directions using a Vernier caliper reading 0.01 mm. Average of 25 determinations was reported.

2.3.2. Geometric mean diameter

The geometric mean diameter was calculated using the following relationship (Mohsenin (1970)). Values are average of 25 replications.

$$D_g = (LWT)^{1/3}$$

2.3.3. Sphericity

The sphericity (φ) was calculated as a function of the three principal dimensions as shown below Mohsenin (1970). Average of 25 determinations was reported.

$$\Phi = [(LWT)1/3/L] \times 100$$

2.3.4. Surface area

The surface area (S) in mm^2 was found using the formula given below, using the method analogous to the one used by Altuntaş et al., 2005; Tunde-Akintunde and Akintunde, 2004; Sacilik et al., 2003 as follows. Values are average of 25 replications.

$$S = D_g^2 \cdot \pi$$

2.3.5. 1000-seed weight

1000-seed weight was determined by counting one hundred seeds manually and weighing. The obtained values were then multiplied by a factor 10 to get 1000-seed weight (AACC, 2000). Average of three determinations is reported.

2.3.6. Length/breadth ratio

10 randomly selected seeds were observed for length/breadth ratio by simply dividing calculated length by calculated

breadth (Sharma and Gujral, 2010). Average of three determinations is reported.

2.3.7. 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 was determined according to the methods of Mohsenin (1980). Average of three determinations is reported.

2.3.8. Porosity

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

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

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

2.3.9. Angle of repose

The angle of repose (Φ) of seed was determined by a cylindrical tube (smallest diameter 45 mm, biggest diameter 200 mm and height 350 mm) having discharge gate at the bottom. After filling the tube with seed sample, the gate was quickly removed. The height (h) of seed pile above the floor and the radius of the heap (r) were measured and used to determine the angle of response.

$$\Phi = \tan - 1(h/r)$$

2.3.10. Static coefficient of friction

The static coefficient of friction (μ) was determined for three different structural materials, namely, corrugated board, mica ply and, fibre glass and according to the method of Gezer et al. (2002). For this measurement one end of the friction surface was attached to an endless screw. The seed was placed on the surface and it was gradually raised by the screw. Vertical and horizontal height values were read from the ruler when the seed started sliding over the surface, then using the tangent value of that angle the coefficient of static friction was found from the formula:

$$\mu = \tan\phi$$

where μ is the static coefficient of friction and φ is the angle of tilt in degrees.

2.4. Cooking properties

2.4.1. Cooking time

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

2.4.2. Gruel solid loss

Seeds (5 g) were cooked in 100 mL of double distilled water for minimum cooking time. The gruel was transferred to 250 mL beakers and then evaporated till completely dried in a hot air oven at 110 °C. The solids were subsequently weighed and gruel solid loss was calculated as percentage.

2.4.3. Cooked length–breadth ratio

The cumulative length and breadth of 10 seeds were measured after cooking for minimum cooking time. The length–breadth ratio of the 10 cooked seeds was determined by dividing the cumulative length to the cumulative breadth of cooked seeds.

2.4.4. Water uptake ratio

Five grams of seeds was cooked in 100 mL of double distilled water for minimum cooking time. The cooked seeds were then removed, drained and surface water on seeds was removed by using filter paper. The samples were weighed and the water uptake ratio was calculated as the ratio of weight gained after cooking to weight before cooking.

2.4.5. Hydration capacity and hydration index

Seeds (5 g) were soaked in 50 mL of distilled water in a measuring cylinder and covered with an aluminium foil. The seeds were left to soak for 24 h in room temperature (20 ± 2 °C), drained and excess water was removed using a tissue paper. The weight of the swollen seeds was measured. Hydration capacity and hydration index were calculated (Adebowale et al., 2005)

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

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

2.4.6. Swelling capacity and swelling index

The volume of 5 g of seeds was predetermined using a graduated cylinder and they were subsequently soaked overnight in distilled water. The volume of the seeds after soaking was then measured. Swelling capacity and the swelling index were determined (Adebowale et al., 2005)

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

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

2.5. Scanning electron microscopy

Raw and cooked samples of cowpea cultivars were dehusked and samples were dried at 40 °C to a constant moisture content of 8%. The cotyledons were scraped at the surface to expose the endosperm. The samples were then placed on an adhesive tape attached to a circular aluminium specimen stub. After coating vertically with gold–palladium, the samples were photographed at an accelerator potential of 5 kV using a scanning electron microscope (Hitachi S-300H-Tokyo, Japan).

2.6. Texture of seeds

Soaked and cooked seeds were analysed for textural parameters like hardness, cohesiveness, chewiness and adhesiveness according to the method of Wani et al. (2013b) using Texture Analyzer (Model XT2i; Stable Micro Systems Ltd., Surrey, UK) loaded 50-kg load cell.

2.7. Statistical analysis

The data reported are averages of triplicate observations. The "*t*-test was applied to determine differences between means using the commercial statistical package (SPSS Inc, Chicago, USA).

3. Results and discussions

3.1. Proximate composition

Proximate composition of cowpea seeds is presented in Table 1. Moisture content of Red cowpea was 10.0% and for Black cultivar was 10.1%. Protein content was found significantly ($p \leqslant 0.05$) higher for Black cowpea (23.90%) compared to Red cowpea (21.29%). Likewise, fat percentage was also significantly higher for Black (1.94%) than Red cowpea (0.49%). However, ash contents did not show a significant difference. Carbohydrates were in the range of 61.53–62.4.5% with significantly higher content in Red cowpea cultivar. The variations in the proximate composition could be attributed to environmental conditions, soil type and genetic factors.

3.2. Physical properties

Knowledge of physical properties is imperative for the design of equipments which are used for processing of seeds in the industries which involves harvesting, threshing, cleaning, separation, transportation and packaging.

3.2.1. Colour

'*L*', '*a*' and '*b*' values of cowpea seeds revealed significant differences between the two cultivars (Table 1). Higher values of '*L*' (29.94) and '*a*' (9.17) were obtained for Red cowpea seeds than Black cowpea ('*L*' is 15.61 and '*a*' is −1.44). This indicates brightness and reddishness in the seed colour of Red cowpea. Lower '*L*' value for Black cowpea shows darker complexion of Black cultivar and negative '*a*' value indicates that there is some greenish tint in the Black cowpea seed. Colour of seeds is due to the presence of polyphenols in the seed coat and the differences in seed colour might be due to genetic factors.

Table 1 Proximate composition of cowpea seeds ($n = 3$).

Parameter	Red cowpea	Black cowpea
Moisture (%)	10.00 ± 0.17[a]	10.10 ± 0.19[a]
Protein (%)	21.29 ± 0.15[a]	23.90 ± 0.14[b]
Fat (%)	0.49 ± 0.02[a]	1.94 ± 0. 15[b]
Ash (%)	1.98 ± 0.02[a]	2.81 ± 0.02[a]
Carbohydrates (%)	62.45 ± 0.42[b]	60.53 ± 0.18[a]
Colour values		
L	29.94 ± 1.22[b]	15.61 ± 1.61[a]
a	9.17 ± 0.14[b]	−1.44 ± 3.49[a]
b	18.12 ± 2.88[b]	17.39 ± 1.61[a]

[a] Values reported are mean ± standard deviation.
[b] Mean in the row with different superscripts are significantly ($p \leqslant 0.05$) different.

3.2.2. Dimensions and length–breadth ratio

Physical properties of two cowpea cultivars are presented in Table 2. The results of seed dimensions indicate that Red cowpea seeds were significantly ($p \leqslant 0.05$) thicker (5.07 mm) than Black cowpea seeds (4.09 mm). However, significant ($p > 0.05$) differences were not observed in length and breadth of seeds between the cultivar. The results for dimensions are in accordance with Appiah et al. (2011) who have reported length, minor diameter and major diameter in the range of 7.73–7.67 mm, 4.51–4.86 mm, and 5.75–6.30 mm, respectively. From the frequency distribution curve it was observed that for Red cowpea maximum number of seeds were having their length range 6.50–6.75 mm, breadth in the range 5.50–5.75 mm and thickness 5.00–5.25 mm. Similarly for Black cowpea maximum number of seeds were having length range 6.50–7.25 mm, breadth 4.75–5.00 mm and thickness 3.75–4.00 mm (Fig. 1). There was no significant difference in length–breadth ratio between the two cultivars. Appiah et al. (2011) have reported length, minor diameter and major diameter in the range of 7.73–7.67 mm, 4.51–4.86 mm, and 5.75–6.30 mm, respectively for cowpea seeds.

3.2.3. 1000 seed weight

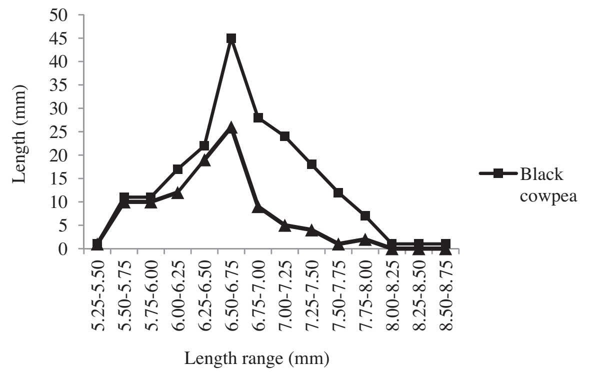
1000 seed weight was found significantly greater for Red variety (130.78 g) than Black cowpea (98.82 g). The results are in accordance with those reported by Appiah et al. (2011) for three cowpea cultivars with 1000-seed weight in the range of 131.6–151.6 g. Sobukola and Abayomi (2011) have reported 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 the flour would occupy as well as their bulkiness. Since the dimensions and 1000-seed weight of the two cowpea cultivars were significantly different, suggesting that equal quantity of each variety would occupy unequal space and the cost of packaging and transportation would be different if based on space occupied.

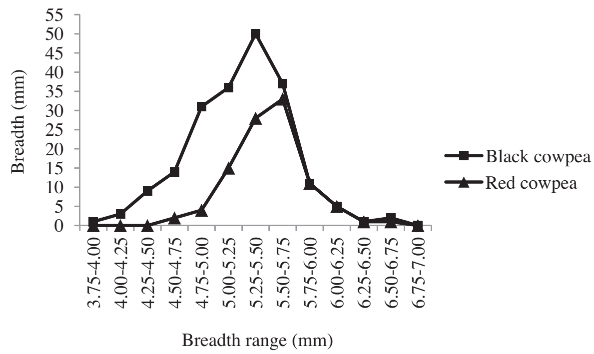
Table 2 Physical properties of cowpea seeds.

Parameter	Red cowpea	Black cowpea
Length (mm)	7.04 ± 0.54[b]	6.46 ± 0.54[a]
Breadth (mm)	4.97 ± 0.39[a]	5.49 ± 0.34[a]
Thickness (mm)	4.09 ± 0.38[a]	5.07 ± 0.38[b]
Length breadth ratio	1.17 ± 0.11[a]	1.42 ± 0.10[a]
Geometric diameter (mm)	5.72 ± 0.18[b]	5.07 ± 0.31[a]
Sphericity (%)	87.64 ± 4.69[b]	72.65 ± 4.1[aa]
Surface area (mm^2)	102.82 ± 6.46[b]	81.02 ± 9.9[aa]
1000 seed weight (g)	130.78 ± 2.32[b]	98.82 ± 2.66[a]
Bulk density(g/ml)	0.72 ± 0.00[b]	0.80 ± 0.00[a]
True density (g/ml)	12.52 ± 0.01[a]	12.53 ± 0.05[a]
Porosity (%)	94.24 ± 0.01[a]	93.60 ± 0.01[a]
Angle of repose	12.52 ± 1.02[a]	13.26 ± 0.26[a]
Static coefficient of friction		
Corrugated board	0.36 ± 0.01[a]	0.43 ± 0.02[b]
Mica ply	0.36 ± 0.01[a]	0.43 ± 0.02[b]
Glass	0.31 ± 0.0[a]	0.37 ± 0.1[b]

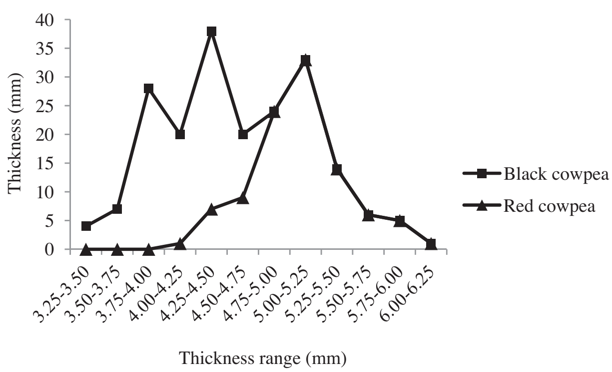
[a] Values reported are mean ± standard deviation.
[b] Mean in the row with different superscripts are significantly ($p \leqslant 0.05$) different.



(a)



(b)



(c)

Figure 1 (a) Frequency distribution curve for length of seeds, (b) Frequency distribution curve for breadth of seeds, (c) Frequency distribution curve for thickness of seeds.

3.2.4. Geometric mean diameter

Geometric mean diameter of two cultivars was significantly different. Geometric mean diameter for Red cowpea was observed as 5.72 mm and for Black cowpea 5.07 mm. These findings are in accordance with observations reported by Sobukola and Abayomi (2011) who reported geometric mean diameter values for cowpea seeds in the range of 5.90–6.91 mm.

3.2.5. Sphericity

It was observed that Red cultivar had significantly higher sphericity value (87.64%) than Black cowpea (72.56%). The values indicate that Red cowpea seed is more spherical than the Black cowpea. These values are in accordance with Davies and Zibokere (2011) who reported the sphericity range of 67–79% range for various cowpea cultivars.

3.2.6. Surface area

Surface area was significantly higher for Red cultivar (102.82 mm^2) than Black cultivar (81.02 mm^2). Surface area is used for designing grader, cleaner and separator for seeds. Thus the two cowpea cultivars need different designs of these equipments for their processing.

3.2.7. Bulk density, true density and porosity of seeds

The values for bulk density, true density and porosity are depicted in Table 2. Black cowpea showed significantly ($p \leqslant 0.05$) higher value of bulk density (0.82 g/mL) than Red cowpea (0.72 g/mL). Bulk densities of 0.69–0.80 g/cm^3 were recorded for three cowpea varieties by Appiah et al. (2011). However, true density and porosity values showed no significant difference for the two cowpea cultivars. Porosity values are in agreement with previously reported values 11.08–14.02% for cowpea seeds (Sobukola and Abayomi, 2011). Porosity of seeds is very important in water uptake as seeds with low porosity may find it difficult to take up water compared with seeds of high porosity (Saguy et al., 2005; Marabi and Saguy, 2004).

3.2.8. Angle of repose

Angle of repose was found significantly higher for Red cowpea (13.26°) than Black cowpea (12.52°) (Table 2). Wani et al. (2013b) reported angle of repose for black gram cultivars in the range of 17.74–19.02°. It is used to estimate the height or width of grain piles. Angle of repose also helps to measure the maximum slope at which grains are stable. According to Teunou et al. (1995) angle of repose is more for cohesive materials and smaller for non-cohesive materials.

3.2.9. Static coefficient of friction

Static coefficient of friction for Black cowpea was significantly higher for the three surfaces viz corrugated board, mica ply and glass with values 0.43, 0.34 and 0.37, respectively (Table 2). Results obtained reveal that corrugated board offered the highest static coefficient of friction for both the cultivars of cowpea. Static coefficient of friction is helpful in determining the loading and unloading of goods. It also gives an idea of material to be used in designing of conveyors.

3.2.10. Cooking properties

Cooking process is the combination of heating and hydration. Cooking characteristics of cowpea seeds were studied by measuring cooking time, water uptake ratio, solid loss, and elongation ratio (Table 3). It was observed that Black cowpea had significantly shorter cooking time (29.77 min) than Red cowpea (64.67 min). The results indicate that Black cowpea would be the first preference for consumers as it would involve lesser fuel and time consumption. These results are in accordance with the results of Appiah et al., 2011 who have reported cooking time of 57 min, 65 min and 84 min for three cowpea varieties viz Nhyira, Tona and Adom, respectively. Water uptake ratio was significantly higher for Red cowpea cultivar (6.07) than for Black cultivar (4.8). Higher value for Red cultivar may be attributed to its lower bulk density. Cooked elongation

Table 3 Cooking properties of cowpea seeds ($n = 3$).

Parameter	Red cowpea	Black cowpea
Cooking time (min)	64.67 ± 2.52[b]	29.77 ± 0.40[a]
Water uptake ratio (g/g)	6.07 ± 0.14[b]	4.86 ± 0.50[a]
Elongation ratio	1.24 ± 0.75[a]	1.39 ± 0.12[a]
Solid loss (%)	8.8 ± 0.10[a]	9.6 ± 0.15[a]
Hydration capacity (g/seed)	0.1 ± 0.00[b]	0.05 ± 0.001[a]
Hydration index	0.7 ± 0.00[b]	0.53 ± 0.01[a]
Swelling capacity (mL/seed)	0.22 ± 0.01[b]	0.12 ± 0.01[a]
Swelling index	1.15 ± 0.07[b]	0.84 ± 0.06[a]

[a] Values reported are mean ± standard deviation.
[b] Mean in the row with different superscripts are significantly ($p \leqslant 0.05$) different.

ratio and solid loss during cooking did not vary significantly as depicted in Table 3. Red cowpea showed solid loss of 0.44 g and Black cowpea 0.48 g.

3.2.11. Hydration capacity and hydration index

Hydration capacity and hydration index were observed from 0.05 to 0.1 g/seed and 0.53–0.7 respectively (Table 3). The values obtained were significantly ($p \leqslant 0.05$) higher for Red cowpea than Black cowpea. The results could be due to lower bulk density of Red cowpea than Black cowpea. Tresina and Mohan (2012) have reported hydration capacity of 0.03 g/seed and hydration index of 0.9 for cowpea.

3.2.12. Swelling capacity and swelling index

Swelling capacity and swelling index of two cowpea cultivars were in the range of 0.12–0.22 mL/seed and 0.84–1.15 (Table 3). Black cowpea cultivar had significantly lower values than Red cowpea cultivar. Tresina and Mohan (2012) have reported swelling capacity and swelling index values as 0.053 mL/seed and 0.001 mL/seed, respectively for cowpea.

3.2.13. Scanning electron microscopy

Scanning electron micrographs of raw and cooked cowpea cotyledons are presented in Fig. 2. It is evident from the figure that raw cotyledons have a well ordered structure with packed starch granules. On the other hand cooked cotyledons have disruption of the ordered structure, due to the phenomenon of gelatinization process. In the presence of excess water and heat, starch granules absorb water causing their swelling, rupturing and leaching out of amylose content leading to total disruption of starch granule structure.

3.3. Textural analysis

Texture properties of cowpea seeds soaked overnight in water are presented in Table 4. Seed hardness was found from 8.92 kg to 7.63 kg. Cohesiveness was observed from 0.15 to 0.17. However, significant differences were not observed in hardness and cohesiveness. Chewiness and adhesiveness showed a significant difference between the cowpea cultivars. Red cowpea showed higher value of chewiness (0.63) than Black cowpea (0.35) while adhesiveness was found significantly higher for Black cowpea (1.26) than Red cowpea (0.004). However cohesiveness and springiness presented no significant difference between the two cultivars.

Textural properties of cooked cowpea seeds are also presented in Table 4. Hardness of cooked seeds was in the range

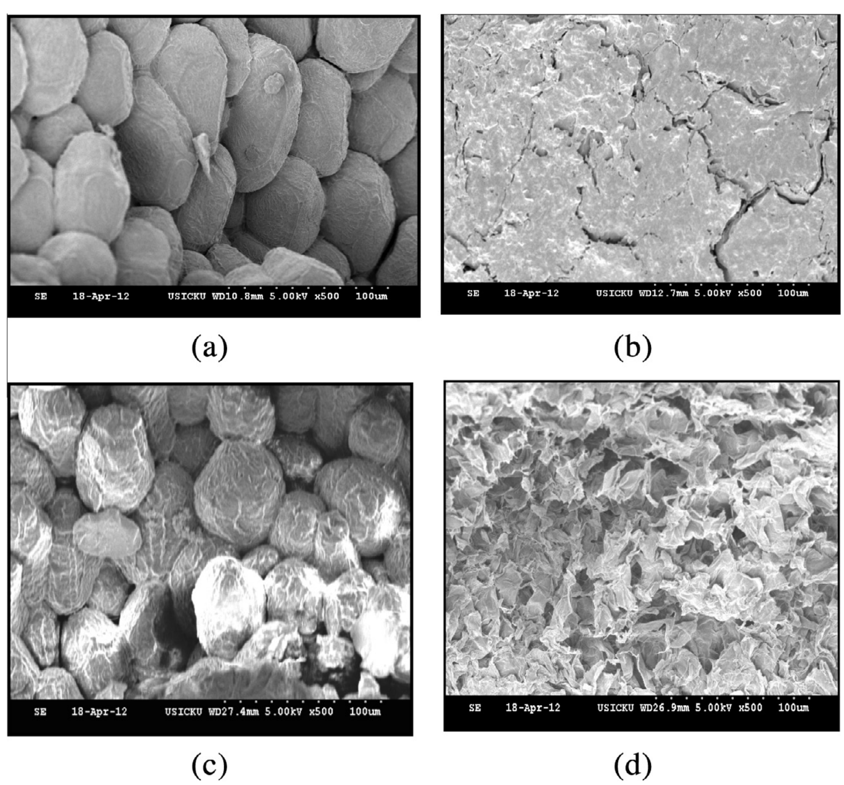


Figure 2 (a) Un-gelatinized Red cowpea seed, (b) Gelatinized Red cowpea seed, (c) Un-gelatinized Black cowpea seed, (d) Gelatinized Black cowpea seed.

Table 4 Textural properties of cowpea seeds ($n = 10$).

Parameter	Soaked seeds		Cooked seeds	
	Red cowpea	Black cowpea	Red cowpea	Black cowpea
Hardness (kg)	8.93 ± 3.63[b]	7.62 ± 3.03[b]	3.13 ± 0.85[a]	2.84 ± 1.23[a]
Cohesiveness	0.15 ± 0.02[a]	0.17 ± 0.04[a]	0.15 ± 0.03[a]	0.18 ± 0.02[a]
Chewiness	0.63 ± 0.11[b]	0.35 ± 0.17[b]	0.12 ± 0.10[a]	0.14 ± 0.05[a]
Adhesiveness (kg s)	0.20 ± 0.03[a]	0.26 ± 0.04[a]	0.44 ± 0.01[b]	0.39 ± 0.02[b]

[a] Values reported are mean ± standard deviation.
[b] Mean in the row with different superscripts are significantly ($p \leqslant 0.05$) different.

of 2.84–4.36 kg. Cohesiveness, chewiness and adhesiveness were observed in the range of 0.15–0.18, 0.12–0.14, 0.09–0.14 kg s, respectively. Significant differences were not observed in the textural properties of cooked seeds between the cultivars. However, significant differences were observed in textural properties between cooked and soaked seeds.

4. Conclusion

The findings of this study show that the two cowpea cultivars (Red and Black cowpea) are rich in proteins and carbohydrates. Sphericity, surface area, bulk density and angle of repose were significantly different for the two cowpea cultivars indicating that these would require some variation in the processing equipment design. Also difference in dimensions and 1000-seed weight of the two cowpea cultivars, suggests 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 of Black cowpea would be more acceptable by the consumers since the main attraction would be high protein content with shorter cooking time.

References

AACC (2000). Approved methods of the AACC international. Methods 44-15A, 56-35, 76-13, and 08-16 (tenth ed.). St. Paul, MN: The Association

Adebowale, Y.A., Adeyemi, I.A., Oshodi, A.A., 2005. Functional and physicochemical properties of flours of six Mucuna species. Afr. J. Biotechnol. 4 (12), 1461–1468.

Akpapunam, M.A., Sefa-Dedeh, S., 1997. Jack bean (Canavalia ensiformis) nutrition related aspects and needed research. J. Plant Food Hum. Nutr. 10, 123–127.

Altuntaş, E., Ozgoz, E., Taser, O.F., 2005. Some physical properties of fenugreek (*Trigonell foenumgraceum L.*) seeds. J. Food Eng. 71, 37–43.

AOAC (1990). Official Methods of Analysis, fifteenth ed. Washington, DC: Association of Official Analytical Chemists

Appiah, F., Asibuo, J.Y., Kumah, P., 2011. Physicochemical and functional properties of bean flours of three cowpea (*Vigna unguiculata* (L.) Walp) varieties in Ghana. Afr. J. Food Sci. 5 (2), 100–104.

Ayyagari, R., Rao, B.S., Roy, D.N., 1989. Lectins, trypsin inhibitors, BOAA and tannins in legumes and cereals and the effects of processing. Food Chem. 34, 229–238.

Bourne, M.C., 1982. Food texture and viscosity. Concept and measurement. Academic Press Inc, NewYork.

Chandrashaker, U., Lalitha, B., Rajamal-Devadas, P., 1981. Evaluation of protein quality of raw, roasted and autoclaved legumes supplemented with sulphur-containing amino acids. Indian J. Nutr. Diet. 18, 283–288.

Davies, R.M., Zibokere, D.S. (2011). Effect of moisture content on some physical and mechanical. Properties of three varieties of cowpea (*Vigna unguiculata* (*L.*) *Walp*). Agric. Eng. Int.: CIGR J., Manuscript No.1700. 13, No.1.

Gezer, I., Hacıseferogulları, H., Demir, F., 2002. Some physical properties of Hacıhaliloğlu apricot pit and its kernel. J. Food Eng. 56, 49–57.

Jood, S., Mehta, U., Singh, R., Bhat, C.M., 1985. Effect of processing on flatus producing factors in legumes. J. Agric. Food Chem. 33, 268–271.

Marabi, A., Saguy, I.S., 2004. Effect of porosity on rehydration of dry food particulates. J. Sci. Food Agric. 84, 1105–1110.

Mohsenin, N.N., 1970. Physical properties of plant and animal materials. Gordon and Breach Science Publishers, New York.

Mohsenin, N.N., 1980. Physical Properties of Plants and Animal Materials. Gordon and Breach Science Publishers, New York.

Odedeji, J.O., Oyeleke, W.A., 2011. Comparative studies on functional properties of whole and dehulled cowpea seed flour (*Vigna unguiculata*). Pak. J. Nutr. 10 (9), 899–902.

Olalekan, A.J., Bosede, B.F., 2010. Comparative study on chemical composition and functional properties of three Nigerian legumes (Jack beans, pigeon pea and cowpea). J. Emerg. Trends Eng. Appl. Sci. 1 (1), 89–95.

Pant, K.C., Chandel, K.P.S., Joshi, B.S., 1982. Analysis of diversity in Indian cowpea genetic resources. SABRO J. 14, 103–111.

Sacilik, K., Ozturk, R., Keskin, R., 2003. Some physical properties of hemp grain. Biosyst. Eng. 86 (2), 213–215.

Saguy, S., Marabi, A., Wallach, R., 2005. New approach to model rehydration of dry food particulates utilizing principles of liquid transport in porous media. Trends Food Sci. Technol. 16, 495–506.

Sharma, P.S., Gujral, H.S., 2010. Milling behavior of hulled barley and its thermal and pasting properties. J. Food Eng. 97 (3), 329–334.

Sharma, P.S., Gujral, H.S., 2014. Antioxidant potential of wheat flour chapattis as affected by incorporating barley flour. LWT – Food Sci. Technol. 56 (1), 118–123.

Singh, A.K., Bhatt, B.P., Sundaram, P.K., Kumar, S., Bahrati, R.C., Naresh Chandra, N., Rai, M., 2012. Study of site specific nutrients management of cowpea seed production and their effect on soil nutrient status. J. Agric. Sci. 4 (10), 191–198.

Sobukola, O.P., Abayomi, H.T., 2011. Physical properties and rehydration characteristics of different varieties of maize (*Zea mays L.*) and cowpea (*Vigna unguiculata* (*L.*) *Walp*) Seed. J. Food Process. Preserv. 35 (3), 299–307.

Stanley, D.W., Aguilera, J.M., 1985. A review of textural defects in cooked reconstituted legumes—the influence of structure and composition. J. Food Biochem. 9, 277–323.

Stanley, D.W., Wu, X., Plhak, L.C., 1989. Seed coat effects in cooked reconstituted bean texture. J. Texture Stud. 20, 419–429.

Tchiagam, J.B.N., Bell, J.M., Ngakeu, D.F., Njintang, N.Y., Diallel, E.Y., 2011. Analysis of cowpea (*Vigna unguiculata* (*L.*) *Walp*) for some physical properties of seed under the Sudano-Guinean conditions. Agric. Biol. J. North Am., 2151–7517.

Teunou, E., Vasseur, J., Krawczyk, M., 1995. Measurement and interpretation of bulk solids angle of repose for industrial process design. Powder Handling Process. 7 (3), 219–227.

Tresina, P.S., Mohan, V.R., 2012. Physico-chemical and anti-nutritional attributes of gamma irradiated *Vigna unguiculata L. subsp. unguiculata* seeds. Int. Food Res. J. 19 (2), 639–646.

Tunde-Akintunde, T.Y., Akintunde, B.O., 2004. Some physical properties of sesame seed. Biosyst. Eng. 88 (1), 127–129.

Vindiola, O.L., Seib, P.A., Hoseney, R.C., 1986. Accelerated development of the hard-to-cook state in beans. Cereal Foods World 31, 538–552.

Wang, N., Hatcher, D.W., Gawalko, E.J., 2008. Effect of variety and processing on nutrients and certain anti-nutrients in field peas (*Pisum sativum*). Food Chem. 111, 132–138.

Wani, I.A., Sogi, D.S., Gill, B.S., 2013a. Physicochemical and functional properties of flours from three Black gram (*Phaseolus mungo L.*) cultivars. Int. J. Food Sci. Technol. 48, 771–777.

Wani, I.A., Sogi, D.S., Gill, B.S., 2013b. Physical and cooking characteristics of black gram (*Phaseolus mungoo L.*) cultivars grown in India. Int. J. Food Sci. Technol. 48, 2557–2563.

World Cowpea Conference, (2010). http://www.sciencedaily.com / releases/2010/09/100927105157 Retrieved, 28/06/ 2012.