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PROXIMATE AND MINERAL COMPOSITION OF *Pentadiplandra brazzeana* STEM BARK

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ABSTRACT

Plants are the cheapest and indispensable constituents of human diets supplying the body nutrients (carbohydrates, protein, fats, amino acids, vitamins) necessary for growth and body development. Therefore, this work was designed to examine the proximate and mineral composition of Pentadiplandra brazzeana stem bark (PBSB). Proximate composition of PBSB revealed the presence of 8.75 % moisture, 91.25 % dry matter, 6.43 % crude protein, 41.03 % crude fibre, 5.70 % ether extract, 12.11 % ash, 17.82 (g/100 g) carbohydrates, 0.47 % total reducing sugar and 632.2 Kj/100g energy respectively. Results on mineral analysis shows that PSSB is abundant in calcium (73.84 mg/100g) followed by phosphorus (41.55 mg/100g), magnesium (32.56 mg/100g), sodium (28.11 mg/100g), zinc (17.56 mg/100g), manganese (10.88 mg/100g), potassium (9.47 mg/100g) and copper (2.33 mg/100g). In order of mineral abundance in PBSB Ca > phosphorus > magnesium > sodium > zinc > manganese > potassium > copper. It was concluded that PBSB is low in protein, energy and some minerals (copper and potassium).

Key words: *Minerals, proximate analysis, Pentadiplandra brazzeana stem bark, nutrients.*

1. Introduction

Pentadiplandra brazzeana is an evergreen shrub or liana that is the only species assigned to the genus *Pentadiplandra*, and has been placed in a family of its own called Pentadiplandraceae. It produces large red berries, sometimes mottled with grey. It is known from West-Central Tropical Africa, between northern Angola, eastern Nigeria, western Democratic Republic of Congo, China and India. The berry is sweet in taste due to the protein, brazzein, which is substantially sweeter than Sacchrose (Kant, 2005; Eyog *et al*., 2006). It is a monoecious shrub of maximally 5 m (16 ft), but can also develop into a liana, climbing up to 20 m (66 ft) high in the trees (Bayer and Appel, 2003). The shrub morph usually has a mass of branched bulging roots, while the liana morph has a large, fleshy tuber. The branches are without hair and carry alternately set, simple and entire leaves, without stipules at the base of the ½–1 cm (0.2–0.4 in) long leaf stalk (Walters and Hellekant, 2006).

Traditionally, the roots are antibacterial, aphrodisiac, cathartic, emmenagogue, laxative, purgative. They are widely used by women to assist in the birth process and also to deal with problems related to the uro-genital system (Assadi *et al*., 2005). A root decoction can stimulate uterine contractions and has been used to induce abortion and should be avoided by pregnant women until the later stages of the pregnancy (Guevara *et al*., 2016; Jin *et al*., 2003). Root decoction of *Pentadiplandra brazzeana* is usually administered orally, or applied as an enema, to facilitate the expulsion of the placenta, and is also said to prevent haemorrhages after parturition (Latham, 2004; Kamtchouing *et al*., 2002).

Phytochemical screening of the roots and leaves have led to the isolation of urea derivatives including sulphur-containing compounds such as methyl N-benzylthiocarbamate, methyl and ethyl N-methoxybenzylthiocarbamate and glucosinolates such as benzyl- and 4-methoxybenzyl glucosinolates (Ngamga, 2005; Tsopmo *et al*., 1999). Carbamates obtained from the roots have shown antibacterial properties in vitro against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, and against the yeast *Candida albicans* (Tancredi *et al*., 2004).The root is also rich in glucosinolates and is believed to contribute to the revitalizing of collagen and to restore skin tonicity (El Migirab *et al*., 1977).Crude extracts of tubers have revealed moderately strong antiplasmodial activity in vitro, but were not as effective as chloroquine (Assadi *et al*., 2005).
In view of these abundant potential, this experiment was designed to examine the proximate and mineral composition of *Pentadiplandra brazzeana* stem bark.

2. Materials and methods

Site of the experiment
The experiment was carried out at Division of Animal Nutrition, Sumitra Research Institute, Gujarat, India during the month of January to Febuarary, 2019.

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Plant collection, identification and processing

The fresh stem bark of *Pentadiplandra brazzeana* was obtained from different plants within Sumitra Teaching and Research Farm, Gujarat, India. The sample was authenticated by a crop taxonomist (Dr. Singh Kumar). The harvested stem bark was washed with running tap water to remove dirt's, shade dried for 15 days to maintain the bioactive chemicals and nutrients in the sample, grounded into fine powder using mortar and pestle, sieved and stored in an air tight well labeled container (PBSP) for further analysis. The analyses were done in triplicates according with the official methods of the association of official analytical chemist (AOAC, 2000).

Measurements

Proximate analysis

Crude fibre (CF), crude protein (CP), moisture, ether extract and moisture content were determined according with the official methods of the association of official analytical chemist (AOAC, 2000). Dry matter was obtained by subtracting moisture content from 100 while energy value (KJ/100g) was calculated using the equation below:

Energy = (37× Ether extract) + (17 × carbohydrate) + (17 × crude protein)

Mineral analysis

Mineral analyses of calcium, phosphorus, potassium, sodium, magnesium, manganese, zinc and copper were determined using Atomic Absorption Spectrophotometer (AAS – Model 110HG).

Statistical analysis

The analyses were done in triplicates and the data obtained were expressed as mean ± standard error of the means (mean ± S.E.M). The data were subjected to one way analysis of variance (ANOVA) and differences between samples were determined Duncan multiple range test (Duncan, 1955). Significant was declared if $P \leq 0.05$.

3. Result and discussion

Proximate composition of *Pentadiplandra brazzeana* stem powder (PBSP)

The proximate composition of *Pentadiplandra brazzeana* stem powder (PBSP) is presented in Table 1. The sample contains moisture (8.75 %), dry matter (91.25 %), crude protein (6.43 %), crude fibre (41.03 %), ether extract (5.70 %), ash (12.11 %), carbohydrate (17.82 %), total reducing sugar (0.47 %) and energy (632.2 Kj/100g). The moisture content in PBSP was lower than the values reported the values reported for *Sida acuta* leaves (54.82 %) by Enin et al. (2014); lower values were reported for *Piliostigma thonningii* stem bark by Alagbe *et al*. (2019). According to Awogbemi and Ogunleye (2009); Alagbe *et al*. (2019) moisture content gives an indication of water present in a sample and it can also be used as an index to determine the storage or shelf life of a sample, thus samples with low moisture is advantageous in improving shelf life. Determining the dry matter (DM) of a sample or feed provides a measure of the amount of a particular feed that is required to supply a set amount of nutrients to the animal. The DM values obtained in PBSB was higher than the values reported for *Desmodium triflorum* root (33.46%), *Clitoria ternatea* leaves (18.61%), *Calopogonium mucunoides* leaves (29.18%), *Leucaena leucocephala* leaves (32.59 %), *Albizia saman* leaves (29.46 %) and *Arachis pintoi* stem bark (30.66 %) as reported by Jusoh and Hafifah (2018) but contrary to the findings of Audu *et al*. (2018) who reported a DM of 95.79 % in Balanites aegyptiaca stem bark, 97.04 % (*Balanites aegyptiaca* leaves) and 95.64 % (*Balanites aegyptiaca* root). Crude fibre content obtained in PBSB (41.03 %) is lower than value for Uvaria chamae root (47.27 %) by Fedelis and Iyere (2017). According to Olanipekun *et al*. (2016); Alagbe *et al*. (2019) adequate intake of fibre aids in efficient digestion of feed and prevents cardiovascular diseases. The sample contained low protein (6.43 %) which is contrary to the reports of Princewill *et al*. (2019) who reported 16.25 %, 17.94 % and 15.74 % in *Magnefera indica*, *Persea Americana* and *Anonna muricata* leaves. Proteins are vital in the repair of worn out tissues and transport of oxygen in the body, the result obtained is an indication that PBSB may not be able to supply adequate amount of dietary protein (Ojewuyi *et al*., 2014). The value for ether extract obtained in this experiment were lower than values obtained by Andrew *et al*. (2018) but the ash content were higher than those reported for *Hua gabonii* stem bark (9.70 %), *Mondia whitei* root (9.60 %), *Pentadiplandra brazzeama* root (9.50 %) and *Scorodophleus zenkeri* stem bark (9.60 %) by Armand *et al*. (2012). According to Aiyesanmi and Oguntokun (1996); Pamela *et al*. (2005) fats are needed in diet to supply energy, facilitate the transport of fat soluble vitamins, retain palatability of foods and contribute to important cell process. Ash content also gives an indication of minerals present in a sample (Onwuka, 2005). A reducing sugar contains aldehyde or ketone in its molecular structure and lowers the risk of developing overweight and obesity and other health conditions (Michael *et al*., 2013). The result obtained confirms the findings of Atamgba *et al*. (2015) who evaluated the proximate composition of *Jatropha curcas* stem bark. Carbohydrate composition of PBSB (17.82 %) was lower than the values obtained for *Sida acuta* (66.21 %), *Jatropha curcas* leaf (36.33 %) by Enin *et al*. (2015); Atamgba *et al*. (2015) but contrary to the findings of Armand et al. (2015) who reported that *Aframomum daniellii* stem, *Dorstenia psilirus* root and *Echinops giganteus* contained 11.9, 8.9 and 12.1 (g/100g) respectively. The result thus suggests that PBSB may not be able to supply adequate amounts of energy in the diets of animals.

Table 1: Proximate composition of *Pentadiplandra brazzeana* stem powder (PBSP)

Parameters	Composition
Moisture	8.75 ± 0.00
Dry matter (%)	91.25 ± 3.12
Crude protein (%)	6.43 ± 0.12
Crude fibre (%)	41.03 ± 1.02
Ether extract (%)	5.70 ± 0.01

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Ash (%)	12.11 ± 0.00
Carbohydrate (g/100g)	17.82 ± 1.22
Total reducing sugar (%)	0.47 ± 0.01
Energy (Kj/100g)	632.2 ± 5.11

Values expressed as mean ± SEM (n=3)

Means in the same row with different superscripts differ significantly (P<0.05)

Mineral composition of *Pentadiplandra brazzeana* stem powder (PBSP)

Table 2 revealed the mineral composition of *Pentadiplandra brazzeana* stem powder (PBSP). The sample contained calcium, phosphorus, potassium, magnesium, sodium, zinc, manganese and copper at 73.84 mg/100g, 41.55 mg/100g, 9.47 mg/100g, 32.56 mg/100g, 28.11 mg/100g, 17.56 mg/100g, 50.88 mg/100g and 2.33 mg/100g. The minerals follow this sequence in order of abundance calcium > phosphorus > magnesium > sodium > zinc > manganese > potassium > copper respectively. Minerals serve as essential components of many enzymes, vitamins, hormones, and respiratory pigments, or as cofactors in metabolism, catalysts and enzyme activators (Alagbe and Motunrade, 2019; Alagbe 2017), they also play key role in the maintenance of osmotic pressure, and thus regulate the exchange of water and solutes within the animal body (Arinola *et al*., 2008; Alagbe et al., 2018). However all values were within the range reported by WHO (1991); PBSP is abundant in calcium which confers it the ability to strengthen the bones, teeth, maintain extracellular fluids and used for transmission of nerve impulses (Mann and Otori, 2014; Vasudevan and Sreekumari, 2007). Phosphorus is an essential component of phospholipids, nucleic acids, phosphoproteins (casein), high energy phosphate esters (ATP), hexose phosphates, creatine phosphate, and several key enzymes (Indrayan *et al*., 2005). Potassium is the major cation of intracellular fluid, and regulates intracellular osmotic pressure; acid-base balance and protein synthesis and its deficiency in animals could lead to anorexia, weakness and respiratory challenges (Ouilly *et al*., 2017; Bamishaiye *et al*., 2011). Enzyme activation, regulation of acid-base and metabolism of carbohydrate, lipid and protein is enhanced by the presence of magnesium (Okwu and Ekeke, 2003). Copper is involved in iron metabolism, haemoglobin synthesis and red blood cell production and maintenance (Okwu, 2005; Andzouana and Mombouli, 2012). Sodium is an important intracellular cation involved in the regulation of plasma volume, acid-base balance and nerve contraction (Akpanyung, 2005). Zinc serves as a cofactor in many enzyme systems, lipid, protein, carbohydrate metabolism as well as metabolism of nucleic acids (Kawo *et al*., 2009). Manganese functions in the body as an enzyme activator, is vital in bone formation, regeneration of red blood cells, carbohydrate metabolism, and the reproductive cycle (Hussain *et al*., 2013).

Table 2: Mineral composition of *Pentadiplandra brazzeana* stem powder (PBSP)

Parameters	Composition (mg/100g)	WHO (1991) range mg/100g
Calcium	73.84 ± 1.33	36.0 – 80.00
Phosphorus	41.55 ± 1.01	20.0 – 45.00
Potassium	9.47 ± 0.03	10.0 – 25.00
Magnesium	32.56 ± 2.11	-
Sodium	28.11 ± 0.18	4.00 - 50.00
Zinc	17.56 ± 0.02	15.0 – 50.00
Manganese	10.88 ± 0.01	10.0 – 20.00
Copper	2.33 ± 0.03	10.0 – 30.00

Values expressed as mean ± SEM (n=3)

Means in the same row with different superscripts differ significantly (P<0.05)

4. Conclusion

Plants are the cheapest and most important available sources of nutrients (carbohydrates, protein, vitamins, minerals and amino acids) and bioactive chemicals with recognized medicinal value; the efficiency of medicinal plants for therapeutic purpose is based on their phytochemical composition which confers them ability to perform multiple biological activities such as: antimicrobial, antifungal, antioxidant, antiviral etc. There are over 250,000 species of medicinal plants, some of which are still underexplored globally. The constant research into some of these plants will promote food safety, livestock production, prevent environmental contamination with synthetic chemicals and reduce high cases of cancer and other ailments in humans.

References

1. Boham, B. A. and Kocipai, A. C. (1974). Flavonoids and condensed tannins from leaves of Hawaiian vaccinium vaticulatum and V. calycinium. Pacific Sci. 48: 458-463.
2. Harborne, J. D. (1973). Phytochemical methods: A guide to modern techniques of plant analysis. Chapman and Hall, London. 279.
3. Odebiyi, A. and Sofowora, A. E. (1978). Phytochemical Screening of Nigerian Medicinal Plant. Part III, Lloydia, 41, 234- 246.

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p-ISSN : 2615 3785

4. A.O.A.C. (2000). Association of Official Analytical Chemists. Official Methods of Analysis 19th Edition Washington, D.C Pages 69-77.
5. Duncan, D.B. (1955). Multiple range and multiple F-test. Biometrics 11(1):1-42.
6. WHO Guidelines for elemental concentration (1991). Journal of Am. Med. 23 (3): 299-305.
7. Michael, E., Chi-Tang Ho and Fereeidon, S. (2013). Browning reactions in foods. Biochemistry of Foods. 2013:245-289.
8. Jusoh, S and Hafifah, C.S. (2018). Nutritive value, palatability and selectivity of 10 different legume herbages by rabbits. Malaysian Society of Animal Production. 21(2):69-75.
9. Audu, I.W., Audu, B.S and Suleiman, Y. (2018). Phytochemistry and proximate composition of root, stem bark, leaf and fruit of desert date, Balanites aegyptiaca. The Journal of Phytophramacology. 7(6): 464-470.
10. Alagbe, J.O., Sharma, D and Xing Liu (2019). Effect of aqueous *Piliostigma thonningii* leaf extracts on the haematological and serum biochemical indices of broiler chicken. *Noble International Journal of Agriculture and Food Technology*, *1*(2): 62-69.
11. Olanipekun, M.K., Adewuyi, D and Adedeji, D.E (2016). Ethnobotanical importance and phytochemical analyses of some selected medicinal plants in Ado-Ekiti Local Govt. Area. *Journal of Herbal Medicine Research, 1*(3):0007-0016.
12. Awogbemi, O and Ogunleye, I.O. (2009). Effects of drying on the quality of some selected vegetables. IACSIT. Int. J. Eng. Tech. 1(5):1793-8236.
13. Ojewuyi, O.B, Ajiboye, T. O, Adebanjo, E. O, Balogun, A, Mohammed, A.O (2014). Proximate composition, phytochemical and mineral contents of young and mature *Polyalthia longifolia* Sonn.leaves Fountain Journal of Natural and Applied Sciences: 2014; 3(1): 10 – 19.
14. Atamgba, A.A., Margret, A.A., Kayode, D and Amonor, J.W. (2015). The biomedical significance of the phytochemical, proximate and mineral composition of the leaf, stem bark and roots of *Jatropha curcas*. *Asian Pacific Journal of Tropical Biomedicine, 5*(8):650-657.
15. Alagbe, J.O. (2019). Proximate, Mineral and Phytochemical Analysis of Piliostigma Thonningii Stem Bark and Roots. *International Journal of Biological, Physical and Chemical Studies*. 1(1):1-7.
16. Arinola, O.G., Olaniyi, J.A and Abibinu, M.O. (2008). Elemental trace elements and metal binding proteins in Nigerian consumers of alcoholic beverages. *Pakistan Journal of Nutrition, 7*(6):766-769.
17. Mann, A and Otori, A.A. (2014). Determination of chemical composition of minerals and antinutritional factors of two wild seeds from nupeland north central Nigeria. American Journal of Chemistry and Application. 1(1):20-26.
18. Indrayan, A.K., Sharma, S., Durgapa, I.D and Kumar, K. (2005). Determination of the nutritive value and analysis of mineral elements for some medicinally valued plants from Uttaranchal. Journal of Current Research. 89: 507-513.
19. Akpanyung, E.O. (2005). Proximate and mineral composition of bouillon cubes produced in Nigeria. Pakistan Journal of Nutrition. 4(5):327-329.
20. Okwu, D. E. (2005). Phytochemical, vitamins and mineral composition of two Nigeria medicinal plants.International Journal of Molecular Medicine and Advance Sciences. 1(4):375-381.
21. Okwu, D.E and Ekeke, O. (2003). Phytochemical screening and mineral composition of chewing sticks in South Eastern Nigeria. Global Journal of Pure Applied Sciences. 88: 234-238.
22. Armand, A.B., Nicolas, Y.N., Harquin, S.F., Joel, S., Didier, M., Carl, M.F and Mbofung, I. (2012). Proximate composition, mineral and vitamin content of some wild plants used in Cameroon. Food and Nutrition Sciences, 3:423-432.
23. Princewill, O., Ogbonna, I.L., Ogboona, P.C and Ogujiofor, I.B. (2019). Proximate composition, vitamin, mineral and biologically active compounds levels in leaves of Magnifera indica, Persea americana and Annona muricata. Journal of Applied Science and Environmental Management. 23(1):65-74.
24. Andrew, I., Chinedum, E., Vera, I and James, N. (2018). Effect of processing on the nutritional and antinutritinal composition of Urena lobata leaves. Food Science and Nutrition. 3(5):000166.
25. Fidelis, E.O and Iyere, O.O. (2017). Proximate analysis and phytochemical composition of Uvaria chamae root. NISEB Journal. 17(2):1585-1590.
26. Alagbe, J.O and Adegbite Motunrade Betty (2019). Haematological and serum biochemical indices of starter broiler chicks fed aqueous extract of *Balanites aegyptiaca* and *Alchornea cordifolia* bark mixture. *International Journal of Biological, Physical and Chemical Studies*. 1(1): 8-15.
27. Kawo, A.H., Abdullahi, B.A., Galiya, Z.A., Halilu, A., Dabai, M and Dakare, M.A.(2009). Preliminary screening, proximate and elemental composition of Moringa oleifrea seed powder. Bayero Journal of Pure and Applied Sciences. 2(1):96-100.
28. Hussain, J., Najeeb, U.R., Abdul, L.K., Liaqat, A., Zabta, K.S and Tania, S.R. (2013). Proximate based comparative assessment of five medicinal plants to meet challenges of malnutrition. European Journal of Medicinal Plants. 3(3):444-453.
29. Andzouana, M and Mombouli, J.B. (2012). Proximate, mineral and phytochemical analysis of the leaves of H. myriantha and Urera trinervis. Pakistan Journal of Biological Sciences. 15:536-540.

e-ISSN : 2620 3502
p-ISSN : 2615 3785

30. Ouilly, T.J., Bazongo, P., Adjima, B.A., Lykke, M.A and Bassole, N.H.I. (2017). Chemical composition, physicochemical characteristics and nutritive value of Lannea kerstingii seeds and seed oil. Journal of Analytical Methods. Pp 6. https://doi.org/10.1155/2017/2840718.
31. Bamishaye, E.I., Olayemi, F.F and Bamishaiye, O.M. (2011). Proximate and phytochemical composition of Moringa oleifera leaves at three stages of maturation. Advance Journal of Food Science and Technology. 3(4):233-237.
32. Vasudevan, M.D and Sreekumari, S. (2007). Textbook of biochemistry for medical students. 5th Ed. Jaypee Brothers Medical Publishers Ltd. New Delhi, India. Pp 283-287.
33. Kant, R (2005). "Sweet proteins- Potential replacement for artificial low calorie sweeteners". Nutrition Journal. **4**: 5. doi:10.1186/1475-2891-4-5
34. Bayer; C and Appel, O. (2003). "Pentadiplandraceae". In K. Kublitski; et al. (eds.). *Flowering Plants: Dicotyledons*. p. 329. doi:10.1007/978-3-662-07255-4_33. ISBN 978-3-642-07680-0.
35. Walters, D. E; Hellekant, G (2006). "Interactions of the Sweet Protein Brazzein with the Sweet Taste Receptor". *Journal of Agricultural and Food Chemistry*. **54**(26): 10129–10133. doi:10.1021/jf062359
36. *Guevara, E.E.; Veilleux, C.C.; Saltonstall, K.; Caccone, A.; Mundy, N.I.; Bradley, B.J. (2016). "Potential arms race in the coevolution of primates and angiosperms: brazzein sweet proteins and gorilla taste receptors". American Journal of Physical Anthropology. **161** (1): 181–185.*
37. Assadi-Porter, F. M; Abildgaard, F; Blad, H; Cornilescu, C. C; Markley, J. L (2005). "Brazzein, a small, sweet protein: Effects of mutations on its structure, dynamics and functional properties". *Chemical Senses*. 30 Suppl 1: i90–1.
38. Ngamga, D., 2005. Antimalarial secondary metabolites from some Cameroonian medicinal plants. African Journal of Traditional, Complementary and Alternative Medicines 2(2): 177–205.
39. Latham, P., 2004. Useful plants of Bas-Congo province, Democratic Republic of the Congo. DFID, London, United Kingdom. 320
40. Kamtchouing, P., Mbongue, G.Y., Dimo, T. & Boukeng-Jatsa, H., 2002. Evaluation of androgenic activity of Zingiber officinale and Pentadiplandra brazzeana in male rats. Asian Journal of Andrology 4: 299–301
41. Jin, Z., Danilova, V., Assadi-Porter, F.M., Markley, J.L. & Hellekant, G., 2003. Monkey electrophysiological and human psychophysical responses to mutants of the sweet protein brazzein: delineating brazzein sweetness. Chemical Senses 28: 491–498.
42. Eyog Matig, O., Ndoye, O., Kengue, J. & Awono, A. (Editors), 2006. Les fruitiers forestiers comestibles du Cameroun. IPGRI Regional Office for West and Central Africa, Cotonou, Benin. 204
43. Tsopmo, A., Ngnokam, D., Ngamga, D., Ayafor, J.F. & Sterner, O., 1999. Urea derivatives from Pentadiplandra brazzeana. Journal of Natural Products 62: 1435–1436.
44. Tancredi, T., Pastore, A., Salvadori, S., Esposito, V. & Temussi, P.A., 2004. Interaction of sweet proteins with their receptor. European Journal of Biochemistry 271: 2231–2240.
45. El Migirab, S., Berger, Y. & Jabot, J., 1977. Isothiocyanates, thiourées et thiocarbanates isolés de Pentadiplandra brazzeana. Phytochemistry 16: 1719–1721
46. Assadi-Porter, F.M., Abildgaard, F., Blad, H., Cornilescu, C.C. & Markley, J.L., 2005. Brazzein, a small, sweet protein: effects of mutations on its structure, dynamics and functional properties. Chemical Senses 30 (supplement 1): i90–i91.
47. Alagbe, J.O., Olanrewaju, A., Adewemimo, A and Tanimomo, B.K. (2019). Carcass, caecal microbial population and immune parameters of broilers given different levels of mixed lemon grass ((*Cymbopogon citratus*) and garlic (*Allium sativum*) extract. *Academic Journal of Life Sciences*. 5(11): 107-111.
48. Alagbe, J.O., Soares, D.M and Eimoga, M.M. (2018). Efficacy of Shea butter (*Butryospermum parkii*) – Neem (*Azadirachta indica*) leaf meal mixture on performance and carcass characteristics, immune response and blood parameters in broiler chickens. *Greener Journal of Agricultural Sciences*. 8(2):42-51.