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Evaluation of the Nutritional Potentials of Three Species of *Canavalia* for Use in Livestock Diets

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ABSTRACT: This paper evaluates the nutritional potentials of three varieties of Canavalia for use in livestock diets. The three species of *canavalia* seeds notably *canavalia gladiata* (sword bean), *canavalia ensiformis* (jack bean) and *canavalia rosea* (bay bean) were obtained from Ahmadu Bello University (ABU) Zaria, Kaduna State. The experiment was conducted at Imo State Polytechnic, Umuagwo, Ohaji, Owerri, Imo State, Nigeria. The samples of the three species collected were then air-dried under the sun for 4-6 days to achieve 80-85% dry matter. Thereafter, the *Canavalia* seeds were crushed in a hammer mill to produce their respective meals which was collected in black nylon bags for proximate, mineral and phytochemical analyses. The results of this study revealed that the chemical composition, protein, amino acid and mineral profile of the three *Canavalia* species are potential cheap sources of unconventional feed resources of animals. *Canavalia* species are rich in digestible protein, Fe, Ca, P and Mg, thus, nutritious food for mono and polygastric animals. Moreover, phytochemical analysis and review of anti-nutritional factors in the three species revealed that through good processing methods like boiling, roasting, toasting, fermentation and autoclaving at controlled temperature of (100-121°c) appears to eliminate these toxic compounds from the seeds/grains while fermentation for 3-5 days renders the toxic substances non-toxic. Optimal values of protein, carbohydrates and minerals are indicatives that these species of Canavalia are potential feed ingredients and hence could be used as feed supplements for livestock.

Keywords: Evaluation, Nutritional potentials, C*anavalia* species, Phytochemical assay, livestock diet

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INTRODUCTION

Population in the globe is increasing in geometric progression and in the year 2050, the World population is predicted to increase to 8.9 billion (MacGlone, 2013; FAO/WFP, 2015). The implication is that the global demand for food will increase and the fate of sub-Saharan Africa of which Nigeria is a classical example will hitherto become bleak as extreme hunger and poverty would revolve in vicious cycle. To reduce protein deficit gap among Nigerians, there is need to access the nutritional qualities of some unorthodox feed raw materials as this would permeate clampdown in the cost of unconventional feed stuffs and promotes profitability.

Canavalia species notably, sword bean (*canavalia gladiata*) otherwise called "magic bean", *canavalia ensiformis* (jackbean) and *canavalia rosea* (bay bean) can be used to cushion the high cost of proteinaceous feed ingredients in the livestock industry (Feedipedia, 2017). It is pink coloured bean that originated from Asia and Africa. It is a leguminous, annual crop grown as a green manure, or cover crop and used as a fodder for livestock (Kerala, 2018).The young pods of

sword bean is eaten as a vegetable in tropical Asia and mature seeds are a good source of protein but should never be eaten raw as they contain toxic amino acids, *canavaline* and *concanavalin* which are anti-metabolite of arginine (Ekanayako *et al.,* (2003).

The fruits of *canavalia* species have been reported as potential sources of nutritional, nutraceutical and pharmaceutical benefits for humans and livestock. Sword bean, jack bean and bay bean also contain thiamin, hemogglutin, fat, sugar, starch, urease, calcium, phosphorus, iron, carotene, Vitamin C and gibberellin A-15, a growth promoting hormone (Grubben and Denton, 2004).

The leaf meal has been shown to be a good source of pigment in egg yolks in laying birds. It exhibits high antioxidant and phenolic properties. It is very interesting to note that the anti-nutritional factors in this plant can be detoxified by soaking/fermentation, heating or roasting, boiling etc.

The seeds, skins and the roots of sword bean plant can be used as medicine for improving circulation, reducing inflammation and killing pain (Yun-Lai Chan *et al.,* 2000). The sword bean contains urea enzyme, blood cell agglutinin, *canavanine*, starch, protein, fat etc. The green bean of sword bean contains *canavalia* glibberellin I and II (Yun-Lai Chan *et al.,* 2000).

Lectin which is a plant protein is found in sword beans, Lectins can bind with carbohydrates and causes blood cells to clump together, hence can suppress tumor cells. The sword bean is rich in Con A that is a type of lectin and has special effect on Cancer prevention.

Therefore, studying the nutritional exigencies of *canavalia specie* would be a step in the right direction to boost food security in Africa.

MATERIALS AND METHODS

Sample collection and preparation

The three species of *canavalia* seeds notably *canavalia gladiata* (sword bean), *canavalia ensiformis* (jack bean) and *canavalia rosea* (bay bean) was obtained from Ahmadu Bello University (ABU) Zaria, kaduna State for use in the experiment. Collected samples of the three species were then air-dried under the sun for 4-6 days to achieve 80-85% dry matter. Thereafter, the *canavalia s*eeds were crushed in a hammer mill to produce their respective meals which was collected in black nylon bags for proximate, mineral and phytochemical analysis.

Chemical characterization of products

The *canavalia* species were analyzed for moisture content, ash, fat and crude fibre (CF) in triplicate as described by AOAC (2019) following which the percentage nitrogen was converted to crude protein (CP) by multiplying by 6.25.

The minerals were analyzed after dry-ashing at 55^0C in a muffle furnace and dissolved in deionized water to standard volume. Potassium was determined by flame photometer while phosphorous was determined by phosphovanadomolybdate method of AOAC (2000). Other mineral constituents (Mg, Ca, and Fe) were determined after a wet digestion with a mixture of trioxonitrate (v) acid (HNO_3), tetraoxosulphate (vi) acid (H_2SO_4) and hydrochloric acid using Atomic Absorption Spectrophotometer (Vogel, 1962).

Phytochemical test

Phytochemical test was carried out at the Federal University of Technology, Owerri, Nigeria. The percentage proportions of the respective toxicants, notably; tannins, flavonoids, alkaloids, saponins, cyanogensetc were evaluated using elaborate laboratory procedures.

Statistical Analysis:

The data generated from Proximate, mineral and phytochemical analysis were subjected to analysis of variance using the Genstat procedure of Analysis to determine any significant difference.

RESULTS AND DISCUSSION

The data on proximate nutrient composition of three (3) varieties of *canavalia* species is presented in Table 1. The result indicated that there is wide variation in the trend of the species of *canavalia.Canavalia gladiata* contained the highest protein level of 29.17% followed by *canavalia rosea* which recorded 25.60%. The least protein content was recorded by *canavalia ensiformis* which recorded 24.94%. The protein, in most legumes, is about 17–30% (Reddy *et al*., 1984) and is considered to be of high quality. The protein content in sword beans ranges from 21 to 28% (Bressani *et al*., 1987; Mohan and Janardhanan, 1994) on a dry weight basis, which is higher than in an average legume. Compared to cereal flours like whole wheat flour, rye flour and also egg where the crude protein content is 8.55%, 2% and 12.6%, respectively, the crude protein content of sword beans is high (Statens, 1988) which makes them a good supplement to cereal diets. Of the three *Canavalia* species, *C. gladiate* and *C. rosea are* observed to have higher amount of protein than *C. ensiformis*). The values reported for protein content of jack beans by two workers are 25.04% [Onuegbu *et al.,* 1993) and 27.5% (*Souza et al*., 1991) and 27.1% (Abbey, 1987) for *C.rosea* DC (brown beans), which are comparable to those of sword beans. Marginally, legumes contained appreciable levels of nutritionally valuable proteins (Larbi *et al*., 2005).

Generally, the protein of sword beans contains high lysine level (6.49%) (Bressani *et al*., 1987, Rajaram and Janardhanan, 1992) in contrast to cereal proteins which are deficient in this amino acid. Lysine content in jack beans is also high (5.90%) with 84% availability (*Souza et al*., 1991). Marginal significant difference (P<0.05) existed between the three varieties of canavalia on their energy values. *Canavalia ensiformis* promoted the highest energy value of 57.59% followed by rosea, 56.50% and *canavalia gladiata* in that order.

The dry legume carbohydrate percentage can vary from 24 to 68% in different varieties. The carbohydrates include monosaccharides, oligosaccharides, starch and other polysaccharides. Starch is the most abundant legume carbohydrate with the sugars representing only a small percentage of the total carbohydrate of the dried seeds (Kerala, 2018). Seeds of c*anavalia gladiata* contain 7.5% soluble sugars and 37.2% starch, on a fresh weight basis (Spoladore and Teixeria, 1987) compared to *C. ensiformis*, which has a starch content of 39.44% (*Souza et al*., 1991). However, the result obtained from this study on carbohydrates levels disagrees with the values of Spoladore and Teixeria, (1987) and Souza *et al.,* (1991) who stated a value range of 37.20 and 39.44%.

Canavalia rosea contains the highest ether extract content of 4.89% which is statistically (P>0.05) similar to *C. gladiata*, 4.68% and significantly different (P<0.05) from *C. ensiformis* which yielded 3.58% respectively. The highest ash content was obtained in *C. rosea* (5.58%) followed by *C. ensiformis* (5.27%) and *C. gladiata* (4.39%) in that order. The ash content on a dry weight basis using the AOAC (2000) method ranged from 3.9% to 4.15% (Mohan and Janardhanan, 1994) which is indicative of a high mineral content. The mineral values obtained from this study align with the stipulated values. The crude fibre fraction of the canavalia species was highest in *C. ensiformis* (2.65%) marginally different (P<0.05) from *C. rosea* which had 2.30%. There was no significant difference (P>0.05) in the percentage of moisture content between *C. gladiata* (6.02%) and *C. ensiformis* (5.97%) but however, the lowest moisture content was observed in *C. rosea* (5.12%) which is statistically different (P<0.05) from *C.gladiata*. The highest calcium content was obtained in *C rosea* (0.427%) followed by *C. ensiformis* (0.320%) and *C. gladiata* (0.222) which statistically (P<0.05) are different from each other (Table 2). Calcium is required in the body to build and fix bones and teeth and it also assists in the clotting of blood. Bressani *et al*., (1987) reported the presence of high levels of potassium (0.36 g/100 g) as in most legumes (Oshodi *et al*., 1993). Daloz, (1988) reported that at the green pod and shelled vegetable stages, the seeds contain more vitamin A, vitamin C, calcium and iron.

Table 1: Proximate nutrient composition of three species of *canavalia*.

Species	Moisture content%	Crude protein%	Ether extract%	Crude fibre%	Ash%	Carbohydrate (NFE)%
Canavaliagladiata	6.02[a]	29.17[a]	4.68[a]	2.50[a]	4.39[b]	53.24[a]
Canavaliaensiformis	5.97[a]	24.94[b]	3.58[b]	2.65[a]	5.27[a]	57.59[b]
Canavaliarosea	5.12[b]	25.60[c]	4.89[a]	2.30[b]	5.59[a]	56.50[c]
SEM	0.51	2.28	0.70	0.18	0.62	2.26

[abc]mean within rows with different superscripts are significantly different (P<0.05).; SEM = Standard Error Mean

Table 2: Mineral constituents (mg/100g) of three varieties of *canavalia* spps.

Species	Fe(mg/kg)	Mg (%)	Ca (%)	P (%)	K (%)
Canavalia gladiata	300[a]	0.130[a]	0.222[a]	7.841[a]	0.068
Canavaliaensiformis	320[b]	0.192[b]	0.320[b]	8.114[b]	0.071
Canavalia rosea	350[c]	0.117[c]	0.427[c]	7.165[a]	0.086
SEM	25.17	0.04	0.10	0.49	0.01

[abc]means within rows with different superscripts are significantly different (P<0.05).; SEM = Standard Error Mean

Mohan and Janardhanan, 1994) reported *C. gladiata* seeds to be a rich source of sodium, potassium and calcium when compared to other commonly eaten pulses such as *Vigna unguiculata* and soyabean.

The highest iron (fe) value was observed in *C. rosea* (350mg/kg) which statistically differed (P<0.05) from C. ensiformis (320mg/kg) while the least fe value was obtained in *C. gladiata* (300mg/kg). Iron is an essential element for blood production carrying red blood cells. *C. ensiformis* contained highest content of Mg followed by *C.gladiata* and *C.rosea* in that order. The present study indicates that all the three species particularly C. *ensiformis* and *C. gladiata*, produced nutritious pods and highly proteinaceous seeds. The disease and drought-resistant nature of these legumes suggest that they might be capable of providing food in marginal areas in the tropics where other pulses fail (Rodrigues and Torne, 1991).

Table 3 shows the phytochemical constituents of three species of *canavalia* for use in livestock diets. The result of phytochemical analysis revealed no significant difference amidst the values of flavonoids, alkaloids, phenols, steroids, oxalate, terpenoids and cyanide, thus implying that the three species of *canavalia* are statistically similar in these anti-nutritional parameters.

The highest saponins concentration was obtained in C. *ensiformis* with the percentage of 5.05% followed by C. *gladiata* that recorded 4.98% and *C. rosea* that pulled 4.95% respectively. C. *ensiformis* with saponins content of 5.05% and *C. rosea* (4.95%) are statistically (C>0.05) the same while significant difference (P<0.05) existed between C. *ensiformis* and C. *gladiate.*

Charavanapvan (2000) reported that the presence of toxic saponins in *canavalia* species can cause nausea and vomition and hence could be eliminated by soaking in water prior to cooking. C. *rosea* contained the highest value in Cardiac glycosides percentage by pulling 9.04% followed by *C. ensiformis* (8.44%) and C. *gladiata* 7.87%. .However, this levels according to Seifert (1996) are tolerable levels for monogastric animals.

Canavalia ensiformis contained the highest value of (12.10%) tannins followed by *C. gladiata* that had 11.77% and *C rosea* with 11.01% respectively. *C. gladiata* and C. *rosea* are statistically similar (P>0.05) in tannins contents.

According to Mohan and Janardhanan, (1994), the total free phenols and tannins in seed flour are 7.1 g/kg and 0.6 g/kg on dry matter basis, respectively. Tannins are known to inhibit the activities of digestive enzymes and through soaking, roasting, fermentation and autoclaving, the concentration of phenols and tannins in *canavalia* species could be reduced to tolerable level.

Table 3: Phytochemical constituents of three varieties of *Canavalia* spps.

Species	Flavonoid %	Alkaloid %	Saponins %	Phenols %	Cardiac glycosides %	Steroid %	Tanins %	Oxalate %	Terpeniod %	Phytate %	Cyanide %
Canavaliagladiata	023.	0.00034	4.98[a]	0.01	7.87[a]	0.25	11.77[a]	3.38	0.08	2.40[a]	0.64
Canavaliaensiformis	0.23	0.00033	5.05[b]	0.01	8.44[b]	0.25	12.10[b]	3.38	0.08	2.41[a]	0.70
Canavaliarosea	0.25	0.00038	4.95[b]	0.011	9.04[c]	0.26	11.01[a]	3.40	0.09	2.48[b]	0.68
SEM	0.01	0.0000	0.05	0.03	0.58	0.01	0.56	0.01	0.01	0.04	0.03

[abc]*mean within rows with different superscripts are significantly different (P<0.05).; SEM = Standard Error Mean*

Phytate has been known to decrease the utilization of several mineral elements such as magnesium, calcium, and phosphorus by forming soluble compounds extracted from faeces(Udeybir *et al*, 2008).C. *rosea* had the highest concentration of phytate (2.48%) followed by C. *ensiformis* that had the concentration of 2.41% while the least was observed in *gladiata* with the level of 2.40% which was statistically different from *C. rosea* .At moderate concentration (30-40 g/kg), condensed tannins may result in nutritional advantages in respect of increased bypass protein availability and bloat suppression in cattle (D`mello, 2000).

Research has shown that processing of leguminous seed crops like *canavalia* species proves very effective for the removal of anti-nutritive substances and its biochemical activity renders phenolic phytochemicals to tolerable level of intake will stabilize animal physiology (Ravindran 1991; FAO 2004).The concentrations of phytochemicals in *canavalia* species may not be an impediment to the use of these seeds in animal nutrition. This is because soyabean seeds which is a conventional feed raw material contains a toxic substance known as trypsin inhibitor which through toasting/roasting could be used to eliminate the toxic compound.

CONCLUSION

The result of this study revealed that the three *canavalia* species are potential cheap sources of unconventional feed resources of animals. The proteins in the three varieties (C. *gladiata*, *C. ensiformis* and *C. rosea*) contain high lysine level in contrast to cereal proteins which are deficient in these amino acids. Good processing methods can ensure the elimination of toxic compounds from the seeds/grains and hence guarantees the safety of the products.

In Nigeria, based on its nutritional exigencies, the legume is underutilized. *Canavalia* species could be used to substitute soyabeans, cowpeas, groundnut cake and other oil seed cakes which are becoming very exorbitant in the livestock industry.

REFERENCES

Abbey, B.W, Ibeh GO (1987). Functional properties of raw and heat processed brown bean (*Canavalia rosea* DC) flour. *Journal Food Sci*. 52: 406–408.

AOAC (2000). Official methods of Analytical Chemists. 17th ed. Association of Analytical Chemists, Washington, D.C.

AOAC. (2019). Official methods of analysis, 21st Edition. Association of Official Analytical Chemist, Washington, D.C. 2019;40-57.

Bressani, R., Gomez, B.R., Garcia, A.and Eliaz, L.G. (1987). Chemical composition, amino acid content and protein quality of *Canavalia* seeds. *Journal Sci Food Agric* 40: 17–23.

Charavanapvan C (2000). The utilization of Jack and sword bean as food. *Trop Agric Mag Ceylon Agric Soc* 99: 157–159.

**D`mello, J.P.F. (2000).** Anti nutritional factors and mycotoxins. In: J. P. F. D` Mello (ed.); *Farm animal metabolism and nutrition*. CABI Publishing, Wallingford. Pp: 383 – 403.

Daloz, C.R. (1988). Productivity of vegetable legumes in the special territory of Aceh, Indonesia. Dessertation Abstracts International B. Cornell University, Ithaca, New York 14850, USA, 317 pp.

Ekanayake, S. Nair, M.B., Asp, N.C and Jansz E.R, (2003). Effect of processing on the protein in nutritional value of canavalia gladiata Seed. *Nah rung/Foods* 47, 256-260

FAO, (2004). Assessing quality and safety of Animal feeds. Animal Production and Health, Food and Agriculture Organization of the United Nations, Rome.https://aps.who.int/iris/handle/10665/42849.

Food and Agriculture Organization (FAO), International fund for Agricultural Development, World Food Programme (2015). "The state of food insecurity in the

World 2015". Strengthening the enabling environment.

Feedipedia, (2017). Animal feed Resources Information System-INRA CIRAD AFZ and FAO © 2012-2017 Food and Agriculture Organization, International Fund for Agricultural Development.www.feedipedia.org

Grubben, G.J.H and Denton, O.A (eds) (2014). Plant resources of Tropical Africa 2. *Nordic Journal of Botany,* 23(3).

Kerala, K. (2018). Minor vegetables. Kirsankerala Operations centre, IIITM-K, NLLA Techno park Campus, ThiruVananthapuram. Vol. 4, (23): 20-24

Larbi, A., Anyanwu, N. J., Oji, U. I., Etela, I., Gbaraneh I. O. and Ladipo, D. O. (2005). Fodder yield and nutritive value of browse species in West Africa humid tropics: response to age of coppice re-growth. *Agro-forestry .System*, 65: 197 – 205.

MacGlone, J.J. (2013). The Future of pork production in the world. *The Professional Animal Scientist.* Volume 29, (3):189-198

Mohan, V.R.andJanardhanan, K. (1994). The biochemical and nutrient assessment of less known pulses of the genus *Canavalia.International Journal of Food Science Nutrition*. 45: 255–262.

Onuegbu BA, Zibokere DS, Chinah M, Ukata D (1993). Unconventional food sources: effects of *Canavalia ensiformis* seeds on growth and development of domestic rats and effects of fungal infection on nutritional composition of the seeds. *Journal Dairy Foods Home Science*. 12: 62–66.

Oshodi, A.A., Olaofe, O. and Hall, G.M. (1993). Amino acid, fatty acid and mineral composition of pigeon pea (*Cajanus cajan*). *International Journal Food Science Nutrition*. 43: 187–191.

Pearson, O. (1976). Chemical analysis of Foods 6thedn. Churchil, London.

Ravindran, V., (1991). Preparation of cassava products and their uses as animal feed. In: Roots, tubers, plantains and bananas in animal feeding. *FAO, Animal production and Health paper,* No 95: 111 – 122.

Rodrigues BF, Tome SG (1991). A chemical study of seeds in three *Canavalia* species. *Tropical Science Journal* 31: 101–103.

Seifert, H. S. H. (1996). *Tropical animal health.* Klurwer academic publishers. Dordrechi, Boston, London. Vol.10 (5): 10-16

Souza, P.A de., Souza HBA de, Durigan JF, Santos JE dos (1991). Physicochemical and nutritional evaluation of jack beans (*Canavalia ensiformis*). Alimentos Nutricao 3: 63–73.

Statens Livsmedelsverk (1988). Energioch Naringsamnen. Livsmedelstabeller. Stockholm, Sweden.

Udedibie, A.B.I., Esonu, B.O. and Okah, U. (2002). Determination of the optimum dietary levels of cracked and cooked jackbean meal for finisher broilers. *Nigerian Journal of Animal Production.* 29 (1-2): 176-180.

Vogel, A.T (1962). Quantitative inorganic analysis, Longmans, London.

Yun-Lai Chan., Chien Chien., Tzong-Hann Lin and Fung-You Lu (2000). Method of producing fermented Sword beans. U.S 6129919A. http://www.google.com/ patients/ us6129919#