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Safety Evaluation on Antinutritional, Bacterial Properties with Sensory Acceptability of Processed Shea (*Vitellaria Paradoxa*) Pulp Juice

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ABSTRACT

The processing of Shea (*Vitellaria paradoxa*) pulp juice plays a crucial role in its nutritional and sensory attributes, as well as its bacterial composition. This study aims to investigate the antinutritional factors, sensory properties, and microbial activity in processed Shea pulp juice. The study utilized various analytical methods, including proximate analysis, sensory evaluation, and microbial analysis. The findings provide valuable insights into the nutritional quality, taste profile, and microbial composition of Shea pulp juice after processing. The nutritional analysis revealed a substantial amount of moisture of 84.39 to 93.01%, as well as high carbohydrate and caloric values of 5.84 to 8.96% and 33.51 to 67.31%, respectively. It also had a high vitamin C concentration (16.45 - 38.99%). The anti-nutritional analysis shows the presence of phytate (42.80 ± 1.42 mg), and oxalate (0.42 ± 0.22 mg), it was also found to be very high in tannin (338.80 ± 1.36 mg). Saponin has a low content of 16.59 ± 0.14 mg and Cyanide had the lowest quantity (13.23 ± 0.13). Cyanide, oxalate, and phytate concentrations were found to be lower than the reference toxic standard level. In terms of sensory evaluation, all samples were accepted favorably with Sample A and B most preferable to C. This research contributes to the understanding of Shea pulp juice as a potential food source and highlights the importance of optimizing processing techniques to enhance its beneficial properties.

Keywords: Shea pulp juice, anti-nutritional factors, sensory properties, processing techniques

1.0 INTRODUCTION

Juice is an unfermented or fermentable liquid product derived from one or more wholesome fruits and only stored physically (Cywińska-Antonik *et al.*, 2023). It is a drink that is typically made by extracting or pressing the natural liquid found in fruits and vegetables. They are frequently consumed as a beverage, as an ingredient or flavoring in foods or other beverages such as smoothies, or as a food or beverage component (Ekanem and Agbendeh, 2022). Fruit juice is a well-known fruit product. The majority of fruit juices do not contain skin, seed, or other coarse fruit components. It can be clear, turbid, or pulpy, and it can be concentrated or water-reconstituted. Fruit juices are widely consumed around the world, not only for their flavor and taste but also for their health benefits (Xu *et al.*, 2022). Many studies have found that fruit juice components have antimicrobial and anticarcinogenic properties in

humans. These characteristics help to prevent chronic inflammatory diseases, cancer, and cardiovascular disease (Asmin and Nusrath, 2023, García-Manríquez *et al.*, 2023). Fruit juice and smoothies have grown in popularity as people become more aware of their health benefits. Given the global market potential for fruit juice, it is desirable to conduct research into discovering new wild fruits. This is because the majority of fruits used for juice today are of the conventional variety. Africa, particularly Nigeria, has a plethora of fruit-bearing trees that could be used in this capacity. One of them is the Shea fruit.

The Shea fruit (*Vitellaria paradoxa*) is a multipurpose tree native to Africa. It is well-known for the high quality of its butter and oil derived from the kernels. The Shea pulp that surrounds the kernels, on the other hand, is frequently overlooked and underutilized. In recent years, there has been

increased interest in investigating the potential of Shea pulp as a raw material for a variety of processed products, including juices (Kolo *et al.*, 2022b). Shea fruit is a multipurpose agroforestry species. The fruit has been reported to have ecological, economic, and medicinal value for humans (Kolo *et al.*, 2022b). It is widely distributed in African countries such as Nigeria, Uganda, Ghana, Mali, Congo etc (Korese and Chikpah, 2022, Nasare *et al.*, 2022). The Shea fruit is a green oval-shaped fruit that ranges in diameter from 2cm to 5cm. It has a green epicarp, a fleshy yellow pulp or mesocarp, and a hard shell or endocarp that encloses the fruit like a nut. The sweet fleshy pulp is consumed as food. When compared to citrus fruits, the pulp of the Shea fruit is said to be rich in some micronutrients. The B vitamins are also found in the Shea fruit pulp. The pulp also has a high sugar content, consisting of glucose, fructose, and sucrose (Kolo *et al.*, 2022a).

The rural population relies on Shea butter for food preparation, cosmetics, therapeutic applications, and healing properties (Kolo *et al.*, 2022b). As a result of ignorance about the nutritional value and bioactive properties of the fruit pulp, significant loss occurs during Shea butter extraction (Akoma *et al.*, 2018, Kolo *et al.*, 2022b, Maanikuu and Peker, 2017). Despite its potential, gatherers throw out more than 99% of this pulp. Several studies on the pulp of the Shea fruit from Chad, Nigeria, and Uganda revealed that it contains a significant amount of nutrients such as proteins, fibers, minerals, and vitamins (Makin and Gwarzo, 2020). Kolo *et al.*, (2022b) discovered that Shea pulp juice can be extracted and will still retain a significant amount of nutrients. However, some safety concerns about Shea pulp juice must be addressed.

Anti-nutritional factors are naturally occurring compounds in food that inhibit nutrient absorption or have negative health effects. They are common in many plant-based foods and can have nutritional and toxicological consequences (Urugo and Tringo, 2023). To assess the safety of Shea pulp juice for consumption, the presence and levels of anti-nutritional factors must be assessed. Tannins, phytates, trypsin inhibitors, and oxalates have been found in various parts of the Shea plant, according to previous research (Anhwange and Ese, 2022,

Choungo Nguekeng *et al.*, 2021). Recognizing the anti-nutritional profile of processed Shea pulp juice can help you understand its potential health benefits and risks. Sensory qualities are also important in determining consumer acceptance of food products. To ensure consumer sensory appeal, the sensory attributes of Shea pulp juice must be evaluated. This will provide valuable information about the sensory characteristics of Shea pulp juice and help in product development and optimization. Furthermore, the microbial composition of processed Shea pulp juice is an important aspect to consider from a food safety perspective. The presence of bacteria in the juice can significantly influence its quality, shelf life, and potential health benefits.

Therefore, there is a need to investigate the anti-nutritional factors, sensory properties, and microbial activity of Shea pulp juice. The present study evaluated the anti-nutritional, sensory acceptance and bacterial quality of the Shea fruit pulp collected from Niger state.

2.0 MATERIALS AND METHODS

2.1 Sample collection

Shea fruits were harvested within Niger State's Bakeko district of Katcha Local Government Area. A stratified random sampling approach was used to collect ten (10) kilograms of Shea fruit. Fruits that were sorted, leaving only healthy and ripe fruits. After that, it was thoroughly washed in distilled water to remove foreign substances like dirt and plant debris. The fruits were packed into boxes and delivered to Ibrahim Badamasi Babangida University's Food Science Department in Lapai. Fruits were preserved in freezers at the Laboratory ahead of processing and laboratory analysis.

2.2 Preparation of Shea fruit pulp juices

Figure 1. depicts the production of shea pulp juice. The shea fruit was defrosted and thoroughly washed under running water. The skin was then peeled to reveal the pulp. It was then separated from the nut. After that, the extracted pulp was blended with water. It was filtered using a muslin cloth. Preservatives and additives were added and then stored in the refrigerator for further analysis. Table 1 displays three different experimental runs for the

Shea fruit pulp juice formulations (Kolo *et al.*, 2022b).

Table 1: Shea Fruit Juice Formulation

Ingredients	A	B	C
Shea fruit pulp (ml)	100	250	500
Boiled water (ml)	700	600	300

Additives :CMC, Carboxy Methyl Cellulose (2.4g), white sugar(48g), citric acid (4g), potassium benzoate(0.24g), sodium benzoate (0.16g), sodium metabisulphite (0.01%), ascorbic acid (0.005%); A, B, C, Formulations

2.3 Nutritional analysis

Proximate composition was determined by standard methods (Carbohydrate, Moisture and crude protein content, ash content, and crude fiber) (AOAC, 2000).

2.4 Antinutritional analysis

For phytate determination, the Ola and Oboh, (2000) method was used. The AOAC, (1990) method was used to determine hydrocyanic acid. Oxalate was determined using the method adopted by (Ahmad *et al.*, 2022). For the determination of tannins, the method of (Tiencheu *et al.*, 2021) was employed.

2.5 Microbial Analysis

The total colony counts on plate count agar (PCA) were determined using the spread plate method. After arranging with different dilutions of microorganism suspension, the plates were incubated at 37o C for 48 hours and colonies were counted (Ayegnon *et al.*, 2021).

2.6 Sensory Evaluation

A 9-point hedonic scale and 25 panelists (both trained and untrained) were used for sensory evaluation. Samples were distributed to each panelist. Each sample was evaluated on a sensory score sheet for attributes such as color, flavor, texture, taste, consistency, sweetness, appearance, and overall acceptability by the panelists. Between product evaluations, panel members washed their mouths with provided bottled water. Each judge was asked to rate each product with coded samples

on a nine-point scale. The same procedures were used to make Shea juice and juice from a local mango variety. All juices were served to the panelists at room temperature in transparent disposable cups under normal lighting conditions.

2.7 Data analysis

The obtained result was subjected to mean and standard error analysis. The trial data were analyzed using a one-way analysis of variance (ANOVA) at p0.05.

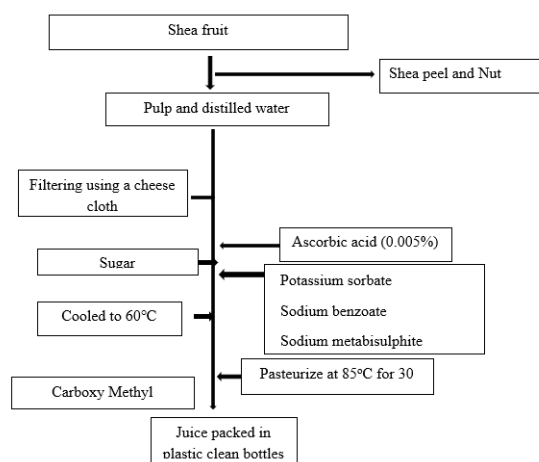


Figure 1: Flowchart for processing of juice from Shea pulp

3.0 RESULT AND DISCUSSION

3.1 Nutritional analysis

The moisture content of juice samples was determined, as shown in Table 2. The formulation values for Shea pulp (10, 25, and 50%) ranged from 84.39 to 93.01 %. According to reports by Bhalerao *et al.*, (2020), the values obtained were found within the acceptable range for fruit juices (80-95 percent). The study also discovered that Sample C contained the most ash, and the presence of ash has been reported to be an indicator of mineral content (Adedeji *et al.*, 2008). Shea pulp and Shea pulp wine have also been reported to have a high ash content; similarly, the ash content in juice can be easily translated (Lowor and Yabani, 2019). Low protein levels (0.61 - 2.72%) were found in Shea pulp juice, as is the case with most fruit juices, which are known to have a low protein content (Granucci *et al.*, 2023). All formulated samples had high carbohydrate and caloric values, as well as high vitamin C levels. Fruit juices receive high ratings due to the presence of vitamin C, which

indicates that when consumed, the juice can improve the immune system (Ajayi *et al.*, 2023).

Table 2: Nutritional Analysis of the Processed Shea Pulp Juice

Parameters	Sample A	Sample B	Sample C	Control (SP)
Moisture content (g/ml)	92.87±0.33 ^b	89.74±0.49 ^a	84.39±0.01 ^a	93.01±0.01 ^b
crude protein (g/ml)	0.62±0.04 ^a	1.45±0.05 ^a	2.72±0.06 ^b	0.61±0.51 ^a
Ash content (g/ml)	0.38±0.04 ^a	1.03±0.07 ^b	1.77±0.05 ^b	1.01±0.0 ^a
Fat content (g/ml)	0.81±0.02 ^a	0.92±0.03 ^a	2.01±0.29 ^a	1.01±0.01 ^a
CHO (g/ml)	5.84±0.17 ^a	6.84±0.26 ^b	8.96±0.06 ^b	9.11±0.01 ^b
VITC	16.45±0.23 ^a	18.935±0.14 ^a	38.99±0.33 ^b	14.20±0.51 ^a
Energy KCAL (kcal/ml)	33.51±0.05 ^a	48.56±0.53 ^b	67.31±0.51 ^c	50.01±0.01 ^b

Note: values in the same column with different superscript letters are statistically significant (P< 0.05). SP=Shea pulp

3.1 Antinutritional analysis

The result of antinutritional factors was presented in Table 3. The phytate content of the pulp was 42.80±1.42mg/100g. this is similar to the result obtained from other fruit juices such as *Sclerocarya birrea* Fruit Juice (Hassan *et al.*, 2010). Phytate has been depicted to interfere with mineral elements and protein bioavailability in monogastric animals (Sahu *et al.*, 2023). The oxalate content of the pulp was 0.42±0.22mg (3.40mg/100g DW). In comparison with other fruit juices, such as Banana (4.50mg/100g DW) and Apple juice, it is relatively low but falls in line with *Sclerocarya birrea* Fruit Juice (3.91mg/100g DW) (Hassan *et al.*, 2010, Onibon *et al.*, 2007). As reported by (Popova and Mihaylova, 2019), The presence of oxalate in food causes mouth irritation and interferes with mineral absorption, particularly calcium absorption, by forming an insoluble salt with them. The pulp was observed to have a very high tannin content of 338.80± 1.36mg. Tannins in the biological system can chelate Protein to make digestion difficult, and the astringency of shea pulp could be linked to its high tannin concentration. This is found in a similar result obtained by Hassan *et al.*, (2010), in the evaluation of *Sclerocarya birrea* Fruit Juice and relatable to the astringency in apple juice (Liu *et al.*, 2022). The Saponin has a low content of 16.59±0.14mg and Cyanide was present in low quantity (13.23±0.13). As reported by Hassan *et al.*, (2010), the cyanide concentration in the juice is within the allowable range of 200mg HCN/100g for human consumption.

Table 3. Anti-nutritional Composition of the Shea Fruit Pulp.

Anti-nutrients	Composition (mg) Mean±SD
Phytate	42.80 ± 1.42
Oxalate	0.42 ± 0.22
Tannin	338.80 ± 1.36
Saponin	16.59 ± 0.14
Cyanide	13.23± 0.13

3.2 Bacterial Analysis

The bacterial counts expressed in cfu/ml of the formulated Shea pulp juice at different percentage is presented in Table 4. The 25% sample had the highest number of bacterial colony counts 4.1×10^3 cfu/ml to 1.6×10^{-4} cfu/ml. It was noted that the 25% formulated Shea pulp juice had the highest bacteria count and the lowest bacterial count was found to be on the 50% formulated Shea pulp juice. According to the guidelines for the microbiological quality of ready-to-eat foods, the shea pulp juice of all samples was not within acceptable limits. i.e. >105 (Mengistu *et al.*, 2022, Oladipo *et al.*, 2022). Poor hygienic conditions during pulp extraction or juice production can be blamed for this. This is because the samples were obtained from farms and forests, and the fruits were exposed to contamination at every stage from farm to fork. It could be caused by the presence of microbes on the surface of raw material used to make Shea pulp juice. Water introduced into the sample and also used to wash utensils and hands in one or more buckets could contaminate the product in most cases. Because of the fluctuating power supply, safe storage.

3.3 Sensory Evaluation

In comparison to the reference mango juice, Shea pulp juice formulations containing 25% and 50% Shea fruit pulp appear to be the most preferred in terms of flavor, appearance, consistency, and

overall acceptability, as shown in Table 5. These two formulations are preferred over the 10% Shea fruit pulp formulation, particularly in terms of taste and color, which have average score values of less than 6 but are deemed acceptable by the panel.

Table 4: Bacterial Load Count (cfu/ml)

Sample dilution factor	number of colony	Microbial Load (cfu/ml)
Sample A (10%)		
A ₁	10 ⁻³	302
A ₂	10 ⁻⁴	280
Sample B (25%)		
B ₁	10 ⁻³	401
B ₂	10 ⁻⁴	302
Sample C (50%)		
C ₁	10 ⁻³	201
C ₂	10 ⁻⁴	106

Table 5: Sensory Evaluation of Formulated Shea Pulp Juice

% Shea pulp	Flavor	Taste	Color	Appearance	Consistency	Sweetness	overall Acceptability
10	6.25±1.8 ^{ab}	4.85±1.4 ^c	4.80±1.6 ^d	6.25±1.6 ^a	5.30±1.2 ^c	4.60±1.5 ^d	5.65±1.5 ^c
25	6.75±1.6 ^a	5.80±2.0 ^b	5.75±2.1 ^b	6.15±1.2 ^a	5.80±1.9 ^b	5.95±2.4 ^c	6.50±2.7 ^b
50	5.55±1.6 ^a	5.75±1.7 ^b	5.50±2.4 ^c	5.55±1.8 ^b	5.90±1.8 ^b	6.5±1.8 ^b	6.35±2.6 ^b
Control	6.85±2.3 ^a	6.85±2.2 ^a	7.85±2.3 ^a	6.75±2.0 ^a	7.05±2.0 ^a	6.91±1.6 ^a	7.45±2.0 ^a

Results are expressed as mean ± standard deviation. Scale: 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, and 9=like extremely. Mean scores in the same column followed by the same superscript letter are not significantly different from each other (P>0.05). control= mango reference sample

4.0 CONCLUSION

This study recognized that Shea fruit pulps can produce high-quality juice. The juice may be a good source of carbohydrates and vitamin C which are abundant. Sensory assessments demonstrate that the products are acceptable and can compete in the market positively with other commonly available products such as mango juice. The molar ratio of anti-nutrients to nutrients indicates that all values obtained are within the safe range for consumption. The microbial analysis results, on the other hand, indicate poor and inappropriate handling and storage of Shea fruit juice, which could be the result of poor adherence to safety practices. As a result, sanitary inspection and practices must be strengthened at all stages of juice production. Further investigation needs to be

carried out to establish the shelf life of the juice, optimize production on a larger scale and assess the potential of the Shea pulp in the confectionaries.

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REFERENCES

Ahmad, D., Gambo, A. & Clement, T. D. (2022). Quality Evaluation Of Some Local Beverages (Zobo Drink, Kunun Zaki, Kunun Aya And Tamarind Juice) Sold In Sabon Gari Market

- Kano State. Journal of Advanced Science and Optimization Research, 23, 297 - 310.
- Ajayi, A.M., Adebajo, I.M. and Ademowo, O.G., 2023. Vitamin C-rich juice co-administration with artemether-lumefantrine ameliorates oxido-inflammatory responses in Plasmodium berghei-infected mice. Parasitology Research, pp.1-10. <https://doi.org/10.1007/s00436-023-07885-5>
- Akoma, O., Nma, N., Musa, S. and Salihu, A., 2018. Nutritional and phytochemical composition of Vitellaria paradoxa (Shea Fruit Pulp). International Journal of Biochemistry Research & Review, 22(1), pp.1-7.
- Anhwange, A. & Ese, H. (2022). Chemical Analysis Of Shea Butter (Vitellaria Paradoxa) Nut Obtained From Benue State. Nigerian Annals Of Pure And Applied Sciences, 5, 287-295. <https://doi.org/10.5281/zenodo.7338397>
- AOAC (1990). Official Methods of Analysis, Association of Official Analytical Chemists, Washington DC.
- AOAC (2000). Official Methods of Analysis, Association of Official Analytical Chemists, Washington DC.
- Asmin, P. & Nusrath, F. (2023). The Effects of Fresh Fruit Extracts and Commercially Available Fruit Extracts on the Growth of Streptococcus Mutans—An In Vitro Study. <https://doi.org/10.38138/JMDR/v9i1.23.4>
- Ayegnon, B. P., Chabi, I. B., Akogou, F. U. G. & Kayodé, A. P. P. (2021). Physicochemical characterization and microbiology quality of the Pentadesma butyacea fruit pulp collected from various parks in Benin. Scientific Reports, 11, 17040. <https://doi.org/10.1038/s41598-021-96211-z>
- Bhalerao, P. P., Mahale, S. A., Dhar, R. & Chakraborty, S. (2020). Optimizing the formulation for a pomegranate-amlamuskmelon-based mixed fruit beverage using sensory analysis and evaluating its thermal stability. LWT, 133, 109907. <https://doi.org/10.1016/j.lwt.2020.109907>
- Choungou Nguekeng, P. B., Hendre, P., Tchoundjeu, Z., Kalousová, M., Tchanou Tchapa, A. V., Kyereh, D., Masters, E. & Lojka, B. (2021). The current state of knowledge of shea butter tree (Vitellaria paradoxa cf Gaertner.) for nutritional value and tree improvement in West and Central Africa. Forests, 12, 1740. <https://doi.org/10.3390/f12121740>
- Cywińska-Antonik, M., Chen, Z., Groele, B. & Marszałek, K. (2023). Application of Emerging Techniques in Reduction of the Sugar Content of Fruit Juice: Current Challenges and Future Perspectives. Foods, 12, 1181. <https://doi.org/10.3390/foods12061181>
- Ekanem, S. & Agbendeh, Z. (2022). Assessment Of The Nutritional Content Of Some Fruit Juices Distributed In Sabon Gari Market, Zaria, Nigeria. Journal of Chemical Society of Nigeria, 47. <https://doi.org/10.46602/jcsn.v47i4.789>
- García-Manríquez, N., Lozano, C., Muñoz, A., Morales, M. F. & Giacaman, R. A. (2023). Anticaries properties of natural berries: a systematic literature review. Nutrition Reviews, nuad063. <https://doi.org/10.1093/nutrit/nuad063>
- Granucci, N., Harris, P. J. & Villas-Boas, S. G. (2023). Chemical Compositions of Fruit and Vegetable Pomaces from the Beverage Industries. Waste and Biomass Valorization, 1-16. <https://doi.org/10.1007/s12649-023-02095-7>
- Hassan, L., Dangoggo, S., Hassan, S., Muhammad, S. & Umar, K. (2010). Nutritional and antinutritional composition of Sclerocarya birrea fruit juice. Nigerian Journal of Basic and Applied Sciences, 18.
- Kolo, S., Dadi-Mamud, N., Aliyu-Paiko, M. & Jubril, B. (2022a). Nutritional Profile of Shea Tree (Vitellaria paradoxa) Fruit Pulp in Lapai, Nigeria. Lapai Journal of Applied and Natural Sciences, 7, 74 - 77.
- Kolo, S., Dadi-Mamud, N., Aliyu-Paiko, M. & Jubril, B. (2022b). Shea (Vitellaria paradoxa) Pulp Juice Production and Quality Evaluation via Proximate and Mineral Composition Analyses. Journal of Applied Sciences and Environmental Management, 26, 1727-1731. <https://dx.doi.org/10.4314/jasem.v26i10.17>
- Korese, J. K. & Chikpah, S. K. (2022). Understanding infrared drying behavior of shea (Vitellaria paradoxa) fruit by-product for the production of value-added products. Biomass Conversion and Biorefinery, 1-15. <https://doi.org/10.1007/s13399-022-03494-x>
- Liu, J., Xie, J., Lin, J., Xie, X., Fan, S., Han, X., Zhang, D.-K. & Han, L. (2022). The material basis of astringency and the deastringent effect of polysaccharides: A review. Food Chemistry,

134946.
<https://doi.org/10.1016/j.foodchem.2022.134946>
- Lowor, S. T. & Yabani, D. T. (2019). Elaboration of wine and vinegar from Shea (*Vitellaria Paradoxa* Gaernt) fruit. *Chemistry Research Journal*, 6:7-21
- Maanikuu, P. M. I. & Peker, K. (2017). Medicinal and nutritional benefits from the Shea tree (*Vitellaria paradoxa*). *Journal of Biology Agriculture and Healthcare*, 7, 51-57.
- Makin, T. & Gwarzo, A. (2020). Phytochemical and Antibacterial Activities of *Vitellaria paradoxa* Stem Bark and Root Extracts against Some Clinical Isolates of Respiratory Tract Infections. *Dutse Journal of Pure and Applied Sciences* 6, 139-149.
- Mengistu, D. A., Belami, D. D., Tefera, A. A. & Alemeshet Asefa, Y. (2022). Bacteriological quality and public health risk of ready-to-eat foods in developing countries: Systematic review and meta-analysis. *Microbiology insights*, 15,.
<https://doi.org/10.1177/11786361221113916>
- Nasare, L. I., Stout, J., Lovett, P. & Kwapong, P. K. (2022). Determinants Of Shea (*Vitellaria paradoxa* CF Gaertn.) fruit yield: A review of research approaches and current knowledge. *Scientific African*, e01371.
<https://doi.org/10.1016/j.sciaf.2022.e01371>
- Ola, F. & Oboh, G. (2000). Food Value Of Two Nigerian Edible Mushrooms (*Termitomyces stratus* and *Termitomyces robustus*). *The journal of technoscience*, 4, 1-3.
- Oladipo, I. C., Oyelami, R., Ogundej, K. D., Akinteye, E. O., Adewoyin, A. G. & Oladipo, A. O. (2022). Microbial Quality, Vitamin, Mineral and Proximate Composition of Some Fresh Fruit Juice Samples. *European Journal of Biology and Biotechnology*, 3, 25-29.
<https://doi.org/10.24018/ejbio.2022.3.5.397>
- Onibon, V., Abulude, F. & Lawal, L. (2007). Nutritional and anti-nutritional composition of some Nigerian fruits. *Journal of Food Technology*, 5, 120-122.
- Popova, A. & Mihaylova, D. (2019). Antinutrients In Plant-Based Foods: A Review. *The Open Biotechnology Journal*, 13.
<http://dx.doi.org/10.2174/1874070701913010068>
- Sahu, A., Verma, R., Gupta, U., Kashyap, S. & Sanyal, I. (2023). An Overview of Targeted Genome Editing Strategies for Reducing the Biosynthesis of Phytic Acid: An Anti-nutrient in Crop Plants. *Molecular Biotechnology*, 1-15.
<https://doi.org/10.1007/s12033-023-00722-1>
- Tiencheu, B., Nji, D. N., Achidi, A. U., Egbe, A. C., Tenyang, N., Ngongang, E. F. T., Djikeng, F. T. & Fossi, B. T. (2021). Nutritional, sensory, physicochemical, phytochemical, microbiological and shelf-life studies of natural fruit juice formulated from orange (*Citrus sinensis*), lemon (*Citrus limon*), Honey and Ginger (*Zingiber officinale*). *Heliyon*, 7.
<https://doi.org/10.1016/j.heliyon.2021.e07177>
- Urugo, M. M. & Tringo, T. T. (2023). Naturally Occurring Plant Food Toxicants and the Role of Food Processing Methods in Their Detoxification.
<https://doi.org/10.1155/2023/9947841>
- Xu, L., Xu, Z. & Liao, X. (2022). A review of fruit juice authenticity assessments: Targeted and untargeted analyses. *Critical Reviews in Food Science and Nutrition*, 62, 6081-6102.
<https://doi.org/10.1080/10408398.2021.1895713>