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Antioxidant Contents in the Pulp of Shea (*Vitellaria paradoxa*) Fruits: The Influence of the Geopolitical Zones of Niger State, Nigeria

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Abstract: *The accumulation of bioactive compounds in plants is influenced by environmental and geographical factors, which may affect their nutritional and health-promoting properties. This study evaluated the influence of geopolitical location on the antioxidant composition of Vitellaria paradoxa fruit pulp collected from the three geopolitical zones of Niger State, Nigeria. Fresh fruits were collected from three Local Government Areas within each zone: Zone A (Mokwa, Bida, and Lapai), Zone B (Suleja, Kuta, and Paiko), and Zone C (Kontagora, Wushishi, and New Bussa). The concentrations of flavonoids, phenolics, carotenoids, β-carotene, chlorophyll, lycopene, and tocopherol were determined using spectrophotometric methods, while ascorbic acid (vitamin C) was analysed by titrimetry.The results revealed significant ($p < 0.05$) variations in antioxidant concentrations among the three zones. Carotenoid, chlorophyll, lycopene, and phenol contents were highest in Zone A (4938.07 ± 128.80 mg/g, 2.68 ± 1.45 mg/g, 803.03 ± 193.39 mg/g, and 220.37 ± 109.13 mg/100 g, respectively), followed by Zone B and lowest in Zone C (666.75 ± 208.74 mg/g, 0.72 ± 0.08 mg/g, 86.59 ± 6.69 mg/g, and 50.65 ± 12.38 mg/100 g, respectively). Flavonoid concentration was also significantly higher in Zone A (74.25 ± 42.74 mg/100 g) than in Zones B (58.53 ± 20.32 mg/100 g) and C (42.72 ± 2.09 mg/100 g). In contrast, vitamin C, tocopherol, and β-carotene concentrations were highest in Zone C (63.35 ± 2.32 mg/100 g, 4.13 ± 2.25 µg/100 g, and 2099.26 ± 1205.73 µg/100 g, respectively), followed by Zone B and lowest in Zone A. The study demonstrates that geographical location significantly influences the accumulation of antioxidants in V. paradoxa fruit pulp. Fruits from Zones A and B generally exhibited higher concentrations of carotenoids, chlorophyll, lycopene, phenolics, and flavonoids, whereas fruits from Zone C contained higher levels of vitamin C, tocopherol, and β-carotene. These findings provide valuable information on the nutritional quality of shea fruit pulp and highlight the role of environmental factors in determining its antioxidant composition.*

Keywords: *Vitellaria paradoxa, Fresh fruit, Pulp, Antioxidants, Geopolitical zones, Niger State*

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1.0 Introduction

Vitellaria paradoxa C.F. Gaertn. (shea tree) is one of the most economically important indigenous tree species in sub-Saharan Africa, valued for its edible fruits and commercially important butter, which are widely utilized in food, pharmaceutical, and cosmetic industries. Shea fruits serve as an important source of food for many organisms and other animals, including birds, bats, elephants, sheep and pigs (Marnaz *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 happens 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 discussion on shea butter should be reduced by approximately 30–40% because the study focuses on fruit pulp rather than butter. Shea butter is an 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 being exported more and more 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 & 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, on newborn babies and adolescents because of its relieving effects (Moore, 2008. Though the nuts have been an essential export commodity, their fruit pulp is nevertheless widely consumed. 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 rural poor, particularly during periods of food shortages, hunger and other catastrophes. Previous studies have shown that shea fruit pulp contains appreciable amounts of natural antioxidants, including phenolic compounds, flavonoids, carotenoids, ascorbic acid, and tocopherols, which contribute to its nutritional and health-promoting properties. These bioactive compounds play important roles in scavenging free radicals, reducing oxidative stress, and preventing the development of several chronic

diseases. In addition to providing health benefits, the green fruit has a fleshy edible pulp, which contains protein, dietary fibre, carbohydrate, mineral elements (such as Fe, Ca, Mg, Na, and K). The pulp is also rich in some vitamins, such as ascorbic acid, vitamins complex (Fobil, 2010). Several researchers have reported variations in the concentrations of antioxidants and phytochemicals in fruits due to differences in environmental conditions such as soil composition, rainfall, temperature, altitude, and geographical location. Such variations may affect the nutritional quality and biological activities of fruits. Consequently, understanding the influence of environmental factors on antioxidant accumulation is essential for identifying regions capable of producing fruits with superior nutritional value.

Although the nutritional composition and industrial importance of shea fruits have been widely documented, information on the geographical variation of antioxidant constituents in the fruit pulp of *V. paradoxa* within Niger State remains scarce. In particular, comparative data describing the influence of the three geopolitical zones of Niger State on the accumulation of antioxidant compounds in shea fruit pulp are limited or unavailable. The concentration and distribution of nutrients and phytochemicals in plant-derived foods are strongly influenced by environmental conditions, including climatic factors, soil characteristics, and geographical location. Therefore, this study was undertaken to evaluate and compare the concentrations of flavonoids, phenolics, carotenoids, β-carotene, chlorophyll, lycopene, tocopherol, and vitamin C in the pulp of *Vitellaria paradoxa* fruits collected from the three geopolitical zones of Niger State, Nigeria, and to determine the influence of geographical location on the accumulation of these antioxidants. The findings of this study will provide valuable information on the nutritional quality of shea fruits from different parts of Niger State and contribute to the understanding of environmental influences on antioxidant accumulation. The results may assist consumers, nutritionists, food scientists, and policymakers in identifying geographical areas that produce shea fruits with superior antioxidant profiles and may further promote the utilization of shea fruits as functional foods and sources of nutraceutical compounds.

2.0 Materials and Methods

2.1 Study Area

Three Local Government Areas were selected from each of the three Zones in Niger State. Niger State is located in North-Central Nigeria between latitudes 8°20′–11°30′N and longitudes 3°30′–7°40′E. The State is characterized by varying climatic conditions, vegetation types, and soil characteristics that may influence plant growth and phytochemical accumulation. The study covered three geopolitical zones of Niger State. Zone A comprised Lapai, Bida, and Mokwa Local Government Areas; Zone B comprised Suleja, Kuta, and Paiko; while Zone C comprised Kontagora, 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.

2.2 Source of Samples

Fresh mature fruits of Vitellaria paradoxa were collected during the fruiting season from selected trees located within the designated Local Government Areas of Niger State, Nigeria. Sampling was conducted from three independent locations within each Local Government Area. At each location, fruits were collected from randomly selected healthy trees to obtain representative samples.

Shea fruit collected from Lapai, Bida and Mokwa represent zone A, those from Suleja, Kuta and Paiko represent zone B, while those collected from Wushishi, Kagara and Kontogora 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 pulp of the fruits was used for the evaluation of the antioxidant constituents. The plant material was authenticated by a taxonomist in the Department of Biological Sciences, Ibrahim Badamasi Babangida University, Lapai, and a voucher specimen was deposited in the departmental herbarium.

2.3 Preparation of Samples

Fresh fruits of *V. paradoxa* were washed thoroughly with tap water and subsequently rinsed with distilled water to remove adhering contaminants. The fruit pericarp was carefully removed, and the edible pulp was separated manually. The pulp samples were homogenized using a laboratory blender and analysed immediately.

2.4 Determination of Antioxidants

Tocopherol content was determined using the Emmerie–Engel colorimetric reaction according to the procedure described by Rosenberg (1992).

while the total carotenoids and lycopene were done by Zakaria *et al*. (1979). The chlorophyll content in the samples was analyzed according to the method of Witham *et al*. (1971). The concentration of ascorbic acid in the samples was determined by 2, 6-dichlorophenol indophenol titrimetric method (Jones and Hughes, 1983). The β-carotene content was analyzed by ethanol and petroleum ether as described by Musa *et al*. 2010. The Aluminum chloride colorimetric method was used for flavonoid determination (Chang *et al*., 2002) and total phenol content was assayed by Singleton *et al*. (1999) method.

2.5 Data analysis

Data were expressed as mean ± standard deviation of triplicate determinations. Statistical analysis was performed using one-way analysis of variance (ANOVA), and significant differences among means were separated using Duncan's Multiple Range Test (DMRT). Statistical significance was accepted at $p < 0.05$.

3.0 Results

3.1Antioxidants in the pulps of Vitellaria paradoxa fruits

Table 1 presents the concentrations of selected antioxidants in the pulp of *Vitellaria paradoxa* fruits collected from the three geopolitical zones of Niger State. The results showed that the concentrations of carotenoid, chlorophyll, lycopene and phenol were significantly ($p < 0.05$) highest in Zone A, followed by Zone B, and lowest in Zone C. Conversely, tocopherol, β-carotene, and vitamin C concentrations were significantly higher ($p < 0.05$) in Zone C than in Zones B and A. Whereas the concentration of flavonoid in the pulp of *V. paradoxa* from zones B and C did not differ significantly, but its content in zone A was significantly higher ($p < 0.05$) compared to zones B and C.

Carotenoid concentration decreased by approximately 43% from Zone A to Zone B and by approximately 87% from Zone A to Zone C. Similarly, lycopene concentration decreased from 803.03 mg/g in Zone A to 86.59 mg/g in Zone C. In contrast, β-carotene concentration increased approximately sixfold from Zone A to Zone C.

3.2 Discussion

The results of the present study demonstrate significant geographical variation in the antioxidant composition of *Vitellaria paradoxa* fruit pulp across the three geopolitical zones of Niger State. Such variations may be attributed to differences in environmental factors, including soil characteristics, rainfall patterns, temperature, solar radiation, and other

ecological conditions that influence plant metabolism and phytochemical accumulation. The variation in the concentrations of the antioxidant constituents observed in the different zones strengthens the influence of environmental conditions on the bioaccumulation of chemical substances in plants (Musa *et al*. 2022). The concentration of β-carotene in the pulp of fruits of *V. paradoxa* obtained from the different zones of Niger State is lower than the adult recommended daily allowance of 900 µg vitamin A (George, 1999; Musa *et al*., 2014).

Table 1: Antioxidant contents in the pulp of *V. paradoxa* fruits obtained from geopolitical zones of Niger State

Antioxidant	Unit	Zone A	Zone B	Zone C
Carotenoid	mg/g	4938.07 ± 128.80c	2802.42 ± 167.84b	666.75 ± 208.74a
Chlorophyll	mg/g	2.68 ± 1.45c	1.70 ± 0.68b	0.72 ± 0.08a
Flavonoid	mg/100 g	74.25 ± 42.74b	58.53 ± 20.32a	42.72 ± 2.09a
Lycopene	mg/g	803.03 ± 193.39c	444.81 ± 99.53b	86.59 ± 6.69a
Phenol	mg/100 g	220.37 ± 109.13c	135.51 ± 48.38b	50.65 ± 12.38a
Tocopherol	µg/100 g	0.25 ± 0.12a	2.18 ± 1.18b	4.13 ± 2.25c
Vitamin C	mg/100 g	33.72 ± 0.51a	48.54 ± 0.90b	63.35 ± 2.32c
β-Carotene	µg/100 g	351.40 ± 71.04a	1225.33 ± 581.05b	2099.26 ± 1205.73c

Means ± 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 Paiko), Zone C (Kotongora, Wushishi and New Bussa)

Although β-carotene was detected in all samples, the concentrations observed suggest that the fruit pulp alone may not constitute a sufficient dietary source to satisfy the daily vitamin A requirement of adults.

This result thus suggests that complete dependency on any of the pulp of the fruits of this economic tree from any of the zones for the provitamin A, could lead to the disease conditions that are associated with β-carotene (vitamin A) deficiency, such as night blindness and increased incidence of cancer formation in various organs (Musa *et al*., 2014). Similar geographical variations in phytochemical and antioxidant contents have been reported in fruits and medicinal plants collected from different ecological regions, where environmental conditions significantly influenced the biosynthesis and accumulation of secondary metabolites.

The concentration of vitamin C in the pulp (63.35 ± 2.32 mg/100 g) of the fruit from zone C, revealed that this part of the fruit from the zone contained enough of the vitamin to meet the recommended daily allowance of 60mg (George, 1999) if 100 g of the samples is consumed. However, the concentration of vitamin C in the pulp from zones A and B is lower than the recommended daily allowance. Generally, fruits are among the major good sources of vitamin C, however, the relatively high vitamin C concentrations observed,

particularly in Zone C, indicate that the fruit pulp may contribute substantially to daily vitamin C intake and may serve as a useful dietary source of this antioxidant. (Musa & Ogbadoyi, 2012). The findings therefore suggest that complete reliance on this fruit pulp for vitamin C may lead to nutritional problems associated with the vitamin deficiency, such as scurvy.

Similarly, the concentration of tocopherol in the pulps of *V. paradoxa* fruits from the different zones is lower than the range of the adult recommended daily allowance, 8-10 mg of the vitamin (George, 1999). The relatively low tocopherol concentrations observed suggest that the pulp contributes only modestly to dietary vitamin E intake. It's also involved in the formation of reproductive cells, and facilitates good operation of the central nervous system and of pituitary gland (George, 1999; Musa *et al*., 2015).

The concentration of chlorophyll in the fruit pulp of *V. paradox* from zone A (2.68 ± 1.45 mg/g) and zone B(1.70 ± 0.68 mg/g) suggest that this fruit part of the tree from these zones contained enough of the antioxidant to meet the adult recommended daily intake of 100 – 200 mg per day (https://www.*webmd. com.diet*. Downloaded: 05/24/2026, 11:50 am). The relatively higher chlorophyll concentrations observed in Zones A and B may contribute to the antioxidant potential of the fruit pulp.

The recommended daily intake of flavonoid and polyphenols is 150 to 600 mg per day (Johannot *et al*., 2007; Zomora-Ros *et al*., 2006) and 1-2 g (Costa *et al*., 2017), respectively. Even though the significant increase in the concentrations of flavonoid and phenol in the pulps of the fruits from the different zones are in the following increasing order; zone A > zone > B > zone C/The presence of flavonoids and phenolic compounds in all samples suggests that the fruit pulp may contribute to dietary antioxidant intake. The significantly higher concentrations observed in Zone A indicate enhanced accumulation of these phytochemicals under the environmental conditions prevailing in that zone. Thus, suggesting that the fruit pulps of *V. paradoxa* may not be good sources of these nutrient antioxidants.

4.0 Conclusion

This study evaluated the influence of geographical location on the antioxidant composition of *Vitellaria paradoxa* fruit pulp collected from the three geopolitical zones of Niger State, Nigeria. The results revealed significant variations in the concentrations of the antioxidants among the zones, indicating that geographical location influences the accumulation of antioxidant compounds in the fruit pulp. Carotenoid, chlorophyll, flavonoid, lycopene, and phenol concentrations were generally highest in fruits obtained from Zone A, followed by Zone B, and lowest in Zone C. In contrast, tocopherol, vitamin C, and β-carotene concentrations were significantly higher in fruits collected from Zone C than those from Zones A and B.

The findings demonstrate that *V. paradoxa* fruit pulp is a valuable source of natural antioxidants and that the antioxidant profile of the fruit varies across the geopolitical zones of Niger State. These variations may be associated with differences in environmental and ecological conditions among the zones. The study therefore provides useful baseline information on the nutritional and antioxidant qualities of shea fruit pulp and highlights the importance of geographical location in determining its phytochemical composition. Further studies are recommended to investigate the specific environmental factors responsible for the observed variations in antioxidant accumulation.

5.0 References

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Declarations:

Conflict of interest

The authors declare that they have no conflict of interest

Data availability

All data used in this study will be readily available to the public.

Consent for publication

Not Applicable.

Ethical consideration

Not applicable

Competing interests

The authors declared no conflict of interest.

Authors' Contributions

Amanabo Musa conceived the study, conducted field sampling, laboratory analyses, data interpretation, and drafted the manuscript. Hadiza Mohammed and Abduljelili Uthman contributed to experimental design, laboratory investigations, and manuscript review. Ele-Ojo Ataguba validated results and edited the manuscript, while Hassana Aliyu participated in ethical community engagement during sample collections and proofreading the manuscript. Muhammad U. Tyabo assisted with data analysis, interpretation of findings, and critical revision of the manuscript. All authors approved the final version.