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Evaluation of nutritional, antinutritional, functional properties and cooking time of improved cowpea (*Vigna unguiculata* (L.) Walp.) varieties grown in Ethiopia

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ABSTRACT: Cowpea (*Vigna unguiculata* (L.) Walp.) is an important legume and an alternative source of protein which can be used as a substitute for animal protein that is limited in supply in Ethiopia. This study was initiated to evaluate the nutritional, antinutritional, functional properties and cooking time of two improved cowpea (*Vigna unguiculata* (L.) Walp.) varieties (Bole and Kanketi) grown in Ethiopia. The crude protein (28.80%), total ash (5.04%) and total energy (336.89 Kcal/100g) contents were higher for Bole variety than Kanketi variety (25.32%, 4.71% and 329.72 Kcal/100g), respectively. Kanketi variety had greater moisture content (8.91%), crude fiber (6.60%), crude fat (2.12%) and digestible carbohydrate (52.34%) than Bole variety (8.45%, 4.71%, 1.91% and 51.12%), respectively. The mineral content of the Bole variety revealed significantly higher values of Ca (43.36 mg/100g), Zn (6.17 mg/100g) and Fe (15.65 mg/100g) than Kanketi variety (41.91 mg/100g, 4.99 mg/100g and 13.32 mg/100g), respectively. Tannin and phytic acid content were found in the range of 28.43 to 31.23 mg/100g and 80.37 to 127.99 mg/100g, respectively, for Bole and Kanketi varieties. Both varieties had no significance ($p < 0.05$) difference on swelling power. Water solubility (20.19%) and oil absorption capacity (2.24 g/g) were significantly ($p < 0.05$) higher for Bole variety than Kanketi variety (17.56% and 2.06 g/g). Bulk density and water absorption capacity were found in the range of 0.75 to 0.79 g/ml and 2.39 to 2.54 g/g, respectively, for Bole and Kanketi varieties. The cooking time was significantly ($p < 0.05$) higher for Kanketi (27.42 min) than Bole variety (17.59 min). The results showed that Bole variety had good nutritional potential, low antinutritional factor, better functional properties and short cooking time than Kanketi variety. Hence, it can be used as a raw material in the food processing industries in the production of quality weaning and supplementary food products.

Keywords: Anti-nutrients, cooking time, cowpea, functional properties, minerals, proximate composition.

INTRODUCTION

Grain legumes occupy an important place in human nutrition, especially in the dietary pattern of low-income groups of people in developing countries (Wani et al., 2013). Legumes, considered as poor man's meat, are generally good sources of nutrients (Bouchenak and Lamri-Senhadji, 2013). They are an important and inexpensive source of protein, dietary fiber, unsaturated fats, complex carbohydrates and essential minerals for a large part of the world's population, mainly in developing countries (Rebello et al., 2014). Among the food legumes, cowpea (*Vigna unguiculata* (L) walp.) is an edible legume belonging to the family Fabaceae (Appiah et al., 2011). It is popularly known by various names such as Southern pea, China pea, Black-eyed bean or Cow gram (Olalekan and Bosede, 2010). It represents an important source of proteins and carbohydrates (Hamid et al., 2016). 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). It differs in shape, size and colour of seed coat (Ashogbon and Akintayo, 2013). Cowpea plant is highly valued for its ability to tolerate drought (Appiah et al., 2011). Cowpea is a rich source of protein for people who cannot afford proteins from animal sources such as meat and fish and are often referred to as poor man's meat (Hamid et al., 2016). They represent one of the dietary staples in many parts of the world (Odedeji and Oyeleke, 2011). Cowpea is considered as an incredible source of many other health-promoting components, such as soluble and insoluble dietary fiber, phenolic compounds, minerals, and many other functional compounds, including B group vitamins (Liyanage et al., 2014).

Like other legumes, cowpea has longer cooking time and some anti-nutritional factors present which restrict its usage rendering it in underutilized category of legumes (Hamid et al., 2015). Meanwhile, research done on various varieties of cowpea has come up with the claim that it is a potent industrial crop that could be used as an effective functional ingredient in various food systems. Research has thus stressed expanding the utilization of cowpeas in the form of meal and flour (Hamid et al., 2015) for use as functional ingredients in food products. Cowpea seeds can be processed into value added product like protein concentrate and food-grade starch (Ashogbon and Akintayo, 2013) since the flour is rich in protein (Mune et al., 2013) and starch. While it is the nutritional quality that eventually decides the cowpea flour as a food ingredient, its successful performance depends largely on functional characteristics imparted to the final products.

In order to increase the cowpea production and consumption, one of the approaches is to develop varieties with higher yields and low cooking time than the existing ones. With this objective, breeding trails for growth potential of new variety such as cowpea have been carried out by plant breeds in Ethiopian agriculture research centers. New cultivars of *V. unguiculata* are continually being developed and released from the research centers. The economic value of a new cultivar depends on its yield, rate of maturity, its resistance to disease, and seed size, color, nutritional quality, cooking time, and the flavor and texture of the cooked food. The criteria for selection have always been resistance to disease, yields and rate of maturation, but never nutritive quality (FSPT, 2001; Shimelis and Rakshit, 2005). Therefore, the objective of this study was to investigate the proximate composition, antinutritional factors, mineral content, functional properties and cooking time of improved cowpea varieties grown in Ethiopia.

MATERIALS AND METHODS

Source of raw material

The cowpea varieties (*Vigna unguiculata* (L.) Walp.) used in this study was grown at Melkassa Agricultural Research Center of Ethiopian Institute of Agricultural Research. The Center is geographically located at latitude of 8˚24'N, longitude of 39˚21' E and at altitude of 1,550 meters above sea level. It is situated at about 107 km from Addis Ababa, capital city of Ethiopia. The varieties of *Vigna unguiculata* (L.) Walp. that were used for the study were Bole and Kanketi. These varieties were grown by the low land pulse research project under similar field conditions and normal agronomic practices required for bean crops were followed. Cowpeas were sown in July 2018 and harvested in early October of same year. Cowpea seeds were cleaned manually to remove foreign materials, immature and damaged seeds and were stored in polyethylene plastic bags and stored at 4^{o}C until used.

Flour preparation

The seeds were processed by direct grinding. The samples were ground by laboratory mill (Model 3510-011p, Collins, USA) to pass through a 730 µm sieve size and were kept in a moisture-proof plastic bag placed at 4˚C until required for analysis and further use. All the reagents used in the study were of analytical grade.

Proximate composition

Protein (method 960.10), fat (method 4.5.01), ash (method 923.03), moisture (method 925.10) and crude fiber (method 962.09) contents were determined according to standard methods of Association of Official Analytical Chemists (2000). Carbohydrate was calculated from the difference (100 − %protein + %fat + %ash + %moisture+ %fiber) (Maclean et al., 2003).

Mineral analysis

Ca, Fe and Zn contents were determined according to standard methods of Association of Official Analytical Chemists (2000) using Atomic Absorption Spectrometry (AAS) (Model 210 VGP Spectrophotometer, Buck Scientific, East Nowalk, CT, USA). Its content was reported on dry weight basis.

Antinutritional factors

Condensed tannin and phytic acid contents were analyzed by modified Vanillin-HCl methanol method (Price et al., 1980) and Vaintraub and Lapteva (1988) methods, respectively using spectrophotometer (UV-Vis spectrophotometer, Model 4001, Germany).

Functional properties

Flour samples of the given varieties were analyzed for bulk density, solubility index and swelling power, water absorption capacity and oil absorption capacity according to AOAC (1990), Shimelis et al. (2006), Sathe et al. (1982) and Beuchat (1977), respectively.

Cooking time

Cooking time was determined according to Jackson and Variano-Martson (1981) and Shimelis and Rakish (2005) using a Mattson cooking device. A cowpea sample (50 g) was soaked-in deionized water (100 mL) for 24 hours at room temperature before cooking, the soaked samples were then positioned into each of the 25 cylindrical holes found in the cooker so that the piercing up of the 82 g rod was in contact with the surface of the cowpea seeds. The cooker was placed into a 2 L metal beaker containing 1.5 L of boiling water (100˚C). The cowpea seeds were considered as "cooked" when the tip of the brass rod passed through the seed. Cooking time (time required to cook 50% of the sample) was then recorded from the point of contact between the cooker and boiling water.

Statistical analysis

The collected of triplicates data was analyzed using one-way analysis of variance (ANOVA). SAS Statistical software (SAS, 2008) was used for statistical data analysis. The critical difference at $p< 0.05$ was estimated and used to find the significant difference among the sample means. The result was expressed as mean±SD.

RESULTS AND DISCUSSION

Proximate composition

Proximate composition of cowpea flours is presented in Table 1. For both varieties, significant differences ($p<0.05$) were observed in the proximate composition. Bole variety showed statistically ($p<0.05$) higher value of crude protein, total ash and energy contents than Kanketi variety, whereas Kanketi variety had greater moisture content, crude fiber, crude fat and digestible carbohydrate than Bole variety. Proximate composition concentrations varied from variety to variety, but were comparable to values obtained by Owolabi et al. (2012), Carvalho et al. (2012), Yadav et al. (2015), Adegunwa et al. (2012), Gunathilake et al. (2016), Appiah et al. (2011), respectively, for moisture, protein, ash, fat, fiber and carbohydrate. According to Chinma et al. (2008), compositional differences in bean could be attributable to soil type, cultivation practices, environmental condition, and genetic factors. Since these two cowpea varieties were grown under similar agro ecology, soil type, temperature, rain fall and similar agronomic practice, its differences could mainly be due to genetic factors.

Mineral content

Concentration of iron, zinc and calcium (dry-weight basis) are presented in Table 2. Iron content was observed in the range of 13.32 to 15.65% and was found statistically higher for Bole (15.65%) than Kanketi variety (13.32%). Iron values obtained are similar to or greater than concentrations given by many researchers (Yadav et al., 2015; Inobeme et al., 2014; Yewande and Thomas, 2015). Therefore, cowpea varieties can be considered as good sources of dietary Iron.

Zinc content was observed statistically higher for Bole (6.17%) than Kanketi variety (4.99%). The level of zinc content in both cowpea cultivars are comparable with the 4.18 to 6.25 mg/100g of four selected Indian cowpea cultivars reported by Yewande and Thomas (2015). Iron, zinc, vitamin A and iodine are the main important micronutrients for normal healthy growth and reproduction. Deficiencies of these nutrients affect public health in Africa. Many Africans still consume insufficient amounts of these nutrients, even though they are only required in relatively small quantities (Todd, 2004). Hence, cowpeas are significant sources of dietary zinc and iron.

Calcium content was observed in the range of 41.91 to 43.36% and was found statistically higher for Bole (43.36%) than Kanketi variety (41.91%). These calcium values are lower than the 194.12 to 201.61 mg/100 g reported by Inobeme et al. (2014) and the 60 to 80 mg/100g by Yewande and Thomas (2015) but greater than 15 to 36.80 mg/100g of five Nigerian cowpea varieties reported by Owolabi et al. (2012). On the other hand, these values of the calcium content of two cowpea varieties were comparable with 29 to 44 mg/100g of 30 Brazilian cowpea genotypes reported by Carvalho et al. (2012). It can be observed from these reports that the calcium content of cowpeas varies considerably.

Antinutritional content

The tannin and phytic acid content of two cowpea varieties are presented in Table 2. The tannin contents of Bole (28.43 mg/100g) and Kanketi (31.23 mg/100 g) were

Table 1. Proximate composition (%) cowpea varieties.

Varieties	Moisture	Protein	Total ash	Fiber	Fat	Carbohydrate
Bole	8.45±0.12[b]	28.80±0.15[a]	5.04±0.07[a]	4.71±0.08[b]	1.91±0.07[b]	51.12±0.28[b]
Kanketi	8.91±0.07[a]	25.32±0.06[b]	4.71±0.03[b]	6.60±0.24[a]	2.12±0.05[a]	52.34±0.19[a]

Notes: Values reported are mean± standard deviation. Mean in the column with different superscript letters are significantly different (p<0.05).

Table 2. Mineral contents and antinutritional factors (mg/100g) of cowpea seeds.

Varieties	Iron	Zink	Calcium	Tannin	Phytic acid
Bole	15.65±0.07[a]	6.17±0.04[a]	43.36±0.48[a]	28.43±0.12[b]	80.37±0.15[b]
Kanketi	13.32±0.09[b]	4.99±0.06[b]	41.91±0.38[b]	31.23±0.13[a]	127.99±0.14[a]

Notes: Values reported are mean± standard deviation. Mean in the column with different superscript letters are significantly different (p<0.05).

statistically (p<0.05) different from each other. This difference could be due to difference in their seed coat, as a large portion of tannin in pulses is found in the seed coat pigments (Vasic et al., 2012). The tannin content of both cowpea varieties were much less than those observed in four Indian cowpea cultivars (360 to 780 mg/100g) reported by Yadav et al. (2015). However, the values observed in this study for both varieties are in agreement with the 3.8 to 278 mg/100g reported for 15 Cameroon cowpea cultivars by Maina et al. (2015). The tannin content in the cowpea samples in this study is far lower than the 150 to 200 mg/100g of safe level reported by Schiavone et al. (2007).

The phytic acid content of the two cowpea varieties were statistically (p<0.05) different from each other. The values of phytic acid in Bole and Kanketi were 80.37 and 127.99 mg/100g, respectively. These values were much less than the 650 to 1131.34 mg/100g observed in four Indian cowpea cultivars reported by Yadav et al. (2015). However, the values observed in this study for both varieties are comparable with 50 to 1497.2 mg/100g of 15 Cameroon cowpea cultivars reported by Maina et al. (2015).

Generally, anti-nutrient concentration in seeds is a function of climatic conditions, irrigation, seed genotype, and soil type (Urbano et al., 2000). Most importantly, the variation in anti-nutrient concentrations could be also related to the colour of the seeds which was white for Bole genotype and red for genotype, thus suggesting influence of genetic origin (Makinde et al., 2020).

Functional properties and cooking time

The functional properties determine the application and use of food material for various products. For instance, properties are very important for the appropriateness of the diet, particularly, for growing children (Omueti et al., 2009). Henshaw et al. (1996) reported that the functionality of cowpea flour can be attributed to its chemical components as determined by the genetic architecture of the seed and postharvest conditions of storage and processing. Cooking time is one of the main considerations used for the evaluation of pulse-cooking quality. Longer cooking times result in loss of nutrients, increased energy use and could limit end uses. Functional properties such as bulk density (BD), swelling power, solubility, water absorption capacity (WAC) and oil absorption capacity (OAC) and cooking time of the flour of two cowpea varieties are presented in Table 3.

Bulk density is affected by the particle size and density of the flour and it is very important in determining the packaging requirement, material handling and application in the wet processing food industry (Karuna et al., 1996). The bulk densities were 0.75 and 0.79 g/ml for Bole and Kanketi flour, respectively, with significant difference (p<0.05) between them. These values were greater than bulk density values (0.43 to 0.72 g/ml) of four Nigerian cowpea flour reported by Obasi et al. (2014). The bulk density determined in this study was comparable with the bulk densities of cowpea flour reported by Appiah et al. (2011) that ranged from 0.69 to 0.80 g/ml and those reported by Hamid et al. (2015) that ranged from 0.67 to 0.82 g/ml. Higher bulk density of Kanketi cowpea flour gives an indication that it is heavier than Bole cowpea and would occupy lesser space per unit weight and hence packaging cost would also be lesser when compared with Bole cultivar (Appiah et al., 2011). In contrast, however, lower bulk density as of Bole cowpea flour would be an advantage in the formulation of complementary foods (Appiah et al., 2011).

The swelling power was 5.17 and 5.22% for Bole and Kanketi flour, respectively with no significant difference (p>0.05) between them. The values of swelling power of both varieties were greater than the 3.29 to 3.65% of three Nigerian raw cowpea seed flours reported by Adegunwa et al. (2012), but as compared to the values (12.64 to 15.16%) of faba bean reported by Eyasu (2015), the

Table 3. Functional properties and cooking time of cowpea seeds.

Varieties	Bulk density (g/ml)	Swelling power (%)	Solubility index (%)	WAC (g/g)	OAC (g/g)	Cooking time (min)
Bole	0.75±0.01[b]	5.17±0.02[a]	20.19±0.24[a]	2.39±0.06[b]	2.24±0.06[a]	17.59±0.71[b]
Kanketi	0.79±0.01[a]	5.22±0.13[a]	17.56±0.13[b]	2.54±0.01[a]	2.06±0.08[b]	27.42±1.09[a]

Notes: Values reported are mean± standard deviation. Mean in the column with different superscript letters are significantly different (p<0.05). WAC = Water absorption capacity; OAC = Oil absorption capacity.

swelling power of cowpea flour studied was lower. The high swelling powers of the cowpea genotypes considered in this work suggests that flour of both cowpea varieties could be useful in food systems where swelling is required.

The water solubility index of the two cowpea varieties were significantly (p<0.05) different from each other with the values of 20.19 and 17.56% for Bole and Kanketi cowpea flour, respectively. These are greater than the 3.29 to 3.65% of three Nigerian cowpea flour reported by Adegunwa et al. (2012) and less than the 24.16 to 26.45% of two improved Ethiopian raw faba bean seed flour reported by Eyasu (2015). Solubility enables evaluation of the denaturing state of proteins. Good solubility can markedly expand the potential utilization of proteins (Gibson and Williams, 2001).

The water absorption capacity (WAC) of cowpea flour of Bole and Kanketi varieties were 2.39 and 2.54 g/g, respecttively. Significance difference (p<0.05) was observed between the two. The results obtained in this study were greater than the values of cowpea flour reported by Appiah et al. (2011) which ranged from 1.89 to 2.15 g/g and of Hamid et al. (2015) which also ranged from 1.22 to 1.39 g/g. However, the value of Bole variety was comparable to the 2.21 to 2.45 g/g of haricot bean flour reported by Shimelis and Rakshit (2006) and of 2.25 to 2.38 g/g faba bean flour reported by Eyasu (2015). The value of Kanketi variety was in agreement with the 2.05 to 2.65 g/g of lupin flour obtained by Tizazu and Shimelis (2010). The observed variation in water absorption among the cowpea flours may be due to different protein content, its degree of interaction with water and its conformational characteristics (Butt and Batool, 2010).

Oil absorption capacity (OAC) was observed statistically higher for Bole (2.24 g/g) than Kanketi variety (2.06 g/g). Oil absorption capacity of both varieties were higher than the 0.71 to 0.72 g/g reported for some Indian cowpeas (Hamid et al., 2015) and the 1.90 g/g reported by Moutaleb et al. (2017). However, the values were comparable to the 1.95 to 2.3 g/g of three Ghanaian cowpea flour obtained by Appiah et al. (2011). The differences in oil absorption capacities may be due to differences in protein content Appiah et al. (2011). The OAC of flour helps improve mouth feel and flavor retention (Kinsella, 1979). The ability of the protein of these cowpea varieties to bind oil makes them useful in food systems where oil imbibitions are desired. The OAC also makes the flours suitable for enhancing flavor and mouth feel when used in food preparations. Bole cowpea could, therefore, be superior to Kanketi cowpea as flavor retainer since it had significantly higher OAC.

Cooking time is one of the main considerations used for the evaluation of pulse-cooking quality. Longer cooking times result in loss of nutrients, increased energy use and could limit end uses. Cooking time of Bole and Kanketi varieties were 17.59 and 27.42 minute, respectively. As the cooking time of the Bole was shorter than that of Kanketi, it would require less fuel energy and should be promoted to consumers. The cooking time of both cowpea varieties were much less than the results 57 to 84 min reported by Appiah et al. (2011) for three Ghanaian cowpea varieties and 29.77 to 64.67 minutes by Hamid et al. (2016) for some Indian cowpea cultivars. Seed mass, thickness, composition of seed coat and cotyledon, genotype, growing conditions, soil type, and postharvest handling may play a role in prolonging the cooking time of pulses (Wang et al., 2003).

Conclusion

The findings of this study show that the cowpea varieties (Bole and Kanketi) are rich in protein and minerals (Fe and Zn) and low antinutritional factors, good functional properties and short cooking time which could be exploited for nutrition and food formulation. The good functional properties make them useful in many food systems where they could play functional roles. The cowpea flour could be used in the production of weaning food and supplementary food mixtures and other value-added products that are affordable for most of the consumers thereby alleviating the protein-energy malnutrition problem in Ethiopia. Nonetheless, the Bole variety could be most suitable than Kanketi for food uses since it had higher protein, better functional properties and shorter cooking time.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Adegunwa, M. O., Bakare, H. A., Alamu, E. O., & Abiodun, O. K. (2012). Processing effects on chemical, functional and pasting properties of cowpea flour from different varieties. *Nigerian Food Journal*, 30(1), 67-73.

Appiah, F, Asibuo, J. Y., Kumah, P. (2011). Physicochemical and functional properties of bean flours of three cowpeas (*Vigna unguiculata* (L.) Walp.) varieties in Ghana. *African Journal of Food Science*, 5(2),100-104.

Ashogbon, A. O., & Akintayo, E. T. (2013). Isolation and characterization of starches from two cowpea (*Vigna unguiculata*) cultivars. *International Food Research Journal*, 20(6), 3093-310.

Association of Official Analytical Chemists (AOAC) (1990). Official Methods of Analysis of AOAC International. William, H. (ed). Volume II, 17th Edition.

Association of Official Analytical Chemists (AOAC) (2000). Official methods of analysis (vol.2 17th edition) of AOAC International. Washington, DC, USA. Official methods 925.09, 923.03, 979.09, 962.09, 4.5.01 and 923.05.

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. *Journal of Agricultural and Food chemistry*, 25(2), 258-261.

Bouchenak, M, Lamri-Senhadji, M. (2013). Nutritional quality of legumes and their role in cardiometabolic risk prevention. *Journal of Medicinal Food*, 16(3),185-198.

Butt, M. S, & Batool, R. (2010). Nutritional and functional properties of some promising legumes protein isolates. *Pakistan Journal of Nutrition*, 9(4), 373-379.

Carvalho, A. F. U., de Sousa, N. M., Farias, D. F., da Rocha-Bezerra, L. C. B., da Silva, R. M. P., Viana, M. P., Gouveia, S. T., Sampaio, S. S., de Sousa, M. B., de Lima, G. P. G., & de Morais, S. M. (2012). Nutritional ranking of 30 Brazilian genotypes of cowpeas including determination of antioxidant capacity and vitamins. *Journal of Food Composition and Analysis*, 26(1-2), 81-88.

Chinma, C. E., Alemede, I. C., Emelife, I. G. (2008). Physicochemical and functional properties of some Nigerian cowpea varieties. *Pakistan Journal of Nutrition*, 7(1), 186-190.

Eyasu, Y. (2015). Effect of processing methods on nutritional composition, anti-nutritional factors and functional properties of improved faba bean (*Vicia faba* L.) varieties grown in Ethiopia, M.Sc. Haramaya University.

Food Science and Post-harvest Technology (FSPT) (2001). Research strategy. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO).

Gibson, G. R., & Williams, C. M. (2001). Functional foods concept to product published by 2nd Woodhead Publishing Limited.

Gunathilake, K. G. T., Herath T, Wansapala J. (2016). Comparison of physicochemical properties of selected locally available legumes varieties (mung bean, cowpea and soybean), Potravinarstvo® Scientific Journal for Food Industry, 10(1), 424-430.

Hamid, S., Muzaffar, S., Wani, I. A., Masoodi, F. A., & Bhat, M. M. (2016). Physical and cooking characteristics of two cowpea cultivars grown in temperate Indian climate. *Journal of the Saudi Society of Agricultural Sciences*, 15(2), 127-134.

Hamid, S., Muzzafar, S., Wani, I. A., & Masoodi, F. A. (2015). Physicochemical and functional properties of two cowpea cultivars grown in temperate Indian climate. *Cogent Food & Agriculture*, 1(1), 1099418.

Henshaw, F. O., McWatters, K. H., Oguntunde, A. O., & Phillips, R. D. (1996). Pasting properties of cowpea flour: effects of soaking and decortication method. *Journal of Agricultural and Food Chemistry*, 44(7), 1864-1870.

Inobeme, A., Nlemadim, A. B., Obigwa, P. A., Ikechukwu, G., Ajai, A. I. (2014). Determination of proximate and mineral compositions of white cowpea beans (Vigna unguiculata) collected from markets in Minna, Nigeria. *International Journal of Scientific & Engineering Research*, 5(8), 502-504.

Jackson, G. M., & Varriano-Marston, E. (1981). Hard-to-cook phenomenon in beans: effects of accelerated storage on water absorption and cooking time. *Journal of Food Science*, 46(3), 799-803.

Karuna, D., Noel, G., & Dilip, K. (1996). *Food and Nutrition Bulletin* 17 (2). United Nations University, Tokyo, Japan.

Kinsella, J. E. (1979). Functional properties of soy proteins. Journal of the American Oil Chemists' Society, 56(3Part1), 242-258.

Liyanage, R., Perera O. S., Weththasinghe, P., Jayawardana, B. C., Vidanaarachchi, J. K., & Sivakanesan, R. (2014). Nutritional properties and antioxidant content of commonly consumed cowpea cultivars in Sri Lanka. *Journal of Food Legumes*, 27(3), 215-217.

Maclean, W., Harnly, J., Chen, J., Chevassus-Agnes, S., Gilani, G., Geoffrey, L., & Warwick, P. (2003). Food energy–Methods of analysis and conversion factors.*Food and Agriculture organization of the United Nations Technical Workshop Report*, vol. 77, 8-9.

Maina, A. N., Tchiagam, J. N., Gonne, S., Hamadama, Y., Bell, J. M., & Yanou, N. N. (2015). Diallel analysis of polyphenols and phytates content in cowpea (*Vigna unguiculata* L. Walp.). *Scientia Agriculturae*, 12(1), 46-51.

Makinde, F. M., & Abolarin, O. O. (2020). Effect of post-dehulling treatments on anti-nutritional and functional properties of cowpea (*Vigna unguiculata*) flour. *Journal of Applied Sciences and Environmental Management*, 24(9), 1641-1647.

Moutaleb, O. H., Amadou, I., Amza T., Zhang, M. (2017). Physico-functional and sensory properties of cowpea flour-based recipes (Akara) and enriched with sweet potato. *Journal of Nutrition Health and Food Engineering*, 7(4), 325-330.

Mune, M. M., Minka, S. R., & Mbome, I. L. (2013). Chemical composition and nutritional evaluation of a cowpea protein concentrate. *Global Advanced Research Journal of Food Science and Technology*, 2(3), 35-43.

Obasi, N. E., Unamma, N. C., & Nwofia, G. E. (2014). Effect of dry heat pre-treatment (toasting) on the cooking time of cowpeas (*Vigna unguiculata* L. Walp). *Nigerian Food*

Journal, 32(2), 16-24.

Odedeji, J. O., & Oyeleke, W. A. (2011). Comparative studies on functional properties of whole and dehulled cowpea seed flour (*Vigna unguiculata*). *Pakistan Journal of Nutrition*, 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). *Journal of Emerging Trends in Engineering and Applied Sciences*, 1(1), 89-95.

Omueti, O., Otegbayo, B., Jaiyeola, O., & Afolabi, O. (2009). Functional properties of complementary diets developed from soybean (Glycine Max), groundnut (*Arachis hypogea*) and crayfish (*Macrobrachium Spp*). *Electronic Journal of Environmental, Agricultural & Food Chemistry*, 8(8), 563-573.

Owolabi, A. O., Ndidi, U. S., James, B. D., & Amune, F. A. (2012). Proximate, antinutrient and mineral composition of five varieties (improved and local) of cowpea, *Vigna unguiculata*, commonly consumed in Samaru community, Zaria-Nigeria. *Asian Journal of Food Science and Technology*, 4(2), 70-72.

Price, M. L., Hagerman, A. E., & Butler, L. G. (1980). Tannin content of cowpeas, chickpeas, pigeon peas, and mung beans. *Journal of Agricultural and Food Chemistry*, 28(2), 459-461.

Rebello, C. J., Greenway, F. L., & Finley, J. W. (2014). A review of the nutritional value of legumes and their effects on obesity and its related co‐morbidities. *Obesity Reviews*, 15(5), 392-407.

Sathe, S. K., Deshpande, S. S., & Salunkhe, D. K. (1982). Functional properties of lupin seed (*Lupinus mutabilis*) proteins and protein concentrates. *Journal of Food Science*, 47(2), 491-497.

Schiavone, A., Guo, K., Tassone, S., Gasco, L., Hernandez, E., Denti, R., & Zoccarato, I. (2008). Effects of a natural extract of chestnut wood on digestibility, performance traits, and nitrogen balance of broiler chicks. *Poultry Science*, 87(3), 521-527.

Shimelis, E. A., & Rakshit, S. K. (2005). Proximate composition and physico-chemical properties of improved dry bean (Phaseolus vulgaris L.) varieties grown in Ethiopia. *LWT-Food Science and Technology*, 38(4), 331-338.

Shimelis, E. A., Meaza, M., & Rakshit, S. (2006). Physico-chemical properties, pasting behavior and functional characteristics of flours and starches from improved bean (Phaseolus vulgaris L.) varieties grown in East Africa. Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 05 015. Vol. VIII.

Tizazu, H., & Emire, S. A. (2010). Chemical composition, physicochemical and functional properties of lupin (*Lupinus albus*) seeds grown in Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development*, 10(8), 3029-3046.

Todd, B. (2004). *Africa's food and nutrition security situation: Where are we and how did we get there?* 2020 discussion paper 37, International Food Policy Research Institute, Washington D.C.

Urbano, G., Lopez-Jurado, M., Aranda, P., Vidal-Valverde, C., Tenorio, E., & Porres, J. (2000). The role of phytic acid in legumes: antinutrient or beneficial function? *Journal of physiology and biochemistry*, 56(3), 283-294.

Vaintraub, I. A., & Lapteva, N. A. (1988). Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. *Analytical biochemistry*, 175(1), 227-230.

Vasić, M., Tepić, A., Mihailović, V., Mikić, A., Gvozdanović-Varga, J., Šumić, Z., & Todorović, V. (2012). Phytic acid content in different dry bean and faba bean landraces and cultivars. *Romanian Agricultural Research*, 29, 79-85.

Wang, N., Daun, J. K., & Malcolmson, L. J. (2003). Relationship between physicochemical and cooking properties, and effects of cooking on antinutrients, of yellow field peas (Pisum sativum). *Journal of the Science of Food and Agriculture*, 83(12), 1228-1237.

Wani, I. A., Sogi, D. S., & Gill, B. S. (2013). Physical and cooking characteristics of black gram (*Phaseolus mungoo* L.) cultivars grown in India. *International Journal of food Science & Technology*, 48(12), 2557-2563.

Yadav, N., Kaur, D., Malaviya, R., & Rathore, B. S. (2015). Evaluation of the nutritional antinutritional and antioxidant properties of selected cowpea (Vigna Unguiculata) cultivars. *International Journal of Food and Nutritional Sciences*, 4(4), 124-130.

Yewande, B. A., & Thomas, A. O. (2015). Effects of processing methods on nutritive values of Ekuru from two cultivars of beans (*Vigna unguiculata* and *Vigna angustifoliata*). *African Journal of Biotechnology*, 14(21), 1790-1795.