



Effect of Different Processing Methods on Chemical Composition of *Bauhinia monandra* Seed Meal

*¹Abegunde, T.O., ²Adegbeye, M.J., ³Ogunbosoye, D.O., ¹Bamidele, D.O., ¹Oluwasegun, O.T., and ¹Falola A.T.

¹Dept of Animal Sciences, Obafemi Awolowo University, Ile-Ife, Osun State

²Dept of Agricultural Science, Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State

³Department of Animal Production, Fisheries and Aquaculture, Kwara State University, Malete, Kwara State.

*Corresponding author email: tayeabegunde2@yahoo.com

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Abstract

The effect of processing methods on the chemical composition of *Bauhinia monandra* seed meal as a feed ingredient in the diets of ruminants was assessed in this study. Seeds of *Bauhinia monandra* were subjected to processing methods [Raw (T1), autoclave for 20 mins (T2), autoclave for 30 mins (T3), one stage cooking (T4), two-stage cooking (T5) and roasting (T6)]. The seeds were assessed for their chemical composition, antinutrients and mineral contents. T4 (one-stage cooking) had the highest crude protein levels of 31.3 %. T2 and T4 had the lowest fibre levels of 4.71 % and 4.67 % respectively. Antinutritional factors were significantly ($P < 0.01$) affected by processing methods with a reduction in the antinutrient concentration. Autoclaving for 30 min had the highest reduction effect on alkaloid, tannin, saponin, glycoside and stachyose. Manganese was significantly ($P < 0.01$) the highest and similar in the seed meals subjected to one-stage and two-stage cooking. Values of Mn in the unprocessed seed meals were significantly ($P < 0.01$) lowest. The values of Fe (ppm) in seed meals ranged from 1.9010 in T1 – 6.8275 (T3). Autoclaving for 30 minutes significantly ($P < 0.01$) increased the Fe contents of seed meals. Values for Cu and Zn were significantly highest ($P < 0.01$) in T3. Zinc value was lowest in the unprocessed *B. monandra* seed meals. Calcium values ranged from 52.97 mg/l in T4 to 74.45 mg/l in T2. Magnesium levels were significantly highest in T6 and lowest ($P < 0.01$) in T3. Seeds cooked twice gave the highest ($P < 0.01$) value for Phosphorus. It is concluded that two-stage cooking of seeds appears to improve their chemical composition, however anti-nutritive contents of seeds were better reduced by autoclaving for 30 minutes. *Bauhinia monandra* seedmeal may serve as one of the ingredients for compounding livestock diets in the Nigerian feed mill industry based on the results on its chemical composition from this study.

Introduction

The high competition between man, his livestock and industries for traditional protein and energy sources has imposed scarcity with consequent astronomical costs (Yashim *et al.*, 2009). Hence, animal protein content in the diet of low-income earners that constitute the majority of the Nigerian populace is very low. This situation has compelled animal nutritionists to explore alternative protein and energy feed ingredients that are locally available, relatively cheaper and can meet the nutrient requirement of animals (Tamburawa, 2010, Ferouz *et al.*, 2012). There are

many legumes whose seeds could be used to fill this gap. One of such legumes is the orchid plant (*Bauhinia monandra* Kurz.) which belongs to the family *Caesalpinaceae*. *Bauhinia monandra* is an ornamental tree commonly found in West Africa and India. It is also known as Cow's foot, Orchid tree, St. Thomas tree, Napoleon's plume, Flamboyant, Mariposa and pink butterfly (Onyije *et al.*, 2012). In Nigeria *B. monandra* is fairly widely distributed throughout the natural grassland of northern Nigeria, stretching throughout the savanna (Abegunde and Odedire, 2015). *Bauhinia monandra* has the potential to serve as protein source in feeds considering its

proximate composition and high mineral contents (Agbede *et al.*, 2007). The major constraints to the use of legumes as animal feed especially in its raw form, is the presence of toxic and anti-nutritional constituents (Agbugui, 2011). These constituents when present in high quantities have different effects on the animal's performance which include loss of appetite, reduction in dry matter intake and effect on protein digestibility (Anwa *et al.*, 2007). The proximate composition of seeds of some wild plants of Nigerian origin shows that they could be adequately used in the formulation of animal feed provided their level of toxic substances is reduced or eliminated (Eromosele and Eromosele, 1993). It has been established that boiling, roasting, soaking in water, autoclaving, extrusion fermentation, alcohol extraction, acid extraction and other processing methods exert beneficial effects by removing the antinutritional factors inherent in them (Francis *et al.*, 2002). Agbede *et al.* (2007) reported that the leaf meal of *Bauhinia tomentosa*, as well as the seed flours, contained appreciable quantities of nutritionally needed mineral elements which appeared more concentrated in the raw whole seed than in the processed seed flours and also concluded that the processing techniques adopted significantly reduced and, in some cases, totally inactivated the anti-nutrient factors quantified in the seed flours. *B. tomentosa* and *B. monandra* belong to the same family, hence likely to have a similar chemical composition and respond similarly to different processing methods.

Studies have shown that apart from using *Bauhinia monandra* as horticultural plants, they have potential as protein supplements in the diets of livestock. However, the paucity of information on the effects of processing on their nutritive value necessitated this study.

Materials and Methods

Study sites

The study was conducted at the poultry meat Laboratory of the Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife and the Physiology Lab, University of Ibadan, Ibadan.

Materials

Bauhinia monandra seeds were harvested from different trees within the Obafemi Awolowo

University campus. The seed was identified and authenticated at the Herbarium unit of the Department of Botany, Obafemi Awolowo University (OAU), Ile Ife. All equipment and chemicals used were available at the Poultry Meat Laboratory, Department of Animal Sciences, OAU, Ile-Ife and Physiology Laboratory, University of Ibadan, Ibadan.

Methods

The matured seeds of *B. monandra* were removed from their pods by breaking the hard pods. The de-podded seeds were divided into 6 parts of 2kg each and were subjected to the following processing methods in triplicates: i. Unprocessed Raw ii. autoclave for 20 mins iii. autoclave for 30 mins iv. one stage cooking v. two stage cooking and vi. roasting. Briefly, the processing steps are as described:

Unprocessed raw: The first part was untreated and considered as whole raw seeds. The seeds were pulverized to fine particle using the laboratory mill (SPI Supplies, PA, USA) and then stored in an airtight container at 4 -6°C until they were used.

Autoclaving: The second part was further divided into 2 portions. The 2 portions were autoclaved at 121 °C in distilled water for different time intervals of 20 and 30 minutes, respectively. After treatment, the seeds were rinsed with distilled water and dried at 70 °C for 2 hours in a hot air oven.

One stage cooking: The fourth part was cooked with tap water at 100°C in an aluminium pot for 30 minutes. The cooked seeds were decanted and air-dried.

Two stage cooking: The fifth part was first cooked at boiling point (100°C) for 30 minutes. The cooked seeds were decanted with distilled water and was further cooked the second time at 100°C, decanted and air-dried.

Roasting: The sixth part was roasted at 120°C for 45 minutes.

Determination of Anti-Nutrient Composition

Anti-nutrient composition of the differently processed seed meals was determined at the Physiology Laboratory, University of Ibadan,

Ibadan. Total alkaloid content and individual alkaloids composition were extracted by gas chromatography. The extraction and analyses were conducted following the procedure presented by Kamel *et al.* (2016). Saponin content of the seed was determined following the procedure outlined by Ruiz *et al.* (1995). Tannin determination was by using the vanillin-hydrochloric acid (V-HCL) procedure of Burns (1971). Stachyose was determined according to procedures described by Valliyodan *et al.* (2015). Glycoside content was determined using alkaline and acid titration method according to the procedure outlined by AOAC (2000).

Determination of Proximate Composition

Proximate analysis of the differently processed seed meals was determined using the methods outlined by AOAC (2005).

Mineral analysis:

The following mineral elements: Calcium (Ca), Iron (Fe), Potassium (K) and Zinc (Zn) were determined as recommended by Funtua (2004), using Energy Dispersive X-Ray Fluorescence (EDXRF) transmission Spectrophotometer. after wet digestion with nitric/perchloric/sulphuric acid mixture (9:2:1 v/v/v). Phosphorus (P), Sodium (Na) and Magnesium (Mg) were analyzed following the methods described (AOAC, 1990). Phosphorus was determined colorimetrically with a Jemway 6100 spectrophotometer. Sodium was analyzed with a corning 400-flame photometer, while magnesium was analyzed complexometrically (AOAC, 1990).

Statistical analysis

All data collected were subjected to a one-way analysis of variance (ANOVA) using the procedure of SAS (1999). Treatment means, where significant, were separated using Duncan multiple range test.

Results

The proximate composition of the raw and processed seeds of *Bauhinia monandra* is presented in Table 1. Treatment T4 (one stage cooking) and T5 (two stage cooking) had no significant effect on the dry matter (DM) content of processed seeds, however, T4 had the highest crude protein levels of 31.3 %. Seeds Autoclaved for 20 minutes (T2) and one stage cooking (T4) had the lowest fibre levels of 4.71 and 4.67% respectively. Ether extract values were similar in T4 and T5 and were significantly highest in these treatments than in others.

Table 2 shows the anti-nutrient composition of differently processed *Bauhinia monandra* seed meals. Processing of seedmeals significantly reduced the level of antinutrients. Autoclaving for 30 minutes had the highest reduction effect on alkaloid (25 %), tannin (50.99 %), saponin (26.66 %), glycoside (29.23 %) and stachyose (62.30 %).

Table 3 shows the macro mineral composition of differently processed *Bauhinia monandra* seed meals. Calcium values ranged from 52.97 mg/l in T4 to 74.45 mg/l in T2. Magnesium levels was significantly highest in T6 and lowest (P<0.01) in T3. Seeds cooked twice gave the highest value for Phosphorus.

Table 1: Proximate composition of differently processed *Bauhinia monandra* seed meals

Parameters (%)	T1	T2	T3	T4	T5	T6	SEM	P Value
Dry matter	85.46 ^c	85.30 ^c	85.07 ^c	88.83 ^a	88.75 ^a	87.76 ^b	0.15	<.0001
Ash	1.56 ^b	2.97 ^a	1.96 ^b	2.13 ^b	1.74 ^b	2.95 ^a	0.13	0.0013
Crude Fibre	7.30 ^a	4.71 ^c	7.09 ^{ab}	4.67 ^c	5.95 ^{abc}	5.39 ^{bc}	0.98	0.0026
Crude Protein	24.06 ^{bc}	22.97 ^c	21.88 ^c	31.28 ^a	26.69 ^b	23.63 ^c	2.19	<.0001
Ether Extract	7.43 ^d	8.99 ^b	6.35 ^e	10.00 ^a	9.83 ^a	8.20 ^c	0.06	<.0001
NFE	45.12 ^a	45.66 ^a	47.79 ^a	40.75 ^b	44.54 ^a	47.58 ^a	3.82	0.0094

abc: means across rows with different superscripts are significantly ($P < 0.01$) different.

Note: T1 = Raw; T2 = Autoclave 20 minutes; T3 = Autoclave 30 minutes; T4 = One stage cooking; T5 = Two stage cooking; T6 = Roasted; NFE = Nitrogen free extract

Micro mineral composition of differently processed *Bauhinia monandra* seed meals is presented in Table 4. Manganese was significantly highest in the seed meals subjected to two-stage cooking. Values of Mn in the unprocessed seed meals were significantly ($P < 0.01$) lowest. The values of Fe in seed meals ranged from 1.9010 ppm (Unprocessed seed meals) – 6.8275 ppm (Autoclaved 30-minute seed meals) Autoclaving for 30 minutes significantly ($P < 0.01$) increased the Fe contents of seed meals. Copper (Cu) and Zinc (Zn) values of differently processed seed meals were highest ($P < 0.01$) in T3 Autoclaved 30-minute seed meals. Zinc value was lowest in the unprocessed *B. monandra* seed meals.

Discussion

Dry matter (DM) contents of the seeds were high and significantly affected by the processing methods. The DM ranged from 85.07 % – 88.83 %. The observed values for DM in this study were higher than values of 8.26 % – 8.53 % reported by Alagbaoso *et al.* 2015 for processed seeds of *Canavalia plagioperma* Piper. Moisture content of any food is an index of its water activity and is used as a measure of stability and susceptibility to microbial contamination (Aruah *et al.*, 2012).

Protein content of *B. monandra* were generally high, but lower than those reported (31.5-36.0%) for processed *B. cheilantha* seeds by Teixeira *et al.* (2013). These values were however similar to that reported by Rajaran and Janardhanan (1991) for seeds of the same genus.

Table 2: Anti-nutrient composition of differently processed *Bauhinia monandra* seed meals

Parameters	T1	T2	T3	T4	T5	T6	Prob	SEM
% Alkaloids	0.16 ^a	0.15 ^b	0.12 ^f	0.15 ^e	0.13 ^c	0.14 ^d	0.14	<0.0001
Ppm Tannin	75.50 ^a	65.50 ^b	37.00 ^f	59.00 ^e	42.00 ^c	47.50 ^d	0.01	<0.0001
% Saponin	0.15 ^a	0.14 ^b	0.11 ^f	0.14 ^e	0.12 ^c	0.13 ^d	0.13	<0.0001
g/kg Glycoside	1.30 ^a	1.23 ^b	0.92 ^f	1.18 ^e	1.04 ^c	1.09 ^d	0.11	<0.0001
g/kg Stachyose	0.61 ^a	0.55 ^b	0.23 ^f	0.49 ^e	0.31 ^c	0.38 ^d	0.04	<0.0001

a,b,c,d, f: means across rows with different superscripts indicate significant difference at $P < 0.01$.

Note: T1 = Raw; T2= autoclave 20 min, T3= autoclave 30 min, T4= One stage cooking, T5= Two stage cooking, T6 = Roasted

Table 3: Macromineral composition of differently processed *Bauhinia monandra* seedmeals.

Parameters (ppm)	T1	T2	T3	T4	T5	T6	Prob	SEM
Mn	0.2765 ^f	0.3600 ^b	0.3115 ^d	0.3085 ^e	0.3805 ^a	0.3405 ^c	<0.0001	0.0008
Fe	1.9010 ^f	2.1255 ^d	6.8275 ^a	2.2485 ^c	2.0880 ^e	3.7660 ^b	<0.0001	0.0013
Cu	0.2230 ^d	0.1695 ^e	0.2940 ^a	0.2240 ^d	0.2470 ^b	0.2295 ^c	<0.0001	0.0005
Zn	0.8000 ^f	0.9485 ^b	1.1745 ^a	0.8050 ^e	0.9025 ^d	0.9100 ^c	<0.0001	0.0015

a,b,c,d, f: means across rows with different superscripts indicate significant difference at $P < 0.01$

Note: T1 = Raw; T2= autoclave 20 min, T3= autoclave 30 min, T4= One stage cooking, T5= Two stage cooking, T6 = Roasted

Cowpea was also reported to have CP values 19.5 % - 26.1 % (Maia *et al.*, 2000). The reduction in protein value (CP) as observed in processed seeds compared to the raw seeds (T1) must have been due to the effect of heat applied during processing and solubilisation of the protein during cooking (Emenike *et al.*, 2016). One stage cooking had higher crude protein level compared to two-stage cooking. The reduction observed may have resulted from further boiling for 30 mins in T5 (two stage cooking) which led to the leaching of soluble proteins into cooking water. There was significant ($P < 0.01$) reduction in fibre levels as a result of the processing methods the seeds were subjected to. This must have been due to the effect of heat on the fibre fraction which helped to break down the links in the fibre structures. The crude fibre levels observed in this study were lower than the values (43.2 - 45.3%) reported for *Bauhinia cheilantha* elsewhere (Teixeira *et al.*, 2013). The values were also lower than those reported for other leguminous seeds widely consumed such as soybean (17.4%) and black beans (22.6%) (Trugo *et al.*, 2000). Ether extract values (6.35 % – 10.00 %) observed in this study were similar to values (8.6 % – 8.7 %) reported for raw and processed *B. cheilantha* seed meals (Teixeira *et al.*, 2013). The significant improvement in the ether extract content of cooked *B. monandra* seeds does not agree with other reports (Agbugui *et al.*, 2010 and Ndidi *et al.*, 2014) for boiled bauhinia seeds and for boiled and roasted *Sphenostylis stenocarpa* seeds respectively. Similarly, Tamburawa (2010) reported a decline in lipids with increasing duration of toasting Parkia seed and a general increase with increased duration of soaking. The reason for the increase observed in the ethanolic extract, values for cooked *B. monandra* seed meals in this study is unknown.

Generally, antinutrients are toxic and may negatively affect the nutritive value of legumes through impairment of protein digestibility and availability of minerals by impairing protein. Their heat labile nature helps to ensure that the antinutrients are deactivated by processing methods involving heat generation (Ndidi *et al.*, 2014). Autoclaving seeds for 30 minutes showed significant reduction in the level of all

antinutrients investigated compared to the raw seeds. Highest reduction levels observed in stachyose (62.30 %) and tannin (50.99 %) corroborates the finding of Vijayakumari *et al.*, 1996 who observed about 71% tannin reduction in *Mucuna pruriens* seeds autoclaved for 45 minutes. Autoclaving the seed for 30 minutes had the highest (29 %) reduction of the concentration of glycosides compared to other treatment methods. This reduction may be due to the faster and more effective breakage of the glycosidic linkages because of the combination of high pressure and heat. This suggests that autoclaving aided the release of glycosidic cyanide from the seed. Saponins in seeds are reportedly susceptible to dissolution during soaking and are highly sensitive to various heat treatment like boiling (Agbugui *et al.*, 2010). The highest reduction in saponin (26 %) occurred when the seed was treated with autoclaving for 30 minutes compared to other heat treatment and lesser period of heat application. This suggest that to reduce the antinutritional factor in *Bauhinia monandra* seed, mode of heat treatment with or without pressure and the timing the heat was applied is important. The removal of these antinutrients would enhance the digestion of macronutrients and also enhance protein digestion. The destruction and inactivation of these antinutrients will enhance digestibility of *Bauhinia monandra*. It will also increase the energy value for metabolism (Faris and Singh, 1990).

Macro and micro minerals play important role in the productivity of livestock. In this study, heat treatment increased the macro and micro mineral level of processed *Bauhinia monandra* seed compared to the raw seed except for Na which reduced. This suggests that as heat treatment was decreasing the level of plant secondary metabolites, the mineral content of the seed was increasing. Overall, 20 minutes of autoclaving and roasting helped to improve the macro and micromineral availability.

Conclusions

This study has shown that the use of *Bauhinia monandra* as feed supplement in ruminant feeding holds some potential. Two stage cooking of seeds appears to improve their chemical composition,

however anti-nutritive contents of seeds were better reduced through autoclaving for 30 minutes.

References

- Abbey, B.W and Berezi, P.E. (1988). Influence of processing on digestibility of African yam bean (*Stenostylis stenocarpa* (Hoerchst Ex. A. Rich. Harms) flour. *Nutr. Reports Intl*, 37: 819 - 827.
- Abegunde, T. O. and Odedire, J. A. (2015). Nutritional assessment of leaves and seeds of some horticultural trees and shrubs as feed for ruminants in Southwest Nigeria. *Trop. Anim. Prod. Invest.* <http://animalsci.agric.ui.edu.ng/TAPI/index.php/tapijournal/index>. University of Ibadan, 18 (1): 12-17.
- Agbede, O. J. (2007). Chemical analysis of leaf meal and processed grain flours of an aesthetic plant: *Bauhinia tomentosa*. *J. Food Agric. Environ.* 5: 233–235.
- Agbugui, M., Oniye, S.J., Auta, J. (2010). Effects of Processing on The Mineral Content, Proximate Composition and Phytochemical Factors of the Seeds of *Bauhinia Monandra* (KURZ). *Bayero J. Pure Appl. Sci.* 2010 3(1): 23 - 25
- Alagbaoso, C.A., Tokunbo, I. I. and Osakwe, O. S. (2015). Comparative Study of Antioxidant Activity and Mineral Composition of Methanol Extract of Seeds of Ripe and Unripe Avocado Pear (*Persea americana* Mill.). *NISEB Journal* 15(4): 123-127.
- Anwar, F., Latif, S., Ashraf, M., Gilani, A. H. (2007). *Moringa oleifera*: a food plant with multiple medicinal uses. *Phytother. Res.* 21, 17-25.
- AOAC (1990). Official Methods of Analysis. (Helrich, K. Ed.) 15th Edition, Vol. 1. Association of Official Analytical Chemists (AOAC), Arlington, VA.
- AOAC (2000) Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16.
- AOAC. (2005). *Official Methods of Analysis of the Association of Analytical Chemists.* (18th ed.). Gaithersburg, MD, United States of America, USA.
- Aruah, B.C., Uguru, M. I. and Oyiga, B. C. (2012). Genetic variability and inter-relationship among some Nigerian pumpkin accessions (*Cucurbita* spp). *Int. J. Plant Breed.*, 6: 34-41.
- Burns, R. E. (1971). Method for estimation of tannin in grain sorghum. *Agronomy J.* 63: 511-512.
- Emenike, H.I., Udedibie, A.B.I., Emenalom, O.O. (2016) Effects of differently processed Jack bean (*Canavalia ensiformis*) meals on the performance of grower pigs. *British J. Appl Sci Technol* 13: 1-8.
- Eromosele, I. C. and Eromosele, C. O. (1993) Studies on the chemical composition and physicochemical properties of seeds of some wild plants. *Plant Foods Hum Nutr.* 43(3): 251-8.
- Faris, D. C and Singh, U. (1990). Pigeon pea nutrition and Products. In: Y. I. Nene *et al.* (eds). *The pigeon pea*. Petan Cheru, A.P. 502 324, India, CRISAT pp 467.
- Ferouz, Y.A., Kurt, A.R. and Kasiuviswanathan, M. (2012). Alternative Protein Sources for Aquaculture feeds. *J. Aquaculture Feed Sci Nutr.* 4(1):1-26.
- Francis, G., Kerem, Z., Makkar, H. P., and Becker, K. (2002). The biological action of saponins in animal systems: A review. *Brit. J. of Nutrition*, 88(6), 587–605.
- Funtua, I. J., (2004). Minerals in foods: Dietary sources, chemical forms, interactions, bioavailability. *Instrumentation Sci. Technol.*, 32: 529-536.
- Kamel, K. A., Święcicki, W., Kaczmarek, Z. and Barzyk, P. (2016) Quantitative and qualitative content of alkaloids in seeds of a narrow-leaved lupin (*Lupinus angustifolius* L.) collection. *Genet Resour Crop Evol* 63:711–719.
- Maia, F. M. M., Oliveira, J.T.A., Matos, M.R.T., Moreira, R.A., Vasconcelos, I.M. (2000) Proximate composition, amino acid content and haemagglutinating and trypsin-inhibiting activities of some Brazilian *Vigna*

- unguiculata* (L) Walp cultivars. *J. the Sci of Food and Agric.* 80(4):453–458.
- Markus, V., Abdulsalami, M. S., Mustapha, M. and Abdulganiyu, A. (2014). Effect Of Processing On *Thevetia Peruviana* Glycoside. *The Bioscientist* 2 (1): 30-36.
- Rajaran, N. and Janardhanan, K. (1991). Chemical composition and nutritional potential of the tribal pulses *Bauhinia purpurea*, *B. racemosa* and *B. vahlii*. *J. the Sci. of Food and Agric.*, 55: 423–431.
- Ramadan, E. A. (2012). Effect of Processing and Cooking Methods on the Chemical Composition, Sugars and Phytic Acid of Soybeans. *Food and Public Hlth*, 2 (1): 11-15.
- Ruiz, R. G., Price, K. R., Rose, M. E., Rhodes, M. J. C. and Fenwick, G. R (1995). Determination of Saponins in Lupin Seed (*Lupinus Angustifolius*) Using High-Performance Liquid Chromatography: Comparison with a Gas Chromatographic Method. *J. Liqd Chromgrphy*, 18:14, 2843-2853,
- SAS (1999) Statistical Analysis System, Statistical Methods. SAS Institute Inc., Cary, NC.
- Tamburawa, M.S. (2010). Effect of Locustbean Seed Meal Diets on the Performance and Carcass Charactersitics of Broiler Chickens A Ph.D Research Proposal, Presented at the Postgraduate Seminar Series of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University (A.B.U.) Zaria. 15pp.
- Teixeira, D. C., Farias D. F., Urano-Carvalho, A. F., Arantes, M. R., Oliveira, J.T., Sousa, D. O., Pereira, M. L., Oliveira, H. D., Andrade-Neto, M., and Vasconcelos, I. M. (2013) Chemical composition, nutritive value, and toxicological evaluation of *Bauhinia cheilantha* Seeds: A legume from semiarid regions widely used in folk medicine. *BioMed Research International*, 2013: 578781. doi:10.1155/2013/578781
- Trugo, L., Donangelo, N., Trugo, M. and Bach, M. (2000). Effect of heat treatment on nutritional quality of germinated legume seeds. *Journal of Agricultural and Food Chemistry*, 48: 2082-2086.
- Valliyodan, B, Shi, H. and Nguyen, H. T. (2015). A simple analytical method for high-throughput screening of major sugars from soybean by normal-phase HPLC with evaporative light scattering detection. *Chromatography Research International*, 2015:757649,
- Vijayakumari, K, Siddhuraju P, Janardhanan K. (1996). Effect of different post-harvest treatments on antinutritional factors in seeds of the tribal pulse, *Mucuna pruriens* (L.) DC. *Int J Food Sci Nutr.* 1996 May; 47(3):263-72.
- Yashim, S.M., Segun, A.J., Abdu, S.B., Duru, S. and Adamu, H.Y. (2009). Effect of Duration of Soaking of Rattlebox seeds (*Crotalaria retusa* L.) on the level of some chemical composition and minerals In: *Proceedings Nig. Soc. for Anim Productn* 34th Annual Conference 236-238.