American Journal of

Food Technology

ISSN 1557-4571

Academic
Journals Inc.

www.academicjournals.com

American Journal of Food Technology 5 (1): 1-12, 2010
ISSN 1557-4571

Nutritional Evaluation of Wild Sicklepod (*Senna obtusifolia*) Seeds from Obanliku, South-Eastern Nigeria

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Abstract: The study evaluated the nutritive value of seeds of wild *Senna obtusifolia* plants as an alternative plant protein source in livestock diets. Proximate composition results showed high dry matter (92.50%), crude protein (29.54%) and crude fiber (10.18%), but low ether extract, nitrogen free extract, ash and calorific values. The vitamin content results showed poor vitamins B_2 , B_1, C and A but the seeds were rich in vitamin B_3 (1.85 mg/100 g) values compared to other seeds. The seeds were also abundant in calcium (960 mg/100 g), potassium (1,200 mg/100 g), phosphorus (810 mg/100 g), sodium (600 mg/100 g), magnesium (640 mg/100 g), iron (234.60 mg/100 g), zinc (53.12 mg/100 g) and copper (10.48 mg/100 g) but low in molybdenum, cobalt, chromium, selenium, sulphur and fluorine. The amino acid profile reveals a high concentration of leucine (7.60 g/100 g protein), histidine (2.11 g/100 g protein), proline (2.33 g/100 g protein) and glycine (4.11 g/100 g protein) while the rest of the amino acids were of low concentration in the raw seed. The concentration of anti-nutrients in the legume seeds recorded high values (260, 185, 388.50 and 83.25 mg/100 g) for alkaloid, saponin, tannin and oxalate respectively, while phytate, hydrocyanic acid and phytohaemaglutinin levels were low. The high level of most anti-nutrients indicates the potential for interfering with the utilization of the nutrients by the animals. This therefore, creates a need for detoxification of the seeds through processing before using in livestock feeds.

Key words: *Senna obtusifolia*, proximate composition, vitamin, mineral, amino acids, anti-nutrients

INTRODUCTION

Soaring food prices have triggered an increase in hunger worldwide, especially in Sub-Saharan African countries like Nigeria. The increase in prices of food has been attributed to several factors that include production shortfalls due to drought and floods; impact of climate change; increased demand for biofuel; emerging consumption habits of fast growing economies of some nations as well as trade policies to stabilize the food market crises

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(FAO, 2008). The hike has aggravated the already precariously low animal source food consumption of about 3-5 kg/capita/year in developing countries compared to the world average of 38 kg/capita/year and the USA's 124 kg/capita/year (Speedy, 2003). In addition, there is the projected 56% growth in the demand for meat by 2020, especially in developing countries (Delgado *et al.*, 1999). This shall likely heighten the demand against a weak supply. The animal protein component of this food demand is more crucial because it is the main determinant of food quality since meat, eggs and milk are an excellent source of high quality protein, containing large amount of minerals and essential B vitamins (Osasanya *et al.*, 2005; Speedy, 2003).

In order to increase the consumption of animal protein in developing countries, it is necessary to reduce the cost of meat, milk and eggs, thereby making them accessible and affordable to the majority of the people. However, feed constitutes 55-80% of the cost of production of livestock products (Carew *et al.*, 1998). Soybean is the main conventional plant protein source for livestock diets in Nigeria. Soybeans also serve as human food. The competition between human and livestock for the consumption of soybean and the increasing role of soybean in the world as a biodiesel feedstock (Cotula *et al.*, 2008) have increased its cost and demand and heightened the competition between human and beast for soybeans. Consequently, the search for a novel, high quality, cheap and readily available source of plant protein to replace soybeans is now a major concern of livestock nutritionists in much of the developing world even more than before (Obun and Ayanwale, 2006; Adeniji *et al.*, 2005). One of such legumes with great prospect as alternative and replacement for soybean is *Senna obtusifolia* (sickle pod).

Sickle pod is an annual plant considered a serious weed in many places. It is a competitive woody shrub that grows vigorously across the tropics. It grows to a height of about 1.5-2.5 m tall and 1 m wide. The seed pod is 10-15 cm long, 3-5 mm wide, slender and sickle shaped. The plant prefers well drained fertile soils and well suited for cleared coastal forest countries. The leaves, seeds and roots are used for folk medicine especially in Asia. The roasted seeds are used for tea, coffee or food additives. It is also used as a thickener and the seeds are used for commercial cassia gum (Queensland Government, 2006). The plant contains some anti-nutrients, therefore, it is thought of as poisonous to livestock (Ednilson *et al.*, 1998). Also, it is regarded as one of the indigenous leafy vegetable of the Sahel with the potential to provide food to the rural population in August and September when grain reserves from the previous year harvest have been exhausted. The domestication of this legume has begun (Paster *et al.*, 2007).

The proximate composition of leaves and seeds of this plant as reported by Faruq *et al.* (2002) gave promising results. However, there is dearth of detailed information on the nutritional profile of the seeds, in relation to livestock feeding, within the guinea savanna environment of Nigeria, where this plant is prevalent. This is very important since the nutritional and chemical value of a feedstuff is partly influenced by geographical location which is shaped by factors like soil and climatic conditions of the place (FAO, 2004). Therefore, to gather reliable information regarding the use of a feedstuff as livestock feed, the chemical and nutritional characteristics of that feedstuff need to be carefully assessed in order to prevent errors in predicting animal performance and environmental effects impairing the economics of animal products.

This study was, therefore, designed to evaluate the chemical and nutritional composition of seeds of wild *S. obtusifolia* plants growing in Obanliku, South Eastern Nigeria in order to generate data for the development of this plant as an alternative plant protein source in the developing countries of the tropics.

MATERIALS AND METHODS

Location of the Study Area and Collection of Seeds

The matured seeds of *S. obtusifolia* were harvested from wild plants growing in mountainous guinea savanna region of Obanliku Local Government Area, Cross River State in South-Eastern Nigeria. Obanliku Local Government Area is located between Latitude 6°15' and 6°30' North of the Equator and longitude 9°6' and 9°15' East of the Greenwich Meridian. The plants were previously identified by a plant taxonomist at the Botany Unit, Department of Biological Sciences of the University of Calabar, Nigeria. The study was carried out at the Department of Animal Science Laboratory of the University of Calabar, Nigeria from November, 2008 to March, 2009.

Preparation of the Seeds

The fresh seeds were picked and oven dried at 55°C in a paper envelope for about 24 h to a constant weight for the calculation of percentage dry matter (%DM) content (Abuye *et al*., 2003). The dry seeds were ground to powder using a laboratory blender and sieved using a 1 mm mesh sieve. Each analysis was done in triplicates and the mean of the three values was presented as the result.

Proximate Composition Determination

The sieved powder was used for the analysis of Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE) and ash while Nitrogen Free Extract (NFE) was calculated. This was done according to the methods of AOAC (1990).

Estimation of Energy

The calorific value of the seeds was estimated by multiplying CP, EE and NFE values by 16.7, 37.7 and 16.7, respectively (Siddhuraju *et al*., 1992).

Vitamin Analysis

Vitamin C was determined according to the method described by Adebooye (2008). Ascorbic acid was measured by titration with phenolindo-2, 6-dichlorophenol (DPIP). The powder (0.2 g) was mixed with 4 m L^{-1} of a buffer solution made up of 1 g L^{-1} oxalic acid and 4 g L^{-1} sodium acetate anhydrous. This was titrated against a solution containing 295 mg L^{-1} DPIP and 100 mg L^{-1} sodium bicarbonate. The results were expressed as mg/100 g DM. Vitamin A was determined using the method described by Zhang and Hamauzu (2004) where 15 g of powdered sample was homogenized with 10 mL acetone at -20°C. The homogenate was filtered with four layers of cheesecloth. The residue was treated with acetone (-20°C) for three successive extractions until the green colour could no longer be visually detected in the extract and residue. The filtrate was combined and centrifuged at 4000 rpm for 10 min. The supernatant was collected and filtered through a 0.45 μm Advantec filter pore for HPLC analysis. Samples were separated on a Luna 5 μ C18 column at 40°C by an HPLC. The mobile phase consisted of acetonitrile: water and ethyl acetate. The flow rate was 1.0 mL min^{-1}. samples were detected at 450 nm. The carotenoids were expressed as IU. Vitamin B1, B2, B3 and E were determined spectrophotometrically as stated by AOAC (1999).

Mineral Elements Analysis

The samples were incinerated at 450°C for 12 h in a muffle furnace and an acid digest was prepared by oxidizing each sub-sample with a nitric/perchloric acid (2:1) mixture.

Aliquots were used to estimate Na and K by flame photometer (Flame Photometer Model-EEL) as reported by Zia-Ul-Haq *et al*. (2007). All other minerals reported except phosphorus were determined using a Perkin-Elmer Model 5000 Atomic Absorption Spectro-photometer (AOAC, 1999). Phosphorus content in the triple acid digested extract was determined by the phosphovanado-molybdate (yellow) method according to the method of AOAC (1999).

Amino Acid Profile Determination

The amino acid profile of the sample was determined using methods described by Shahidi *et al*. (1999). The sample was dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino Acid Analyzer (TSM) using ion-exchange chromatography (Technicon Instruments Corporation, Dublin, Ireland). Details have been outlined by Adeyeye and Afolabi (2004).

Antinutritional Factors Determination

Phytates were determined according to the methods described by Muhammad *et al.* (1986) using chromatophore reagent. Tannins were analyzed using the modified Vanidlin-HCl method as described by Zia-ul-Haq *et al*. (2007). One gram of test sample was treated with methanol (28°C, 12 h) with occasional shaking. Decanted methanol was made up to 25 mL and filtered (Whatman No. 1). One milliliter of the extract was treated with 5 mL of the reagent mixture (1:1, 4% vanillin in methanol and 8% concentrated HCl in methanol). The colour developed was read at 500 nm after 20 min, using catechin as a standard, with a spectrophotometer. The tannin contents were then determined from standard curves. Saponins were extracted and estimated according to the methods of Shukla and Thakur (1986). Estimation of oxalates was by the procedures described by Tuleun and Patrick (2007). Hydrocyanic acid was determined according to the method of Rao and Hahn (1984). Phytohaemagylutinin activity was estimated as stated by Liener and Hill (1953).

RESULTS

The DM content of the wet seeds was 92.50% while the percentage CP, EE, CF, NFE and ash contents of *S. obtusifolia* were 29.54, 2.31, 10.18, 46.77 and 3.70% DM, respectively. The calorific value of *S. obtusifolia* was 325.28 kcal/100 g (Table 1).

Vitamins B_2 (riboflavin), B_1 (thiamine), B_3 (Niacin) and C (Ascorbic acid) values in mg/100 g of sample were 0.10, 0.60, 1.85 and 11.88, respectively, while vitamin A value in IU/100 g sample was 213.60. However, vitamin E (α-tocopherol) was not detected (Table 2).

Alkaloid, saponin, tannin, oxalate and phytate contents were 260, 185, 388.50, 83.25 and 240.50 mg/100 g DM respectively. Also, the hydrocyanic acid (HCN) and phytohaemaglutinin concentrations were 6.98 mg/kg/DM and 1026 Hu g^{-1}, respectively (Table 3).

Table 1: Proximate composition of raw *S. obtusifolia* seeds

Parameters	Concentration (% DM)*
Dry matter	92.50**
Crude protein	29.54
Ether extract	2.31
Crude fibre	10.18
Nitrogen free extract	46.77
Ash	3.70
Calorific value (kcal/100 g)	325.28

*Values are means of three replicates, **Value is percentage of wet weight

Table 2: Vitamin composition of raw *S. obtusifolia* seeds

Vitamins	Composition (mg/100 g)*
Riboflavin	0.10
Thiamine	0.60
Niacin	1.85
Ascorbic acid	11.88
Vitamin A (IU/100 g)	213.60
Tocopherol	ND

*Values are means of three replicates, ND: Not detected

Table 3: Anti-nutrient composition of raw *S. obtusifolia* seeds

Phytochemical	Concentration (mg/100 g)*
Alkaloid	260.00
Saponin	185.00
Tannin	388.50
Oxalate	83.25
Phytate	240.50
Hydrocyanic acid (mg/kg DM)	6.98
Phytohaemaglutinin (Hu/g)	1026.00

*Values are means of three replicates

Table 4: Mineral composition of raw *S. obtusifolia* seeds

Mineral elements	Concentration (mg/100 g)*
Calcium	960.00
Potassium	1,200.00
Phosphorus	810.00
Sodium	600.00
Magnesium	640.00
Iron	234.60
Zinc	53.12
Copper	10.48
Molybdenum	0.04
Cobalt	0.38
Chromium	0.26
Selenium	0.03
Sulphur	0.03
Fluorine	1.34
Iodine	ND

*Values are means of three replicates, ND: Not detected

The results show that calcium (Ca), potassium (K), phosphorus (P), sodium (Na), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu), molybdenum (Mo), cobalt (Co), chromium (Cr), selenium (Se), sulphur (S) and fluorine (F) contents were 960, 1200, 810, 600, 640, 234.60, 53.12, 10.48, 0.04, 0.38, 0.26, 0.03, 0.03 and 1.34 mg/100 g, respectively (Table 4). Iodine (I) was below the detectable limit. Potassium was the most abundant mineral element while the least value was recorded for S and Se.

The concentration of essential amino acids (EAA) was 4.50, 4.02, 4.39, 7.60, 3.01, 2.21, 1.02, 0.92 and 3.54 mg/100 g protein for phenylalanine (Phe), lysine (Lys), valine (Val), leucine (Leu), isoleucine (Ile), threonine (Thr), methionine (Met), cystine (Cys) and tyrosine (Tyr), respectively (Table 5). The total essential amino acid (TEAA) content was 31.21. This was 45.5% of the total amino acid concentration in 100 g of the protein. The semi-essential amino acid content shows that histidine and arginine were 2.11 and 4.67 g/100 g protein, respectively while the total semi-essential amino acid content was 6.78. This value was 9.88% of the total. The non essential amino acid (NEAA) content of *S. obtusifolia* shows that Asp, Ser, Glu, Pro, Gly and Ala contents were 8.30, 3.00, 9.16, 2.33, 4.11 and 3.71 g/100 g protein. The total non-essential amino acids (TNEAA) content was 37.39. This was 54.50% of the total amino acid concentration in a 100 g of protein. Among all the amino acids detected, glutamic acid was predominant while cystine was the least abundant.

Table 5: Amino acid composition of raw *S. obtusifolia* seeds

Amino acid	Concentration (g/100 protein)*
Phenylalanine	4.50
Lysine	4.02
Valine	4.39
Leucine	7.60
Isoleucine	3.01
Threonine	2.21
Methionine	1.02
Cystine	0.92
Tyrosine	3.54
Total essential amino acids	31.21
Total essential amino acids (%)	45.50
Histidine	2.11
Arginine	4.67
Total semi essential amino acids	6.78
Total semi essential amino acids (%)	9.88
Aspartic acid	8.30
Serine	3.00
Glutamic acid	9.16
Proline	2.33
Glycine	4.11
Alanine	3.71
Total non-essential amino acids	30.61
Total non-essential amino acids (%)	44.62

*Values are means of three replicates

DISCUSSION

The DM value was high. The high dry matter content was similar to values obtained for most raw seeds of legumes like *Milletia obanensis*, *Lablab purpuresus*, *Phaseolus aureus* and *Vigna sinensis* (Umoren *et al*., 2005; Osman, 2007; Mubarak, 2005; Khattab *et al*., 2009). This will reduce the cost of handling and ensure long term storage. The CP content was high. This was higher than the range 15.52-20.74% DM reported for its close relative, *Cassia hirsuta* (Vadivel and Janardhanan, 2000) and another Nigerian legume, *Afzelia africana* (Obun and Ayanwale, 2008) but comparable to the value for raw African locust bean (*Parkia filicoidea*) and *Mucuna utilis* (Bawa *et al*., 2007; Tuleun and Patrick, 2007). Differences observed with its close relative could be due to the variety. The high CP value will enhance its replacement value for soybeans. The EE value was low compared to values reported for *C. hirsuta* (3.77-7.04%), *M. utilis*, *P. filicoidea*, *M. obanensis* and other African bean seeds (Vadivel and Janardhanan, 2000; Bawa *et al*., 2007; Tuleun and Patrick, 2007; Umoren *et al*., 2005; Ajah and Madubuike, 1997) and could be attributed to genetic differences as they affect the composition of seeds. Low EE value of foods contributes to poor energy content of such material compared to soybean that is an oil bean seed. The calorific value was lower than 566-580, 426-430, 390-415 and 560-580 kcal/100 g reported for *A. africana, Brachystegia eurycoma, Canavalia ensiformis* and *Pentaclethra macrophylla* (Ajah and Madubuike, 1997) and that reported for maize (Aduku, 1993). This could be due to the low EE and NFE values which are the major contributors to the energy value of foods. The low energy value will create a need for the supplementation with high energy sources like palm oil.

The riboflavin and thiamine contents of *S. obtusifolia* were low compared to 4.24 and 2.75 mg/100 g of *Amaranthus hybridus* (Akubugwo *et al*., 2007). This is in line with literature which reports that grains are poor sources of these vitamins but green leafy vegetables, yeast and milk are rich (McDonald *et al*., 1995). Riboflavin forms the prosthetic part of many enzymes and its deficiency in diets causes marked swelling and softening of sciatic and brachial nerves in chicks (Banerjee, 2004). The niacin content was high compared to *A. hybridus* leaves. The high niacin content agrees with reports by Vasudevan and Sreekumari (2007) that legumes (pulses) and oil seeds are rich sources of niacin. Also, these authors further stated that niacin supplementation helps to prevent a livestock skin disease called pellagra. Vitamin C content of *S. obtusifolia* was low. This was lower than 25.40 mg/100 g reported for *A. hybridus* (Akubugwo *et al*., 2007). This agrees with Vasudevan and Sreekumari (2007) and Banerjee (2004) who reported that vitamin C is generally poor in seeds but rich in citrus, guava and leafy vegetables. The poor level of vitamin C in diets causes scurvy in animals. The content of vitamin A in *S. obtusifolia* seeds was low. This was lower than 710 IU/100 g in soybeans but higher than 158 IU/100 g (Vasudevan and Sreekumari, 2007) reported for mung beans (*Phaseolus aureus*). This agrees with reports by Banerjee (2004) that apart from animal sources, vitamin A source in plants is mainly in fruit and green leafy vegetables while legumes are poor sources. The low level of vitamin A in diets has implication for poor vision, growth and reproductive ability. In an *S. obtusifolia* rich diet therefore, supplementation should be done with fish oils and green leafy vegetables (Banerjee, 2004).

The alkaloid content was high. Though lower than 2000 mg/100 g in lupin seed meal, it is still above the upper limit of 60 mg/100 g recommended for a safe feed (McDonald *et al*., 1995). This therefore makes it potentially toxic to livestock especially young ruminants and monogastric fed raw *S. obtusifolia* seeds in diet. There is need therefore for processing of this pulse.

The saponin value was higher than the recommended value for a safe feed (McDonald *et al*., 1995). The high value of saponin must have contributed to the high content of the alkaloid saponin is an alkaloid. High values of saponin and other alkaloids in diets rich in this seed will expose the animals to the risk of haemolysis of some blood tissues and injury to the digestive mucosa especially in pigs. Also, high bitter taste and low palatability will be common (McDonald *et al*., 1995).

The tannin content was high. This was higher than values obtained for *M. obanensis* (0.44 mg/100 g) Umoren *et al*. (2005) but comparable to 330 mg/100 g reported for mung beans (Mubarak, 2005). Tannins are known to cause growth depressing effects on non-ruminants. Processing of the seeds before feeding is therefore necessary.

The oxalate value was high compared to 37.5 mg/100 g in *M obanensis* (Umoren *et al*., 2005) though lower than 195 mg/100 g reported for *M. utilis* seed meal (Tuleun and Patrick, 2007). High oxalate content in *S. obtusifolia* seeds has the potential to cause metabolic calcium deficiency by inhibiting its absorption from the intestine (McDonald *et al*., 1995).

The phytate level was low compared to 605.39 mg/100 g reported for raw sweet Lablab bean variety (Osman, 2007) and 888.33 mg/100 g recorded for *Hibiscus sabdariffa* (karkade or rosselle) seeds (Yagoub *et al*., 2008). However, this was higher than 6.00-14.31 mg/100 g reported for different varieties of Lablab beans (Abeke *et al*., 2008); 3.98 mg/100 g reported for *M. obanensis* (Umoren *et al*., 2005) and 5.0 mg/100 g of raw mung bean seeds (Mubarak, 2005). The high phytate level could render the phosphorus value of the beans unavailable to man and livestock inhibit certain digestive enzymes as well as lowering the availability of other mineral elements like Ca and Mg (McDonald *et al*., 1995; Siddhuraju *et al*., 1995; Umoren *et al*., 2005).

The hydrocyanic or hydrogen cyanide (HCN) content was low. This was lower than 2.60 mg/100 g (i.e., 26 mg/kg DM) and 1.79-3.47 mg/100 g (i.e., 17.9-34.7 mg kg^{-1} DM) reported for *M. obanensis* (Umoren *et al*., 2005) and *L. purpureus* bean (Abeke *et al*., 2008), respectively.

The concentration of phytohaemaglutinin for *S. obtusifolia* was low. This was lower than 2670 Hu g^{-1} reported in raw mung bean seeds (Mubarak, 2005), therefore necessitating no processing to reduce the concentration of these ANFs to an acceptable level.

The high level of some anti-nutritional factors in *S. obtusifolia* limits its utilization as livestock feed and human food. However, different heat treatments and other processing methods have been found to render these anti-nutrients inactive, improving its value as a feed and food source.

The Ca value was high. This was high compared to 139, 47.4, 582.00 and 84 mg/100 g reported for raw *Lathyrus maritimus* (beach pea), *M. obanensis* (odudu) Nigeria Cowpea (*Vigna* spp.) and mung bean (*P. aureus*) seeds, respectively (Shahidi *et al*., 1999; Umoren *et al*., 2005; Chinma *et al*., 2008; Mubarak, 2005). Calcium is necessary for teeth and bone formation, blood clothing, the working of muscles, regulation of heartbeat and maintenance of acid base equilibrium in the body of animals and legumes are abundant in it (Banerjee, 2004).

The K level was very high compared to 451, 45.3 and 3.62 mg/100 g recorded for beach pea, odudu and mung bean seeds (Shahidi *et al*., 1999; Umoren *et al*., 2005; Mubarak, 2005). This high value of K is not surprising as members of the bean family are rich in K (Vasudevan and Sreekumari, 2007). Potassium is necessary for nerve transmission; maintenance of osmotic pressure and acid base equilibrium; activation of certain enzymes; uptake of certain amino acids as well as carbohydrates; and protein metabolism (Banerjee, 2004).

Phosphorus in the form of phosphate ion is needed for formation of bone and teeth, production of high energy compounds e.g ATP, DNA and RNA formation and activation of enzymes. The P content of *S. obtusifolia* was in this case high compared to the values reported for most tropical legume seeds (Umoren *et al*., 2005; Mubarak, 2005; Shahidi *et al*., 1999; Chinma *et al*., 2008; Elleuch *et al*., 2007).

The Na content of *S. obtusifolia* seeds was above the levels reported for beach pea (Shahidi *et al*., 1999) and sesame (*Sesame indicum*) seeds (Elleuch *et al*., 2007). Feeding livestock feed that is rich in *S. obtusifolia* has the potential to maintain body fluid pH, support nerve transmission and muscular contraction in livestock (McDonald *et al*., 1995).

The Mg content was high compared to 128-145, 92.3, 183 and 55.6 mg/100 g reported for Nigerian cowpea, *M. obanensis* and mung beans (Chinma *et al*., 2008; Umoren *et al*., 2005; Mubarak, 2005; Shahidi *et al*., 1999). This implies that feeding livestock on feed abundant in *S. obtusifolia* seed meal has the potential to lower the irritability of neuromuscular system and activate enzymes like phosphatases which require ATP (Banerjee, 2004).

Iron content was high compared to 11.5 and 8.4 mg/100 g for soybean and mung beans (Vasudevan and Sreekumari, 2007). This indicates the possibility of this legume if fed to livestock, to improve transport of oxygen to the tissues as well as enzymes of electron transport chain and therefore, useful in feeding pigs to prevent Fe deficiency anaemia (McDonald *et al*., 1995). The high level of Fe agrees with literature that legumes and seed coats are rich in iron (Vasudevan and Sreekumari, 2007; McDonald *et al*., 1995).

The Zn content compared to 3.1 mg/100 g reported for raw beach pea seeds was high. This agrees with literature (Vasudevan and Sreekumari, 2007). Zinc is an antioxidant and aids in Cu absorption in some disease conditions. Many enzymes are dependent on Zn for proper functioning.

The concentration of Cu in the seed is higher than that reported for some Nigerian cowpea varieties and beach pea (Chinma *et al*., 2008; Shahidi *et al*., 1999) but similar to the value reported for roselle seed (Yagoub *et al*., 2008). Since, this seed is high in Cu, its inclusion in livestock diets could protect the heart by increasing high density lipoprotein

(HDL). It is also a co-factor for vitamin C, necessary for tyrosinase activity and Fe absorption and incorporation into haemoglobin. In cases where the minerals were higher or lower than values reported for other legumes, soil type and genetics could be implicated (McDonald *et al*., 1995).

The Mo, Co, Cr, Se, S and F values were all low compared to reviewed values. Except S, considering the trace requirement for these minerals in livestock diets, their low level may not be of serious consequence especially when they are rich in soils where the *S. obtusifolia* plants are grown.

The Phe, Val, Lys, Ile, Met, Cys, Thr and Tyr contents were low but within the range of most legumes compared to the values reported for Karkade seeds, kidney beans, cowpea and many other legumes (Yagoub *et al*., 2008; Khattab *et al*., 2009; FAO/WHO 1973, 1990; Siddhuraju *et al*., 1995; Mubarak, 2005; Yanez-Ruiz *et al*., 2009). The essential amino acids in this situation need to be supplemented in livestock diets for optimum performance to be ensured when feeding monogastrics with *S. obtusifolia* seed meal rich diets. The Leu content was high. This was higher than 7.0 g/100 g reported for the Food and Agriculture Organization/World Health Organization (1973) reference protein. The concentration was also comparable to values obtained for most legumes reviewed (Shahidi *et al*., 1999; Yagoub *et al*., 2008; Khattab *et al*., 2009; Siddhuraju *et al*., 1995). Supplementation with Leu rich sources is therefore not necessary in a diet rich in this seed meal.

This TEAAS was lower than the Food and Agriculture Organization/World Health Organization (1973) reference protein value of 36. This suggests supplementation with other sources especially for monogastric animals for the animals to realize their full potential.

Compared to the Food and Agriculture Organization/World Health Organization (1973) reference protein, the His content was high. This value was similar to that obtained for Egyptian pea, Canadian pea, Egyptian kidney bean, Canadian kidney bean, roselle bean and mung bean (Mubarak, 2005; Khattab *et al*., 2009; Yagoub *et al*., 2008). Histidine, a semi essential amino acid, is necessary in food for growing animals. It is also needed for the formation of histamine (Vasudevan and Sreekumari, 2007).

The Arg, Asp, Ser, Glu, Pro, Gly, Ala values were low compared to values reported for most legumes. However, they were within the range common to legume seeds (Dubey *et al*., 2008; Mubarak, 2005; Siddhuraju *et al*., 1995; Khattab *et al*., 2009; Yagoub *et al*., 2008). The highest and lowest values observed for glutamic acid and cystine respectively agrees with results of many workers (Siddhuraju *et al*., 1995; Khattab *et al*., 2009; Mubarak, 2005).

CONCLUSION

The study investigated the nutritional value of *S. obtusifolia* seeds of plants growing in Obanliku, SE Nigeria, as potential plant protein source in livestock diets. It reveals that *S. obtusifolia* seeds are rich in crude protein, crude fibre, some minerals (Ca, K, P, Na, Mg, Fe, Zn and Cu), amino acids (leucine, histidine, proline and glycine) but also high in some anti-nutrients (alkaloid, saponin, tannin and oxalate). We conclude that *S. obtusifolia* seeds have the ability to partially replace soybean as a protein source in livestock diets. However, the processing of these seeds before feeding to livestock will help undermine the anti-nutritional effects of the phytochemicals that are abundant in the raw seed meal.

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