American Journal of Applied Sciences and Engineering | *ISSN 2766-7596*
Published by AIR JOURNALS | *https://airjournal.org/ajase*
12011 WestBrae Pkwy, Houston, TX 77031, United States
airjournals@gmail.com; enquiry@airjournal.org

Research Article

Nutrient Compositional Characteristics of Coconut Kernel, Palm Kernel, Cocoa Seed, Bitter Kola, Breadfruit and African Yam Bean

Okolotu G. I.[1], Akpoghelie P. O.[2], Akwenuke O. M.[3], Okoronkwo K. A.[4], Adaigho D. O.[5], Ogbodhu C. U.[6], Owheruo J. O.[7], Uguru H.[8], & Nyorere O.[9]

[189]Department of Agricultural Engineering, Delta State University of Science and Technology, Ozoro, Nigeria
[246]Department of Food Science and Technology, Delta State University of Science and Technology, Ozoro, Nigeria
[3]Department of Civil Engineering, Delta State University of Science and Technology, Ozoro, Nigeria
[5]Department of Agricultural Economics, Delta State University of Science and Technology, Ozoro, Nigeria
[6]Department of Chemical Engineering, Delta State University of Science and Technology, Ozoro, Nigeria

Abstract

The nutrient compositional characteristics of the coconut kernel, palm kernel, cocoa seed, bitter kola, breadfruit and African yam bean are of great importance in identifying their major constituents. Prior sample collection and preparation, ash content, moisture content, fat/lipid content, crude fiber, crude protein, and carbohydrate content were proximately analyzed. Also, the obtained results were reviewed with relative works. The coconut kernel contained 2.99% ash content, 1.43% moisture content, 45.50% fat/lipid content, 14.59% crude fiber, 19.56% protein content, and 15.93% carbohydrate. The palm kernel contained 10.30% ash content, 0.23% moisture content, 24.60% fat/lipid content, 20.50% crude fiber, 29.05% protein content and 15.32% carbohydrate. The cocoa seed contained 5.30% ash content, 1.70% moisture content, 44.90% fat/lipid content, 1.49% crude fiber, 15.80% protein content, and 30.81% carbohydrate. The bitter kola contained 1.00% ash content, 0.84% moisture content, 26.70% fat/lipid content, 52.50% crude fiber, 9.10% protein content, and 9.86% carbohydrate. The breadfruit contained 0.50% ash content, 1.18% moisture content, 9.90% fat/lipid content, 0.14% crude fiber, 33.00% protein content, and 55.28% carbohydrate. The African yam bean contained 3.45% ash content, 1.30% moisture content, 7.40% fat/lipid content, 8.15% crude fiber, 21.16% protein content, and 58.54% carbohydrate. It was found that: the coconut kernel possesses more fat/lipid content, protein content and carbohydrate. The palm kernel possesses more protein content, fat/lipid content and crude fiber. The cocoa seed possesses more fat/lipid content, carbohydrate and protein. The bitter kola seed possesses more crude fiber, fat/lipid content and protein content. The bread fruit possesses more carbohydrate, protein and fat/lipid content. The African yam bean possesses more carbohydrate, protein and crude fiber content. The results review showed that the results will be useful in future range determination. Research recommendation on specie influence on compositional (nutrient) variations of these food produce is thus proffered as vital future research topic.

Keywords	*Compositional Characteristics; Coconut Kernel; Palm Kernel; Cocoa Seed; Bitter Kola; Breadfruit; African Yam Bean*
Citation	Okolotu, G. I., Akpoghelie P. O., Akwenuke O. M., Okoronkwo K. A., Adaigho D. O., Ogbodhu C. U., Owheruo J. O., Uguru H., & Nyorere O. (2024). Nutrient Compositional Characteristics of Coconut Kernel, Palm Kernel, Cocoa Seed, Bitter Kola, Breadfruit and African Yam Bean. *American Journal of Applied Sciences and Engineering, 5(1) 1-9.* https://doi.org/10.5281/zenodo.10892455

Introduction

The world population is on the increase even with a declining growth rate (Egharevba, 2009; Okolotu and Oluka, 2021). The need for food compositional characteristics is a requisite for choosing appropriate food substances for required purpose. The coconut kernel, palm kernel, cocoa seed, bitter kola, breadfruit and African yam bean were being examined for their compositional characteristics.

Coconut Kernel: The coconut kernel is the white last layer inside the coconut. Coconut (*Cocos nucifera L*.) is a member of the Palmacea family, popularly known as the coconut palm in the tropics. Coconut palm produce a drupe of about 52% kernel composition, 38% shell composition and 10% water composition. The kernel is the white flesh in the coconut. It is the eatable white inner most part of the coconut that is found inside the hard brown shell. Generally, the entire coconut fruit takes a year to mature with various developmental stages: the husk and shell develop first, followed by enlargement of embryo sac cavity, which is then filled with liquid; the husk and shell becomes thicker after 4 months; the meat starts to form against the inner wall of the cavity after 6 months with the first layer being thin and gelatinous; after 8 months the soft white endocarp turns dark brown and becomes hard; and lastly the fruit becomes mature within 1 year (12 months) (Patil and Benjakul, 2018; Adoyo *et al*. 2021).

Palm Kernel: The palm kernel is the edible seed of the oil palm fruit (Wikipedia, 2022). The palm kernel is a tropical nut produced from the palm fruit tree (*Elaeis Guineensis*). Palm tree produces seed that has an outer edible part (when plug fresh) and the inner edible part (when cracked). Both the inner and outer part of the seed are used in production of oil, thus the host body is called oil palm tree. Palm kernel nut is the enclosed seed inside the hard fibrous material known as the shell which are cracked manually with harder solids or mechanically using the shelling machine. Okoli (2020) noted that at industrial scale, every 100 tons of palm fruit bunch processed yields about 4 tons of crude palm oil, and about 4 tons of palm kernel, while the remaining 74 tons end up as by – products, and wastes during different stages of milling process.

Cocoa Seed: The Cocoa bean (Technically cocoa seed) or simply Cocoa, also called Cacao, is the dried and fully fermented seed of *Theobroma Cacao*, from which Cocoa solids (a mixture of non-fat substances) and Cocoa butter (the fat) can be extracted (Wikipedia, 2023). It has three main varieties. The three main varieties of Cocoa plant are Forastero, Criollo, and Trinitario, with Forastero being the most widely used (Wikipedia, 2023). The cocoa bean is the seed of the cacao tree (*Theobroma Cacao*), a tropical plant indigenous to the equatorial regions of the Americas (Singh and cook, 2023). The Cocoa tree grows in a limited geographical zone, and today West Africa produces nearly 81 % of the worlds crop (Wikipedia, 2023). The cocoa plant produces its pods containing many seeds. Singh and cook (2023) noted that the ripe seed pods are cut from the trees, split open, and the cocoa beans removed from the pods.

Bitter Kola: Bitter Kola (*Garcinia Kola*), a popular nut consumed in virtually all parts of West Africa contains substances that are attributed to its numerous effects on human (Aniwada and Ezema, 2022). The seed is eaten raw as a stimulant because of its better astringent taste, which is followed by a slight sweetness. The seeds are habitually chewed as part of traditional, cultural and social ceremonies and for their aphrodisiacal effect (Manourova *et al*. 2019; Tauchen *et al*. 2023). It is a brownish shell - coated nut with a whitish seed. Although G. kola seeds are more valued for their medicinal properties rather than as food stuff, the kernels are still commonly consumed, which justifies concerns about their nutritional value (Tauchen *et al*. 2023).

Breadfruit: The African breadfruit (*Treculia Africana Decne*) is large evergreen tree found in tropical and sub – tropical humid forests (Ojimelukwe and Ugwuona, 2021). The species originated in Oceania, and is grown across the pacific region; it is now found in many countries in tropical zones across the world, including in Africa, Australia, South America, South and Southeast Asia (FAO, 2023). The African breadfruit is locally called Ukwa in Nigeria. Breadfruit is highly diverse (Over 120 known varieties) tropical fruit tree growing to heights of 9 to 18 metres with large (20 – 90 cm long) dark green leaves (FAO, 023). It belongs to the family Moraceae and can grow to a height of 30m while the stem can be up to 6m wide (Ojimelukwe and Ugwuona, 2021). The tree bears fruit which can be eaten raw, cooked or processed. The fruit ranges from 9 to 45cm in length and from 5 to 30cm in diameter and weighs up to 6kg (FAO, 2023).

African Yam Beans: The African yam bean, *Sphenostylis Stenocarpa Hochst ex. A. Richmond, Harms*, is an indigenous tuberous legume of the humid tropics of Africa (Adewale and Nnamani, 2022). It belongs to the class Magnoliopsida; order Fabales; family Fabaceae; sub family Papilionoideaea; and genus Sphenostylis (Adewele and Dumet, 2014). It grows up to height of 1.5 to 3m or more with pods flat or raised in a ridge – like form. Each pod can yield up to 20 seeds which may be round, oval, oblong, or rhomboid (Adewele and Dumet, 2014).

Materials

The major materials used for this research are; coconut kernel, palm kernel, cocoa seed, bitter kola, breadfruit, African yam bean, and secondary data of reviewed relative works.

Other materials include; Water Bath, Hot Plate, Electronic Weighing Balance, Oven, Muffle Furnace, Grinder, Crucible, Conical Flask, Test Tubes, Beaker, Kjeldal Flask, Distillation Apparatus, Soxhlet Extractor, Spatula, Volumetric Flask, Measuring Cylinder, Thermometer, Petri Dish, Titration Apparatus, Reagents (Sulphuric Acid, Ethanol, Sodium Hydroxide, Sodium Sulphate, Copper Sulphate, Boric Acid, Methyl Red, N Hexane, Zinc Metal, Desiccators, Distilled Water), *etc*.

Methods

The methods used in actualization of this research work include: sample collection and preparation, compositional characterization, and presentation and review of results.

1. Sample Collection and Preparation These are presented below;

i. **Coconut Sample Collection and Preparation** The coconut fruit used for the analysis was collected with its husks and transported to the Laboratory. The husk was removed from the thick mesocarp and cracked open. The coconut fruit was collected and sliced into smaller particles. The sample was allowed to dry for 6 days with ambient temperature to remove the excess moisture. The sliced coconut fruit was grounded to mini particles used for analysis

ii. **Palm Kernel Sample Collection and Preparation** The palm kernel used for analysis was collected fresh from its palm tree, knocked off from the host, bagged and transported to the Laboratory. The raw kernel was dried for 8 days before crushing. The nuts were crushed into smaller particles and the crushed palm kernel nuts were air-dried for three (3) days and were stored in a plastic container for its analysis.

iii. **Cocoa Seed Sample Collection and Preparation:** The cocoa seed used for the analysis was collected and transported to the Laboratory using the polyethylene bag. The sample collected was in semi-dried form but was further dried using air-drying method for about 14 days. The dried sample was transferred to the electronic blender and was pulverized to powder. Furthermore, the powdered cocoa seed sample was weighed (4kg) and stored in an air-tight container for its analysis.

iv. **Bitter Kola Seed Sample Collection and Preparation** Six bitter kola seeds used for the analysis were carefully selected and transported to the Laboratory. The mesocarp was removed from each seeds and the bitter kola seeds were sliced into smaller components using the laboratory knife. The sliced bitter kola seeds were allowed to dry for 12 days with ambient temperature. The dried sliced bitter kola seeds were grounded into powder and stored in an air - tight container for the purpose of analysis.

v. **Breadfruit Sample Collection and Preparation** The fresh breadfruit used for the analysis were collected and carefully sorted out to remove the damaged ones and the remaining seeds were transported to the Laboratory with a clean polyethylene bag for further analysis. The samples were allowed to dry under room temperature for a period of 12 days. These drying processes were carried out in a clean sterilized table in the laboratory and the reason is to remove excess water content and moisture in the plant produce. The dried sample was grounded to powder with a mechanical grinder and was stored in a storage bottle for its analysis.

vi. **African Yam Beans Sample Collection and Preparation** The African yam beans used for the analysis were collected, sorted and transported to the Laboratory using a clean polyethylene bag. The samples were allowed to dry under room temperature for a period of 12 days. The dried sample was grounded to powder with a mechanical grinder and was stored in a storage bottle for its analysis.

2. Compositional Characterization: This was obtained prior proximate analysis which involves the determination of the constituents of the following parameters: ash content, moisture content, fat/lipid content, crude fiber, crude protein, and carbohydrate content. These analyses were in line with the guidelines of Joy *et al*. (2015), Adoyo and Onyango, (2021), and Okolotu *et al.* (2024). The methods used in obtaining the proximate analysis of these parameters were based on Okolotu *et al.* (2024).

Results

The obtained results are presented below:

Table 1: The results of the compositional values for various agricultural food parameters

S/N	*Parameters*	*Ash content (%)*	*Moisture content (%)*	*Fat/Lipid content (%)*	*Crude fiber (%)*	*Protein content (%)*	*Carbohydrate (%)*
1	Coconut Kernel	2.99	1.43	45.50	14.59	19.56	15.93
2	Palm kernel nut	10.30	0.23	24.60	20.50	29.05	15.32
3	cocoa seed	5.30	1.70	44.90	1.49	15.80	30.81
4	bitter kola seed	1.00	0.84	26.70	52.50	9.10	9.86
5	Bread Fruit	0.50	1.18	9.90	0.14	33.00	55.28
6	African Yam Bean	3.45	1.30	7.40	8.15	21.16	58.54

The percentage (%) values of the nutrients in the agricultural processed food produce are presented in the figures one to six (1 – 6) below;

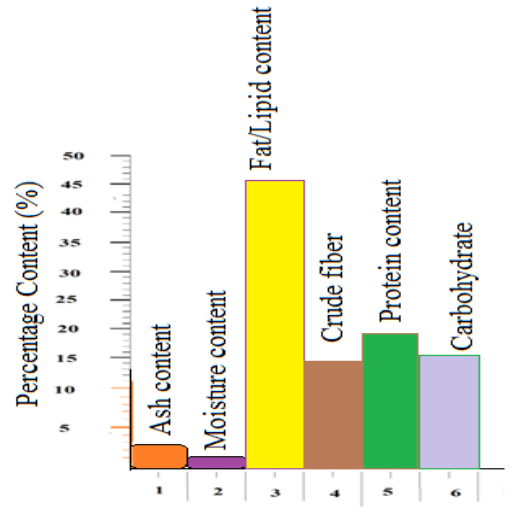

Figure 1: Percentage (%) values of the nutrients in the coconut kernel

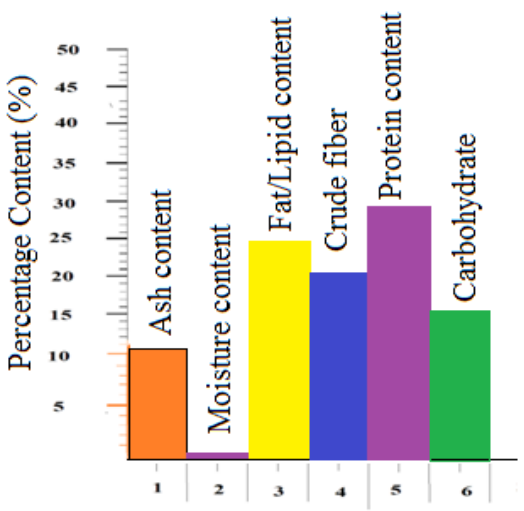

Figure 2: Percentage (%) values of the nutrients in the palm kernel nut

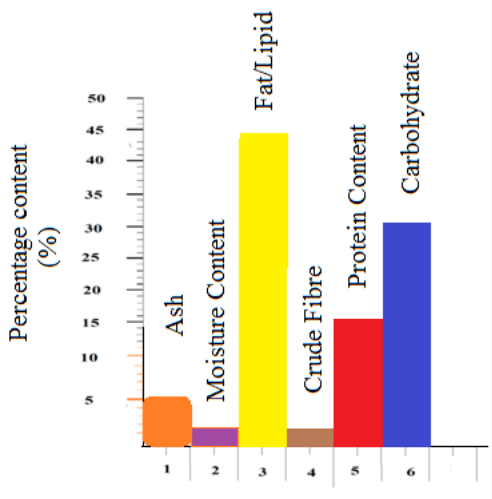

Figure 3: Percentage (%) values of the nutrients in the cocoa seed

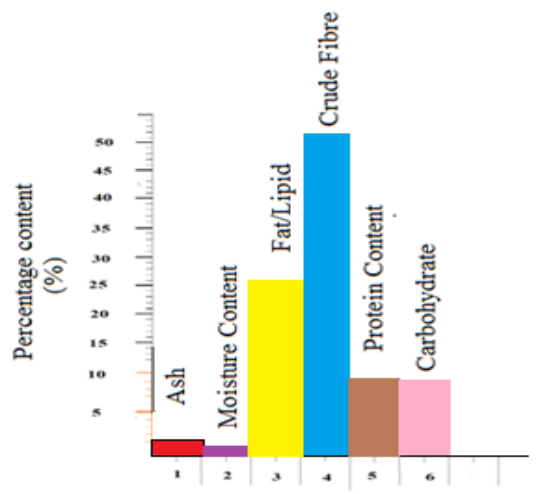

Figure 4: Percentage (%) values of the nutrients in the bitter kola seed

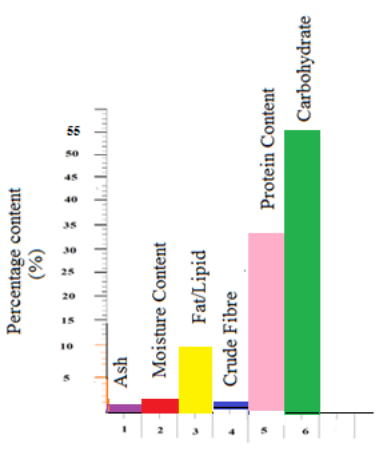

Figure 5: Percentage (%) values of the nutrients in the breadfruit

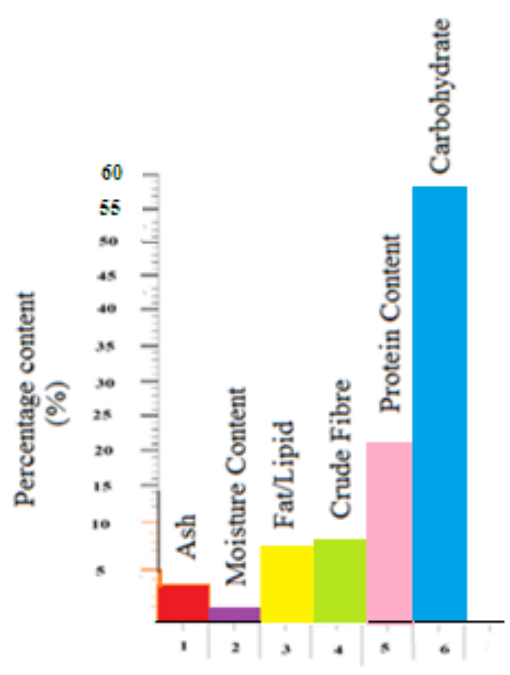

Figure 6: Percentage (%) values of the nutrients in the African yam bean

Discussions

The research discussions from the results obtained are presented below:

The coconut kernel contained 2.99% ash content, 1.43% moisture content, 45.50% fat/lipid content, 14.59% crude fiber, 19.56% protein content, and 15.93% carbohydrate. Thus, the fat/lipid content was higher than the other analyzed components, while the moisture content showed the least value. Other component values were in between. Adoyo *et al.* (2021) reported that ash was 1.02 - 1.15, moisture 43.17 - 48.23, fat 35.01 - 38.28, fiber 2.14 - 3.75, protein 3.63 - 5.81 and carbohydrate 6.15 - 13.30 for coconut kernel. Ash was above their range by 1.75% and Carbohydrate was above their range with 2.93%. Both results showed that fat content is high in the agricultural food produce. Other components were in between. Their moisture content was 43.17 - 48.23% signifying that they may have reported analysis range for the whole kernel seed and not the white kernel nut alone. Another reason that may influence the variation could be the specie of the coconut kernel due to geographical location.

The palm kernel contained 10.30% ash content, 0.23% moisture content, 24.60% fat/lipid content, 20.50% crude fiber, 29.05% protein content and15.32% carbohydrate. Thus, the protein content was higher than the other analyzed components, while the moisture content showed the least value. Other component values were in between. Atasie and Akinhanmi (2009) reported that fat is 42%, Moisture 6.5%, Crude protein 7.01%, crude fiber 11.09%, and carbohydrate 33.40% for Palm Kernel. Moisture content was lowest in both results, fat was high in both while other values showed some variations.

The cocoa seeds contained 5.30% ash content, 1.70% moisture content, 44.90% fat/lipid content, 1.49% crude fiber, 15.80% protein content, and 30.81% carbohydrate. Thus, the fat content was higher than the other analyzed components, while the crude fiber content showed the least value. Other component values were in between. IITA (2023) noted that cocoa has 20% protein, 40% carbohydrate and 40% fat. In their work they did not acknowledge ash and fiber. Feedinamics (2021) reported 17% crude protein, 20.7% crude fiber, 6% crude fat, 9.4% ash. Feedinamics (2021) did not provide carbohydrate value, while carbohydrate level in this result is lower than that of IITA (2023). Also, Ash was present though low in this result and Feedinamics (2021) but absent in IITA (2023) results. Fat content was high, followed by carbohydrate and protein in this result and that of IITA (2023). This is not in accordance with Feedinamics (2021) work. Specie variation in the cocoa may have led to the variations.

The bitter kola contained 1.00% ash content, 0.84% moisture content, 26.70% fat/lipid content, 52.50% crude fiber, 9.10% protein content, and 9.86% carbohydrate. Thus, the crude fiber content was higher than the other analyzed components, while the ash content showed the least value. Other component values were in between. Mikistas (2022) note that a 2013 study found that bitter kola was high on the following nutrients: Carbohydrates, fat and protein. This was not in correspondent with the obtained results, except for the fat content.

The breadfruit contained 0.50% ash content, 1.18% moisture content, 9.90% fat/lipid content, 0.14% crude fiber, 33.00% protein content, and 55.28% carbohydrate. Thus, the carbohydrate content was higher than the other analyzed components, while crude fiber showed the least value. Other component values were in between. Ragone (2014) reported that protein was 4.0, carbohydrate 31.9, fiber 5.4 for breadfruit. These values were for nutritional composition of the breadfruit per 100 g serving. However, same three components were higher than others with carbohydrate having the highest value.

The African yam bean contained 3.45% ash content, 1.30% moisture content, 7.40% fat/lipid content, 8.15% crude fiber, 21.16% protein content, and 58.54% carbohydrate. Thus, the carbohydrate content was higher than the other analyzed components, while the moisture content showed the least value. Other component values were in between. George et al. (2020) reported that carbohydrate is 49.88 - 63.51 %, protein 19.53 - 29.53%, Ash 1.86 - 5.35%, fat 1.39 - 7.53%, and fiber 2.47 - 9.57% in their review on African yam bean. These ranges are in accordance with the obtained results. Thus, African yam bean has more carbohydrate, followed by protein and fiber.

The differences in reports may have been influenced by some factors during analysis, for example, temperature variations in the reports (40 ^{o}C, ambient temperature or room temperature differences in regions, *etc*). Sample condition before analysis could also play role in the variation (healthiness or deficiency, fresh or processed, *etc*). Species variation prior individual nutrient composition characteristics may contribute to the differences. However, the results will be useful in future range determination.

Conclusion

It was found that: the coconut kernel possesses more fat/lipid content, protein content and carbohydrate. The palm kernel possesses more protein content, fat/lipid content and crude fiber. The cocoa seed possesses more fat/lipid, carbohydrate and protein. The bitter kola seed possesses more crude fiber, fat/lipid content and protein content. The bread fruit possesses more carbohydrate, protein and fat/lipid content. The African yam bean possesses more carbohydrate, protein content and crude fiber content. Thus, a conclusion was drawn that the above stated parameters are their major constituent characteristics.

Recommendation

Research recommendation on specie influence on compositional (nutrient) variations of these food produce is thus proffered as vital future research topic.

References

Adewale, B. D., & Nnamani, C. V. (2022). Introduction to food, feed, and health in African yam bean, a locked-in African indigenous tuberous legume. *Frontiers in Sustainable Food Systems: Sec. Crop Biology and Sustainability, 6*(2).

Adewele, D. B., & Dumet, D. J. (2014). Descriptors for African yam bean, *Sphenostylis stenocarpa* (Hochst ex. A. Rich.) Harms. *Genetic Resources Center, International Institute of Tropical Agriculture, Ibadan, Nigeria*.

Adoyo, G. O., Sila, D. N., & Onyango, A. N. (2021). Physico-chemical properties of kernel from coconut (*Cocos nucifera* L.) varieties grown at the Kenyan coast. *African Journal of Food Science, 15*(18), 314-318. http://www.academicjournals.org/AJFS

Aniwada, E. C., & Ezema, G. C. (2022). Bitter kola and kola nut use and their effect on treatment outcome on people living with HIV at a military hospital in Benue State, Nigeria. *Ethiopian Medical Journal, 60*(3).

Atasie, V. N., & Akinhanmi, T. F. (2009). Extraction, compositional studies and physico-chemical characteristics of palm kernel oil. *Pakistan Journal of Nutrition, 8*(6), 802.

Egharevba, N. A. (2009). *Irrigation and drainage engineering principles, design, and practices*. Jos University Press.

Feedinamics. (2021). Cocoa hulls. Feed Tables Organization. http://www.feedtables.com/content/cocoa-hulls

Food and Agriculture Organization of the United Nations [FAO]. (2023). Traditional crops. http://www.fao.org/traditional-crops/breadfruit/en/

George, T. T., Obilana, A. O., & Oyeyinka, S. A. (2020). The prospects of African yam bean: Past and future importance. *Heliyon, 6*(3).

IITA. (2023). Cocoa (*Theobroma cacao*). International Institute of Tropical Agriculture. http://www.iita.org/cropsnew/cocoa/

Joy, P. P., Surya, S., & Aswathy, C. (2015). *Laboratory manual of biochemistry* (1st ed.). Pineapple Research Station.

Manourova, A., Leuner, O., Tchoundjeu, Z., Damme, P. V., Verner, V., Pribyl, O., & Lojka, B. (2019). Medicinal potential, utilization and domestication status of bitter kola (*Garcinia kola* Heckel) in West Central Africa. *Forests, 10*(2).

Mikistas, C. (2022). Health benefits of bitter kola. *WebMD*. https://www.webmd.com/diet/health-benefits-bitter-kola

Ojimelukwe, P. C., & Ugwuona, F. U. (2021). The traditional and medicinal use of African breadfruit (*Treculia africana* Decne): An underutilized ethnic food of the Ibo tribe of South East, Nigeria. *Journal of Ethnic Foods, 8*(21).

Okoli, I. C. (2020). Oil palm tree waste 6: Uses of the palm kernel shell. *Tropical Research Reference Platform*. http://www.researchtropica.com

Okolotu, G. I., & Oluka, S. I. (2021). Shore reclamation for agricultural use, a combat to shoreline erosion. *Advance Journal of Science, Engineering and Technology, 6*(5), 14.

Okolotu, G. I., Adaigho, D. O., Akwenuke, O. M., Oluka, S. I., Udom, E. A., & Uguru, H. (2024). Proximate analysis of processed cashew nut (*Anacardium occidentale* L.): An agricultural processed food produce. *International Journal of Engineering and Environmental Sciences, 7*(1), 4-6.

Patil, U., & Benjakul, S. (2018). Coconut milk and coconut oil: Their manufacture associated with protein functionality. *Journal of Food Sciences, 83*(8), 2020.

Ragone, D. (2014). Breadfruit nutritional value and versatility. *Breadfruit Institute, National Tropical Botanical Garden*. http://www.breadfruit.org

Singh, R. P., & Cook, L. R. (2023). Cocoa. *Encyclopedia Britannica*. https://www.britannica.com/topic/cocoa-food

Tauchen, J., Frankova, A., Manourova, A., Valterova, I., Lojka, B., & Leuner, O. (2023). *Garcinia kola*: A critical review on chemistry and pharmacology of an important West African medicinal plant. *National Library of Medicine. PubMed.* https://pubmed.ncbi.nlm.nih.gov/37359709

Wikipedia. (2022). Palm kernel. https://en.wikipedia.org/wiki/Palm_kernel

Wikipedia. (2023). Cocoa bean. https://en.wikipedia.org/wiki/Cocoa_bean