



Concentrations of Antinutrients and Toxic Substances in the Pulp of *Vitellaria paradoxa* fruit obtained from the different Geopolitical Zones of Niger State

Mohammed H, Uthman A, Umar M.T. and *Musa A.

Department of Biochemistry, Ibrahim Badamasi Babangida University, Lapai, Nigeria

ABSTRACT

The chemical contents and compositions of plants are generally influenced by environmental factors where they are grown, it is against this background the present research is designed to evaluate the concentrations of some antinutrients and toxic substances (saponin, tannin, oxalate, phytate, cyanide and nitrate) in the pulp of the fruits of *Vitellaria paradoxa* obtained from the three different geopolitical zones in Niger State. The fresh fruits of *V. paradoxa* were obtained from three Local Government Areas from each zone; Zone A (Mokwa, Bida and Lapai), Zone B (Suleja, Kuta and Kpaiko), Zone C (Kotongora, Wushishi and New Bussa) and used for the analysis. The concentrations of nitrate, saponin and tannin were analysed by spectrophotometric method while the concentrations of phytate and oxalate were done by the titrimetric method. The results showed that the concentrations of saponin in the pulp of the fruits from zone B and C did not differ significantly from each other, however, the concentration of the parameter from these zones was significantly higher ($p < 0.05$) than that of zone A. Similarly, the concentration of tannin in the pulp of the *V. paradoxa* in Zone B and C were not significantly different from each other, however, its concentration in the fruit pulp from zone A was significantly higher ($p < 0.05$) when compared with those of zone B and C. Whereas the oxalate content in the fruit pulp from zone B was significantly lower ($p < 0.05$) than those obtained of zone A and C, the phytate content in zone C was significantly lower ($p < 0.05$) than those from zone A and B. The cyanide content in fruit pulp from zone A and C did not differ significantly from each other; however, its content in the fruit pulp of *V. paradoxa* from these zones was significantly lower when compared with zone B. The significant order of increased concentrations of nitrate in the pulp of *V. paradoxa* fruits obtained from the three geopolitical zones of Niger State was zone A > zone B > zone C. The study concludes that the pulp of the fruits of *V. paradoxa* from the three geopolitical zones of Niger State bioaccumulates various concentrations of the antinutrients and toxic substances evaluated.

Keywords: *Vitellaria paradoxa*, Antinutrients and toxic substances, Geopolitical zones, Niger State.

INTRODUCTION

Vitellaria paradoxa recently has gained importance as an economic crop because of the increasing demand for its butter, both domestically and internationally. Shea fruits serve as an important source of food for many organisms and other animals including birds, bats, elephants, sheep and pigs (Maranz *et al.*, 2004; Fobil, 2010). The fruits also contribute to food security in forest areas of Nigeria, mainly for the rural poor, especially since their ripening happen together with the lean season of food production (Fobil, 2010). It plays a crucial role in its highly nutritional capacity, food security and availability during the period of low food availability. The production of shea nut and processing of the butter serves as one

of the main sources of employment for the rural women and children who are engaged in gathering it. Shea butter is important edible oil for the people of Southwestern and Northern Nigeria and most of Western Africa, being the most essential source of fatty acids and glycerol in their diet (Saul *et al.*, 2003; Moore, 2008). It is also useful in the pharmaceutical and cosmetic industries as an important raw material and a precursor for the manufacture of soaps, candles, and cosmetics (Fobil, 2010). Shea nuts are also more and more being

Received 12 November, 2022

Accepted 13 December, 2022

Address Correspondence to:

musaamanabo@gmail.com

exported for the utilization in the cosmetics industry as a constituent in lotions, makeup, baby ointments, hair care products and soaps (Akosah-Sarping, 2003; Moore, 2008). Regardless of being increasingly substituted by commercially produced lotions in many communities, shea butter is traditionally used as a skin and hair moisturizer and for protection against the sun (Ezema and Ogujiofor, 1992). The healing properties and effects of shea butter are thought to be somewhat attributable to the existence of allantoin, a substance known to trigger the growth of healthy tissue in ulcerous wounds (Wallace-Bruce, 1995). It is also traditionally smeared on pregnant women during childbirth, newborn babies and on adolescents because of its relieving effects (Moore, 2008). Though, the nut is an essential export commodity, the fruit pulp nevertheless is widely consumed for its nutritional benefits. It also plays a major role in the local economy and diet as well as occupies an important period of time in the annual local dietary cycle (Maranz *et al.*, 2004). The edible part of the shea fruit is extremely nutritious and has important nutrients for the human body. The fruit provides an important source of food for communities and the rural poor, particularly in period of food shortages, hunger and other catastrophes. In addition to providing health benefits, the green fruit has a fleshy edible pulp, which contains protein, dietary fibre, carbohydrates and mineral elements (such as Fe, Ca, Mg, Na, and K). The pulp is also rich in some vitamins such as ascorbic acid and vitamins complex (Fobil, 2010).

Despite the importance of shea butter fruit, the *V. paradoxa* fruits like other fruits may contain some antinutrients and toxic substances that may cause health and nutritional problems. The chemical contents and compositions in plants are generally influenced by environmental factors where they are grown. This study is therefore designed to investigate the influence of geographical locations on antinutritional contents and quality of shea fruit from the three different geopolitical zones of Niger State, Nigeria.

METHODOLOGY

Study Area

Three Local Government Areas were selected from each of the three Zones in Niger State. Namely, Zone A (Lapai, Bida and Mokwa),

Zone B (Suleja, Kuta and Kpaiko) and Zone C (Kontogora, Wushishi and New Bussa). The fresh fruits of *V. paradoxa* were obtained from three different locations in each of the Local Government Areas and were used for the required analysis.

Source of Samples

Vitellaria paradoxa fruits were obtained from three Local Government Areas from each Zone in Niger State in the Middle belt, Nigeria. Shea fruit collected from Lapai, Bida and Mokwa represent zone A, Those from Suleja, Kuta and Kpaiko represent zone B while those collected from Wushishi Kontogora and New Bussa represent zone C. The fruits were kept in sterile polythene bags and taken to the laboratory of the Department of Biochemistry, Ibrahim Badamasi University, Lapai, Niger State. The pulps of the fruits were used for evaluation of the antinutrient and toxic constituents.

Analytical Procedure

The nitrate content in the samples was determined by the colourimetric method of Sjoberg and Alanko (1994). The alkaline picrate method of Ikediobi *et al.* (1980) was used to estimate the cyanide concentration in the samples. Titrimetric methods as described by AOAC (1984) and Maga (1983) were used to evaluate the oxalate and phytate contents in the sample, respectively. Similarly, the concentrations of saponin and tannin in the sample were evaluated by the colourimetric method of AOAC (1984).

Data Analysis

Data obtained was subjected to the Analysis of Variance (ANOVA) and mean values were separated using Duncan's Multiple Range Test (DMRT). Significance was tested at $P < 0.05$.

RESULTS

Concentrations of Antinutrients and Toxic Substances in the Pulp of *Vitellaria paradoxa* Fruits

The determination of the effect of different geopolitical zones of Niger State on the concentrations of antinutrients and toxic substances in the pulp of the fruits of *V. paradoxa* showed that the concentration of saponin in the pulp of the fruits from zone B and C did not differ significantly from each other, however, the concentration of this parameter from these zones was significantly

higher ($p < 0.05$) than that of zone A. The saponin content in the pulp of the shea fruits from zone A, B and C were 9.02 ± 2.25 , 24.68 ± 2.84 and 18.74 ± 9.62 g/g, respectively. Similarly, the mean value of 2.10 ± 0.77 , 0.32 ± 0.07 and 1.04 ± 0.60 mg/g of tannin were recorded for zone A, B and C, respectively. The results showed that the concentration of tannin in the pulp of the *V. paradoxa* in zone B and C were not significantly different from each other, however, its concentration in the pulp from zone A was significantly higher ($p < 0.05$) when compared with those of zone B and C (Table 1).

Whereas the oxalate content in the pulp of the fruits from zone B was significantly lower ($p < 0.05$) than those obtained in zone A and C, the phytate content in zone C was significantly lower ($p < 0.05$) than those from zone A and B. The mean values of 18.01 ± 6.10 , 12.07 ± 3.13 and 20.35 ± 2.64 g/100 g were obtained for oxalate in the pulp of the fruits from zone A, B and C, respectively while the corresponding value phytate were 2.09 ± 0.33 , 1.60 ± 0.50 and

0.83 ± 0.18 g/100 g, respectively. The cyanide content in fruit pulp from zone A and C did not differ significantly from each other; however, its content in the pulp of *V. paradoxa* from these zones was significantly higher when compared with that obtained from zone B. The concentration of cyanide in the pulp of *V. paradoxa* fruits from zone A, B and C were 185.14 ± 82.68 , 299.01 ± 69.59 and 191.19 ± 78.94 mg/kg, respectively. The significant order of increased concentrations of nitrate in the pulp of *V. paradoxa* fruits obtained from the three geopolitical zones of Niger State was zone A (643.93 ± 286.50 mg/kg) > zone B (390.83 ± 212.18 mg/kg) > zone C (253.89 ± 146.96 mg/kg).

Table 1: Antinutrients and toxic substances content of the Pulp of *V. paradoxa* fruits obtained from geopolitical zones of Niger State

Parameters	Zones		
	A	B	C
Saponin (mg/g)	9.02 ± 2.25^a	24.68 ± 2.84^b	18.74 ± 9.62^b
Tannin (mg/g)	2.10 ± 0.77^b	0.32 ± 0.07^a	1.04 ± 0.60^a
Oxalate (mg/g)	18.01 ± 6.10^b	12.07 ± 3.13^a	20.35 ± 2.64^b
Phytate (mg/100g)	2.09 ± 0.33^b	1.60 ± 0.50^b	0.83 ± 0.18^a
Cyanide (mg/kg)	185.14 ± 82.68^a	299.01 ± 69.59^b	191.19 ± 78.94^a
Nitrate (mg/kg)	643.93 ± 286.50^c	390.83 ± 212.18^b	253.89 ± 146.96^a

Means \pm standard error on the same row with different superscripts are significantly different ($p < 0.05$) from each other. Key: Zone A (Mokwa, Bida and Lapai), Zone B (Suleja, Kuta and Kpaiko), Zone C (Kotongora, Wushishi and New Bussa).

DISCUSSION

The fruit pulp of the *V. paradoxa* obtained from the different zones of Niger state contains various concentrations of saponin, tannin, oxalate, phytate, cyanide and nitrate. The variation of the antinutrients and toxic substances which affect nutrients availability and utilization with attendant health and nutritional problems may be due to differences in the environmental condition of the different zone which is generally known to influence the

chemical contents and compositions of fruits and vegetables (Wilhelmina, 2006; Musa *et al.*, 2022). Although the concentration of saponin in the pulp of the *V. paradoxa* fruits obtained from zones B and C was significantly higher than that of zone A, The inhabitants of these two zones need not to worry of the effect of saponin intoxication because the concentration of the saponin in the fruit pulp from the two zones are within the permissible limit of less than 10 % ($< 10\%$) in the diet, which is said to

be harmless to the body (Igili *et al.*, 2013). Therefore, the health problems associated with high ingestion of saponin such as gastroenteritis, manifested by diarrhoea, dysentery and haemolysis of blood cells (Igili *et al.*, 1995) may not likely affect the people from these zones as a result of consumption of the fruit pulp of *V. paradoxa*.

Tannins which are phenolic secondary metabolite compounds are widely distributed in the plant kingdom and in different parts of the plant. They can produce undesirable effects in food when present in considerably high concentrations. Tannins form a complex with proteins through hydrogen bonding and covalent linkages and reduce the bioavailability of the proteins. This can lead to enzyme inhibition and therefore may interfere with gastrointestinal digestion and absorption of nutrients (Serrano *et al.*, 2009; Sharma *et al.*, 2021; Musa *et al.*, 2022). Though the concentration of tannins in the fruit pulp of *V. paradoxa* from zone A of Niger State was significantly higher compared to zones B and C, the tannins content from all the three zone is greatly below the mean acceptable daily intake of the general population in the United States which is estimated as 53.6 mg/day/person for tannins (Prior and Gu, 2005; Serrano *et al.*, 2009). This finding also suggest that eating the fresh fruit pulp of *V. paradoxa* from these zones does not pose any health effect with regard to tannin toxicity in human.

Consumption of fresh fruits is considered a good lifestyle due to derivable nutritional and health benefits abound in them. However, ingestion of fruits is of concern when there is a risk of high oxalate content in them owing to the public health problems connected with the intake of this potent antinutrient which includes, reduction of bioavailability of mineral elements, formation of kidney stones (calcium oxalate is common) and electrolyte imbalance (Musa, 2021; Musa *et al.*, 2022). Though oxalate content in the fruit pulp of *V. paradoxa* from zone B was significantly higher than those of zone A and C, the inhabitants in the three zones of Niger State have to tread cautiously in the consumption of the fresh fruit pulp of this important economic fruit. This is because the concentration of the oxalate in the fruit's pulp obtained from the three zones is higher than the average content of oxalate of 250 mg/ 100 g of

fresh-weight spinach as reported by Oguchi *et al.* (1996) and this may constitute to some extent the nutritional risk of some mineral deficiencies, especially calcium and kidney stone formation.

Even though recent studies have demonstrated that phytate has potential health benefits as it can act as an antioxidant, exhibits anticancer properties, and have a positive impact in lowering cholesterol and blood glucose. Nevertheless, at high concentrations, phytate is a strong antinutrient which forms complexes with mineral elements, particularly divalent and trivalent cations. This compound has six reactive phosphate groups and meets the criterion of a chelating agent. The major nutrition and health concern about the high concentration of phytate in the diet is its negative effect on mineral uptake. The chelating of the minerals by phytate affects the bioavailability of the dietary minerals for absorption and utilization in the body. This potent antinutrient also interacts with proteins and reduces their bioavailability of the dietary proteins (Musa, 2021; Musa *et al.*, 2022). Our current findings indicated that the phytate content in the fruit pulps of *V. paradoxa* from the three zones of Niger State is lower than the acceptable intake of 600-800 mg per day if 100 g of diet is consumed (Wise *et al.*, 1987). Thus, consumption of fruit pulps from any of these zones from the state will not lead to health problems associated with phytate toxicity.

The mean concentration of cyanide (299.01 ± 69.59 mg/kg) in the fruits pulp of *V. paradoxa* from zone B of Niger State which was significantly higher than in the fruit's pulp from both zone A and C is higher than the permissible level of 200 mg/kg fresh weight vegetables or forages (Richard, 1991). Therefore, regular ingestion of raw fresh fruits pulp of *V. paradoxa* obtained from zone B of Niger state could lead to cyanide intoxication with attendant health problems such as cellular hypoxia, respiratory paralysis, dizziness, heart blockage and even death (Musa, 2021). Therefore, it is pertinent to be cautious of the presence of a high level of cyanide in the fruits pulp of *V. paradoxa* from the zone and the possible health implications.

The significantly increasing order of nitrate concentration in the fruit pulp of *V. paradoxa* from the three different zones of Niger State is

zone A > zone B > zone C. However, the concentration of nitrate in the fresh fruits pulp of this economic tree from the different zones of the State is within the acceptable daily intake (ADI) of 3.65 mg/kg for 60 kg body weight (219.00 mg/day) if 100 g samples are consumed per day (Anjana *et al.*, 2007). This finding, therefore suggest that the fruit pulp of *V. paradoxa* from any of the zones is safe for consumption with respect to nitrate content without fear of nitrate intoxication and its possible attendant health problems such as cancers and methaemoglobinaemia (Musa, 2021).

Conclusion

The study concludes that the fresh fruit pulp of *V. paradoxa* accumulates various concentrations of antinutrients and toxic substances in them. While, the concentrations of phytate, tannin, saponin and nitrate in the fruit's pulp of the plant from the three zones of Niger State are within the permissible limits and can be well tolerated in our meals, the concentration of cyanide in the fruits pulp from zone B and that of oxalate in the three zones are more than the permissible limits and thus can induce cyanide and oxalate toxicities on consumption with their attendant nutrition and health problems.

Acknowledgements

The authors acknowledge the TETFund for sponsoring this research and the Management of Ibrahim Badamasi Babangida University, Lapai, Niger State, particularly the Vice Chancellor, for providing the enabling environment for the success of this study. The role of the Chairman, University Committee on Research and Publication and Director, Centre for Applied Sciences and Technology Research (CASTER), of the University toward the execution of the study is very much appreciated.

REFERENCES

Akosah-Sarping, K. (2003). Demand for West Africa's shea butter in cosmetic industry. *West Africa Review*, 4 (1):12-20.

Anjana, S.U., Muhammed, I. and Abrol. Y.P. (2007). Are nitrate concentrations in leafy vegetables within safe limits? *Current Science*, 92(3): 355-360.

AOAC (Association of Official Analytical Chemist) (1984). Standard Official Methods of Analysis, Association of Analytical Chemist. 14th Edition, Washington DC: AOAC Press.

Ezema, D.O, Ogujiofor, K.O. (1992). The evolution of *Butyrospermum paradoxum* as a suppository base. *International Journal of pharmacognosy*, 30:275-280

Fobil, J. N. (2010). Research and development of the shea tree and its products. In: HORIZON International. USA: Yale University Department of Biology.

Igile. G.O., Iwara, I.A., Mgbeje, B.I.A., Ubooh, F.E. and Ebong, P.E. (2013). Phytochemical, proximate and nutrient composition of *Vernonia calvaona* Hook (Asteracea): A green-leafy vegetable in Nigeria. *Journal of Food Research*, 2(6):1-8.

Igile, G.O., Oleszek, W., Burda, S. and Jurzysta, M. (1995). Nutritional assessment of *Vernonia amygdalina* leaves in growing mice. *Journal of Agriculture and Food Chemistry*, 43 (8):2162-2166.

Ikedioji, C. O., Onyia, G. O. C., & Eluwah, C. E. (1980). A rapid and inexpensive enzymatic assay for total cyanide in cassava (*Manihot esculenta crantz*) and cassava product. *Agriculture and Biological Chemistry*, 44, 2803-2308.

Maga, J. A. (1983). Phytate: Its chemistry, occurrence, food interaction, nutritional significance and methods of analysis. *Journal of Agriculture and Food Chemistry*, 30:1-9.

Maranz S, Kpikpi W, Wiesman Z, Sauveur AD, Chapagain B.(2004) Nutritional values and Indigenous preferences for shea fruits (*Vitellaria paradoxa* C.F. Gaertn. F.) in African Agroforestry Parklands. In: *Journal of Economic Botany*, 58(4): 588-600.

Moore, S. (2008). The role of *Vitellaria Paradoxa* in poverty reduction and food security in the Upper East region of Ghana. *Earth & Environment*, 3: 209-245.

Musa A. (2021). Anti-nutrients and toxic constituents of leafy vegetables: Obstacles to harnessing their full nutritional and health-enhancing potentials. Ibrahim Badamasi Babangida University, Lapai. Inaugural Lectures No. 16. Senate Committee on

- Conferences and Seminars, IBB University, Lapai. 1-85 p.
- Musa, A., Abu, M. L., Lawal, A. B. and Uthman, A. (2022). Soil amendment with graded levels of *Crasonycteristhonglongyai* compost on the concentrations of some phytotoxins in the leaf of *Cnidoscolumaconitifolius* (tree spinach). *Tropical Journal of Natural Product Research*, 6(2): 265-269.
- Oguchi, Y., Weerakkody, W.A.P., Tanaka, A., Nakazawa, S. and Ando, T. (1996). Varietal differences of quality-related compounds in leaves and petioles of spinach grown at two locations. *Bulletin of the Horishima Prefectural Agriculture Research Center*, 64: 1 – 9.
- Prior, R. and Gu, L. (2005). Occurrence and biological significance of proanthocyanidins in the American diet. *Phytochemistry*, 66: 2264 – 2280.
- Richard, D.W. (1991). Cooperative Extension Service: Cooperative Extension work acts may 8 and June 30, 1914, as amended, Kansas State University, County Extension Councils. Extension Districts and U.S. Department of Agriculture Cooperating.
- Saul, M., Ouadba, J. and Bognounou, O. (2003). The wild vegetation cover of Western Burkina Faso colonial policy & post-colonial development. In: African Savannas: global narratives & local knowledge of environmental change. Portsmouth: Reed Elsevier.
- Serrano, J. Puupponen-Pimi, R., Dauer, A., Aura, A. and Saura-Calixto, F. (2009). Tannins: Current knowledge of food sources, intake, bioavailability and biological effects. *Molecular Nutrition & Food Research*. 53: 310-329.
- Sharma, K., Kumar, V., Kaur, J., Tanwar, B., Goyal, A., Sharma, R., Gat, Y. and Kumar A. (2021). Health effects, sources, Utilization and safety of tannins: a critical review. *Toxin Reviews*. 40 (4): 432-444.
- Sjoberg, A. M. K. and Alanka, T. A. (1994). Spectrophotometric determination of nitrate baby food: Collaborated study. *Journal of AOAC International*, 77 (2), 425-430.
- Wallace-Bruce, Y. (1995). Shea butter extraction in Ghana. In: Do It Herself. Women and technical innovation. London: Intermediate Technology Publications, 157-161.
- Wilhelmina, K. (2006). Effect of production and processing factors on major fruits and vegetable antioxidants. *Journal of Food Science*, 70 (1); 11-19.