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Biochemical Composition, Potential Food and Feed Values of Aerial Parts of Cowpea (*Vigna unguiculata* (L.) Walp.)

***Enyiukwu DN, Amadioha AC and Ononuju CC**

Department of Plant Health Management, Michael Okpara Universty of Agriculture, Umudike PMB 7267 Umuahia, Abia State, Nigeria.

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****Corresponding Author***
Enyiukwu DN
E-mail: *enyidave2003 @ gmail.com*

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ABSTRACT

Cowpea is a multi-purpose crop tolerant to drought and salinity. In farming systems it plays important roles of mitigating climate change by sinking greenhouse gases, lowering aluminum toxicity in the rhizosphere and restoring soil fertility. Its haulms, hay, leaves and grains are reported as good sources of nutrients required for proper functioning of metabolic processes in livestock and humans. However, variations in biochemical compositions amongst its aerial organs are thought to exist; and this could affect its possible nutritional values and the attendant health benefits from these organs. The results of the biochemical profiling of cowpea aerial organs in this study indicated the presence at varying degrees of a wide array of nutrients in the organs. It showed that protein occurred in the range (11.21-34.91%), carbohydrates (31.11-54.02%), crude protein (prebiotics) (3.94-22.12%), fat (0.81-5.42%), iron (0.89-65.21 mg/100 g), calcium (1.50-16.15.20 mg/100 g), phosphorus (171.55-554.01 mg), magnesium (0.26-1658.84 mg), potassium (1.03-13,445.25 mg/ 100 g) and sodium (0.13-2,216.10 mg/ 100 g). The results further showed that the leaf was the most nutrient-dense, being especially rich in terms of protein, potassium, phosphorus, calcium, magnesium, zinc, iron and sodium contents; followed by the seed and then stem samples. Though the husk was the least in mean nutrient density, however, the highest levels of crude fibre and carbohydrate contents were recorded in the husk specimen. Amongst leafy vegetables and fruits for human consumption, the leaves and seeds are probably the highest known sources of organic potassium (13.5 g and 1.29 g), phosphorus (554.01 mg and 498.06 mg) and iron (65.21 mg and 11.00 mg) for the leaf and seed respectively which function to alleviate muscle cramps prevent hypertension, stroke, maintain sexual virility, confer strength and fight anaemia. Knowledge of the disparities in nutrient contents of these organs could aid in combining feedstuff for animal nutrition especially during dry season, to formulate feeds for poultry in intensive production systems and to prepare concentrates for infants and the elderly during bouts of famine, wars or natural disasters.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) (Fabaceae) an annual legume native to Africa is one of the most important pulses in the world (Abdullahi and Tsowa, 2014). The crop is widely cultivated in Africa, Asia and the Americas as sole or intercrop with yam, cassava, maize, sorghum, millet and rice (AATF, 2012; Awurum and Enyiukwu, 2013a). The crop is heat, drought and salinity tolerant (Davis *et al*., 2007). In rotation systems, it functions as diseases breaker, aids to eliminate or reduce cereal-cereal fallow periods and improve the yield of component crops by 30 % (Heuza *et al*., 2015). cowpeas restore soil fertility through symbiosis with nodular *Bradyrhizobia spp.*, fixing up to 140-240kgN/ha per annum (Enyiukwu and Awurum, 2013a; 2013b, Heuza *et al*., 2015). Cowpea also plays several important environmental roles. In tropical soils, it helps to lower aluminum ion toxicity and serves to control erosion (Source: www.leafforlife.org>VIGNAUNG). In addition, it also actively sinks greenhouse gases (GHGs) and ameliorates climate change effects (FAO, 2016).

Cowpeas are used as medicine, fodder, feed and food (Awurum, 2000; Okwu and Njoku, 2009). The root is used by natives to prepare antidote against snake bite; In animal husbandry, the crop is used as forage or cut-and-carry fodder during the season and silage or in some cases hay during off seasons (Duke, 1983). The husks are also valuable off-season feedstuff for livestock in arid zones; whose sales earn 25% more income for herd-farmers in drier agro-ecologies of West African region (SADAFF, 2013). The grains are utilized in intensive poultry management to formulate concentrates for (Awurum, 2000; Balaiel, 2015).

All parts of the crop can be consumed as food (AATF, 2012). The leaves, green pods, dry pods, green grains and dry grains (Fig. 1) can be eaten as vegetables or processed food-forms such as bean cake (*akara*) and paste popularly known as *moi moi* in Nigeria (Abdulalahi and Tsowa, 2014). The dry ground pods are used to supplement (or compliment) melon in making *Egusi* soup in some parts of the country (Chikwendu *et al*., 2014). Cowpea leaves is reported to compare favourably in nutrient status and density with vegetables such as amaranth, taro, spinach, pumpkins, lettuce and sweet potato (Nielsen *et al*., 1997). Besides the grains, the mild-flavoured leaves are also significantly rich in protein, micro- as well as macronutrients (Aveling, 2007; Alemu *et al*., 2016). As such the crop could play significant roles in fighting malnutrition and provide protein-calorie and minerals security (Abdulalahi and Tsowa, 2014; FAO, 2016). Though its leaves are higher in nutrients than the seeds; both contain significant amounts of essential amino acids such as lysine, valine, phenylalanine and isoleucine (Nielsen *et al*., 1997; Mamiro *et al*., 2011; AATF, 2012). Its nutrient rich status could therefore be exploited to offset the recommended daily averages of majority of essential nutrients for humans and in so doing strengthen the immunity, vision, heart and circulatory health, fight depression and diabetes, prevents cold sores and enrich the blood and overall health of its consumers (Hallensleben *et al*., 2009; HBT, 2016). In the end, cowpea will thus contribute to ameliorating protein-calorie deficiency in sub-Saharan Africa (Okonya and Maas, 2012; Enyiukwu *et al*., 2018).

Food insecurity ranks major amongst the indices of poverty in a nation. Malnutrition is reported to underpin low resistance to various diseases especially among children and young human adults. In recent years surveys suggested that malnutrition caused up to 50% mortality of children on a global basis (Abdulalahi and Tsowa, 2014). These authors argued that factors of high cost of animal protein coupled with inadequate intake of macro- and micronutrients during pregnancy and periods of rapid growth in children from other sources contributed to malnutrition and child-mortality in developing countries of the world. Estimates further show that 80% of the world's population is deficient in iron with 30 % actually coming down with iron deficiency anaemia (Axe, 2018). Some workers as a result believe that adequate knowledge about the nutrient and/or anti-nutrient values of food and feedstuffs could lead to adoption and utilization of varied plant sources to maintain human health especially in meat scare environments (Chikwendu *et al*., 2014; Enyiukwu *et al.,* 2018).

Nutrients are generally known to play important roles in the productive performance and to maintain health and well being of livestock, poultry and humans (Campos-Vegas *et al*., 2010; Afolabi et al., 2012; Abdullahi and Tsowa, 2014). Variations in nutrient contents and values of forage, feed and food ingredients between seasons and amongst organs of the same or related plant species have been reported (Addass *et al*., 2011; Chikwendu *et al*., 2014). In the light of these therefore, this study evaluated the biochemical composition, potential food and feed values of aerial organs cowpea for animal and human consumption.

Figure 1: Cowpea plant and some of its aerial organs

A. = Cowpea; growing in the field; **B.** = Mature cowpea leaves; **C.** = Fresh pods of cowpea; **D.** = Dry pods of cowpea; **E.** = Grains (seeds) of cowpea; **F.** = Husks of the plant

MATERIALS AND METHODS

Sources of seeds Preparation of plant samples for analyses.

The experiment was conducted at the Greenhouse and Plant Pathology Laboratory of the College of Crop and Soil Sciences of Michael Okpara Universty of Agriculture, Umudike as well as the Analytical Laboratories of the Federal Institute for Industrial Research Oshodi, Lagos. The seeds of cowpea (Var. IAR-48) obtained from the Research and Training (R&T) Unit of the College of Crops and Soil Sciences were used for the study. They were sown 3 per 20 cm diameter pots containing heat sterilized top soil (4 kg) and watered twice daily. Pots were laid out in completely randomized design (CRD). At maturity the seedlings were harvested. Collected samples were air-dried at the laboratory bench for 1 day and then enveloped and oven-dried at 60^oC for 3 days. Fifty grams of the specimens (leaves, stems, pods and seeds) were weighed out with a digital balance and ground into powder using a hand milling machine (Corona Lavesh 250) (Amadi and Oso, 1996). The powdered specimens were stored separately in air-tight bottles and kept in dark cupboard until required for nutrients and biochemical analyses.

Biochemical analyses of aerial organs of cowpea

Standard methods based on the protocols of AOAC (2000) as adopted in the studies by Kayode *et al.* (2008) and Enyiukwu *et al*. (2018) were employed in the determination of the proximate compositions (moisture, protein, fat, crude fibre, ash and carbohydrate contents) of the specimens. The samples were first scanned with the moisture analyzer (Model: MS-70, A & D Company limited, UK) to obtain the optimum temperature suitable for the specimens to be dried. The percentage moisture contents of the samples were then determined and shown automatically on the light emitting diode (LED) of the digital analyzer.

One gram (1 g) of the samples was weighed separately and then charred to complete decarbonization on a hot plate, and thereafter they were put in the furnace (Model 186A, Fisher Scientific Co.) to obtain their ashes. The ashes thus obtained were dissolved in 1N nitric acid and the resulting solutions were taken to the Atomic Absorption Spectrometer (Model: AA 7000, Schimadzu, Japan) for the analyses of their elemental nutrient (calcium, zinc, magnesium, phosphorus and iron) contents based on their absorbances from the machine.

Standards were prepared and run on the AAS, and a calibration curve **generated and from the calibration curve the comparative amounts of the elements were determined.** The biochemical compositions of the specimens to ascertain their nutrient values as food and feed were assessed in triplicate determinations (Kayode *et al.*, 2008; Enyiukwu *et al.*, 2018).

STATISTICAL ANALYSIS

Data collected from this study were analyzed by analysis of variance (ANOVA) using the general linear model procedure in Genstat Release (Windows/PC Vista, version 12.10) at significant level of 5%. Means were separated and compared using Fishers LSD at probability of 0.05.

RESULTS

The results presented in Table 1 indicated the presence of essential proximate nutrients such as protein; carbohydrate, fats, crude fibre, and ash in all the aerial organs of cowpea. It showed that protein occurred in the range (11.21-34.91%), fat (0.81-5.45%), carbohydrate (31.11-57.02%), ash (2.81-12.05%), and crude fibre (3.94-22.12%). Values of all the nutmeats tested in the leaf, husk, seed and stem samples were significantly different amongst themselves. In the leaf samples, protein was the highest (P≤0.05) occurring nutrient (34.91%) followed by carbohydrate (31.11 %), however both were statistically (P≤0.05) superior to the values recorded for crude fibre, ash and fat. Carbohydrate which was recorded at 43.6 1% was the highest occurring nutrient in the stem tissues and it was significantly (P≤0.05) greater than crude fibre (16.87 %) and protein (15.64 %). The later parameters were higher (P≤0.05) in the stem than fat recorded at 1.29 %. Values of crude fibre and carbohydrate obtained in the husk were statistically (P≤0.05) not different, they were however superior to 11.21 % obtained for protein content (Table 1). In the seed, carbohydrate (57.02 %) was the highest occurring nutrient, followed by protein at 24.09 % and fat recorded at 1.70 % was the least.

Amongst the aerial organs of cowpea, protein was found in the largest amount in the leaf, followed by the seed but least in the husk, Compared to the husk and stem, carbohydrate was recorded in the highest amount in the seed, followed by the husks and least in the leaf. Crude fibre recorded at 22.12 % was highest in the husk, next to this was 19.46 % obtained from the leaf but least (3.94 %) in the seed samples. In terms of fat content, the husk recorded the least amount (0.81 %) while 5.42 % obtained from the leaf was the highest (Table 1).

Table 1: Proximate composition of dried above ground organs of cowpea per 100 g (dry weight)

	Aerial Parts of Cowpea			
Nutrients (%)	**Leaf**	**Stem**	**Husk**	**Seed**
Moisture content	10.88	11.80	19.09	13.00
Protein	34.91	15.64	11.21	24.09
Fat	5.42	1.29	0.81	1.70
Carbohydrate	31.11	43.61	55.06	57.02
Ash	11.15	12.05	11.25	2.81
Crude fibre	19.46	16.87	22.12	3.94
LSD (0.05)	**0.50**	**0.80**	**36.05**	**0.64**

Table 2 shows the results of the macro- and micronutrients evaluations of the aerial specimens of cowpea. In the aerial specimens, calcium was recorded in the range (1.110-1615.20 mg), phosphorus (171.85-554.01 mg) and potassium (1.03-13445.25 mg). The results furthermore indicated that the trace elementals such as iron were recorded in the range (0.89-65.21 mg), zinc (0.17-121.84 mg), magnesium (0.26- 1658.84 mg) and sodium (0.13-2216.10 mg). In the leaf samples, K detected at 13.50 g was the highest occurring nutrient and it was statistically (P≤0.05) superior to 2.22 g and 1.62 g recorded for magnesium and sodium respectively, whereas Fe at 65 mg was the least. Zn (1.66 mg) was the least amongst the nutrients detected in the stem samples and this was statistically (P≥0.05) inferior to Na (111.28 mg), K (230.12 mg), and P (554,01 mg) with the latest being the highest occurring nutrient. Similarly in the husk, phosphorus obtained at (171.01 mg) was also the highest detected nutrient and this was significantly (P≤0.05) higher than Na (78.29 mg); however both were significantly (P≤0.05) greater than Mg (0.26 mg) which was the least. Also, in the seed Mg was recorded at trace amount (0.13 mg), whereas Ca, P, K, (93.0 mg, 498.06 mg and 1.29 g respectively) were significantly (P≤0.05) different from one another with K being the highest occurring nutrient in this specimen.

Table 2: Elemental nutrients composition of dried above ground organs of cowpea per 100 g (dry weight)

Nutrients	**Aerial Organs of cowpea**			
	Leaf	**Stem**	**Husks**	**Seeds**
Zinc	121.84	1.66	2.00	0.17
Calcium	1,615.2	2.09	1.15	93.10
Sodium	2,216.1	111.28	78.29	0.13
Magnesium	1658.84	0.95	0.26	0.09
Iron	65.212	0.89	1.54	11.00
Potasssium	13,445.25	230.12	1.03	1,292.25
Phosphorus	554.01	326.50	171.85	498.06
LSD (0.05)	**249.00**	**62.11**	**36.33**	**105.42**

****values are in mg/ 100 g**

Results of the mean content of nutrients (proximate and elemental) of all the above ground organs of cowpea are shown in Fig 2. It shows that in terms of nutrient density, the leaf presenting a mean of 1522.22 was the most nutrient dense. It also reveals that the seed which gave a mean of 153.53 was next while the husk with a mean of 36.33 was the least in terms of nutrient density. In all the aerial organs of the crop, except for the crude fibre content (22.12 mg) which was highest in the husks, generally the proximate nutrients (protein, carbohydrate, fat, crude fibre and ash) were highest in the leaf specimen; followed by the seed (grain) sample, and least in the husk (Fig. 2). Also, compared to stem, husk and seed samples, the highest amounts of the elemental nutrients K, P, Ca, Na, Mg Fe and Zn was recorded from the leaf samples.

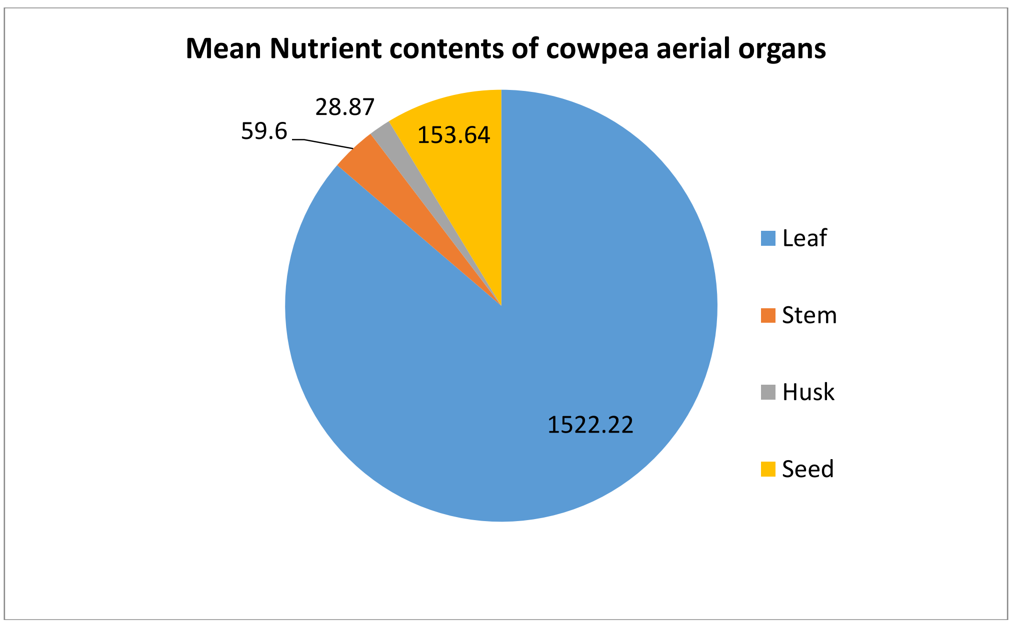

Figure 2: Mean nutrient contents of cowpea aerial organs

DISCUSSION

Cowpea a legume grown for centuries as companion and relay crop in many farming systems to improve soil fertility, reduce fallow periods and eliminate aluminum toxicity in the rhizosphere; is an important source of grains, leafy vegetables and haulms. Results of the biochemical and nutrient profiling of cowpea aerial organs in this study indicated the presence of a wide spectrum of nutrients including proteins, carbohydrates, ash, crude fibre and fat in the specimens. This conforms to the findings of several workers who also reported the presence of these compounds (nutrients) in the above ground organs of cowpea and several other legumes such as jack bean and pigeon pea (Afolabi *et al*., 2012; Chikwendu *et al.,* 2014; Igbatim *et al*., 2014; FAO, 2018). Findings in this study showed that the protein, carbohydrate and crude fibre contents of the leaf and husk specimens (Table 1) conform and compare well with the range of values (39.20 % and 13.96 %; 30.39 %

and 53.90 %; 14.26 % and 20.42 %) reported for these parameters by Chikwendu *et al*. (2014) in the leaf and husk samples of the crop respectively. In contrast however, findings in this study also indicate that the protein and carbohydrate contents in the husk samples (Table 1) where superior to 7.4 % and 43.10 %; 4.1 % and 33.70 %; as well as 6.2 % and 47.4 % reported for protein and carbohydrate in mung bean, jack bean and pigeon pea respectively. Similarly, husk crude fibre content recorded at 22.12 % in this study was inferior to 32.3 % in mung bean, 44.3 % jack bean and 35.30 % in pigeon pea.

Cowpea can make protein rich contribution to food for humans (FAO, 2018)). As leafy vegetable, cowpea is reported as a good substitute for amaranth, lettuce, potato and pumpkins in several countries of Afro-Asia (Nielsen *et al*., 1997). The dry ground pods (husks) of the crop is used to complement (or supplement} melon in making Egusi soup in some parts of Nigeria. In humans, literature suggests that several health benefits has been attributed to consumption of cowpea leaves including preventing cancer and hypertension and enhancing heart functions (Enyiukwu *et al*., 2018). Finding from this study where significantly high amounts of protein, carbohydrate, prebiotics (crude fibre), and fat were recorded in the leaf and husk specimens may explain why these organs have been used as condiments, thickeners and taste-enhancers in some continental soups and tuber-based recipes in Nigeria (Olayiwole *et al*., 2012; Igbatim *et al*., 2014; Chikwendu *et al.,* 2014).

In the seeds, our findings in terms of protein, carbohydrate and crude fibre contents (24.09 %), (57.02 %) and (3.94 %) strongly agree with 22.30 % protein, 57.4-58.10 % carbohydrate and 4.2-4.8 % crude fibre reported for mung bean and cowpea by FAO (2018). The grains were found in a study to significantly improve the nutritional values and sensory attributes of cocoyam-based recipes (Olayiwole *et al*., 2012; Chikwendu *et al*., 2014). Also, according to Oluwatofunmi *et al*. (2015) flours derived from grains of cowpea and bambara groundnut immensely boosted cereals for infant supplements. Trials on mice these authors noted showed that the supplement did not reduce their food acceptability, while liver and kidney function tests conducted on the animals indicated no impairments of any organs.

Nutrients play important roles in the productive performance of livestock and poultry (Addass *et al*., 2012; Balaeil, 2014). Besides elementals, carbohydrates, lipids and proteins are determinants of the nutritive value of forages. Variation in nutrient values amongst organs of cowpea has been reported, necessitating the combination of two or more feedstuffs in order to provide the required nutrients for proper performance of animals (Addass *et al*., 2012). Results of the Fe, Zn, Ca, and P profiling in this study (Table 2) sharply deviated from values of 7.50 mg, 1.66 mg, 1.40 mg and 135. 60 mg reported for the elementals in cowpea leaf by other scholars (Chikwendu *et al*., 2014). This may have been due to differences in the cowpea cultivars or sensitivities of the methods of nutrient profiling used in the study. Potassium is an essential elemental for conducting electrical impulses in the nerve tissues. It also plays important role in regulating the blood pressure in the circulatory systems whereas phosphorus is known to function in sexual virility. The high potassium (13.50 g) and phosphorus (0.55 g) contents have been suggested as reasons to encourage the adoption, utilization and consumption of cowpea leaves as vegetable (Enyiukwu *et al*., 2018). Iron recorded at 65.21 mg and 11.00 mg in the leaf and seed samples compared well with 17.8 mg and 1.8 mg reported in spinach (Axe, 2018). Besides, the high protein and carbohydrate contents of concentrates derived from the dried leaves of the crop, iron (Fe) could be another important reason for its adoption, and utilization in fighting malnutrition and ferrous deficiencies during periods of serious food insecurity outbreaks (www.leafforlife>VIGNAUNG). The ability of cowpea to play roles as soup ingredients, enhance tuber-based recipes and act as spinach-substitute was attributed to presence of large number of macro and micronutrients, fats, carbohydrates and protein in the crop (Olayiwole *et al*., 2012; Chikwendu *et al*., 2014).

Dry or fresh, variations in nutrient contents of various aerial organs of cowpea have been reported (Mamiro *et al*., 2011). Findings in this study where the seed protein content (24.09 %) is less than the 34.91 % recorded for the leaf are congruent with the reports of Mamiro *et al*. (2011) who showed that the cowpea leaf protein and amino acids contents outweigh that of the seed. Similarly, in this study with mean nutrient contents of 1522.22, 153.64, 59.60 and 28.89 for the leaf, seed, stem and husk respectively (Fig 2) our findings indicated that the leaf is the most nutrient dense organ of cowpea, followed by the seed, and stem with the husk being the least. This phenomenon is strongly concurrent with the report of Nielsen *et al*. (1997) that the leaf of the crop is more nutrient dense than the seed. It also agrees with the report of FAO (2018) where the proximate composition (especially protein and carbohydrate contents) of seeds of mung bean, pigeon pea and cowpea were greater than those of their respective husks. Most of the crop residues used for grazing during the dry season is low in nitrogen content; this usually results in poor feed intake and digestibility in animals (Addass *et al*., 2012). Cowpea can make valuable contribution of useful proteins for animal feed (Neil, 1992). On the basis of variation in nutrient contents of feedstuffs Addass *et al*. (2012) therefore concluded that supplementation of cereal crop residues with haulms of cowpea improved both feed intake and feed digestibility in test animals. Adequate knowledge of the nutrient values of different organs of feedstuffs especially legumes like cowpea will therefore contribute to increasing animal performance through proper feedstuff combination and aid to alleviating the problem of malnutrition, protein-iron deficiency and kwashiorkor in food insecure regions of the continent.

CONCLUSION

The nutrient profiling in this study showed that cowpea leaf is the most nutrient dense organ of the crop; especially in terms of protein, potassium, phosphorus, calcium, magnesium, zinc, iron and sodium contents followed by the seed and stem samples. Though the husk was the least in mean nutrient density, however, the highest level of crude fibre and carbohydrate contents were recorded in the husk specimen. Adequate knowledge of this variation could lead to better feedstuff combination or feed formulation to improve animal feed intake, performance and production on the one hand. On the other hand it could improve food value, organoleptic properties of tuber or cereal-based recipes, as well as food consumption and digestibility especially in children and the elderly. In these ways cowpea could contribute greatly in the long run to reducing protein-calorie or iron malnutrition in the developing countries of Afro-Asia through improved animal protein production on the one hand and leafy vegetable or grain consumption by humans on the other.

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