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Effects of Two Drying Methods —Sun Drying and Shade Drying—on the Nutrient Composition of *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* Leaves

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Abstract

This study examined the effect of two drying methods—sun drying and shade drying—on the nutrient content of *Afzelia africana* (Akparata), *Cajanus cajan* (Fio-fio) and *Abelmoschus esculentus* (Okra) leaves. The samples were divided into three portions. One portion was analyzed fresh; the second was sundried while the third was shade dried. The samples were analyzed for their proximate, vitamin and mineral contents. Data obtained were analyzed using IBM SPSS version 23. Descriptive (mean and standard deviation) statistics was used to describe the data. The result showed that shade dried fio-fio leaves had the highest protein (29.76± 0.02), ash (5.98 ± 0.01) and fibre (2.60 ± 0.01) with the least moisture content (12.63± 0.02). Sundried akparata leaves had the highest fat (27.45±0.02) while shade dried akparata leaves had the highest carbohydrate (58.01 ± 0.02), Vitamin C (85.34 ± 0.02 mg), Vitamin A (3314 ± 0.01 IU). Shade dried okra leaves had the highest Iron (125.28 ± 0.02 mg). Fresh okra and fresh fio-fio leaves had the highest zinc (51.08 ± 0.01 mg) each, respectively. The study concludes that fio-fio, okra and akparata leaves contain considerable amounts of nutrients like protein, fiber, Iron and Zinc. Therefore, increase in the consumption of these leafy vegetables will help to supplement diets and alleviate the problems associated with malnutrition in the country.

Keywords: *Afzelia africana*, *Cajanus cajan*, *Abelmoschus esculentus*, sun drying, shade drying, nutrient composition

Introduction

Leguminous plants are more often than not being used as potential solution to low protein diet in most populated regions of the world (Stagnari et al., 2017). This is because most developed and developing countries do not produce sufficient amount to feed its populace, thus, the prices of imported foods are increased, leading to high rate of food scarcity and malnutrition. Some of these countries have insufficient food supply, especially protein, and they depend on carbohydrates for their daily requirement, which in turn causes incidences of non-communicable diseases such as hypertension, diabetes and obesity (WHO, 2016). Africa has diverse sources of seed bearing tree plants whose leaves are usually underutilized. Some of these plants are found in the semi-arid, sub-Saharan and

tropical zones of Africa and they include *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* (Igbabul et al., 2014; Omokpariola et al., 2021).

Afzelia africana also known as counter wood tree or African oak is a deciduous tree belonging to the family Fabaceae and sub-family Caesalpiniaceae. It is widely distributed by many African countries including Senegal, Sudan, Uganda, Tanzania, Sierra-Leone, Ghana and Nigeria (Ogbimi et al., 2020). It is called 'yiase' among the Tivs, 'akparata' among the Igbos and 'apa', 'ukpo' and 'kawa' among the Yorubas, Idomas and the Hausas of Nigeria respectively. According to Omokpariola et al. (2021), akparata seed is a good source of protein and dietary fiber that can compare with animal protein from meat, egg and fish. Soluble dietary fiber has beneficial effects on blood glucose and lipid levels in diabetes mellitus; it lowers blood pressure and serum cholesterol. It also offers protection against cardiovascular diseases, obesity and colon cancer (Chen et al., 2016). The seed has also been reported to contain rich amounts of ash and lipids (Olorunmaiye et al., 2019). Akparata has been reported to have relatively high quantities of Iron, Zinc, Phosphorus and exceptionally high amounts of Calcium (Ukeyima et al., 2019). In Nigeria, akparata cotyledons or seeds are used as soup thickeners and its leaves are fermented and used in preparing yam pottage. In developing countries like Nigeria, attention is being drawn to the consumption of vegetables especially high quality plant proteins to combat protein energy malnutrition and enhance nutrition and food security of the teeming population. However, there is sparse information in literature on the nutrient composition of *Afzelia africana* leaves.

Cajanus cajan popularly called pigeon pea is a leguminous shrub belonging to the family Fabaceae and the genus cajanus. It evolved in south Asia and appeared around 2000 BC in West Africa which is considered a second major enter of origin (Fuller et al., 2019). It is called fio-fio in Igbo, ofili in Yoruba and waken-masar in Hausa. Fio-fio is economically and nutritionally an important legume and is a major source of protein for the poor communities in developing and underdeveloped countries of the world (Karri & Nalluri, 2017). In Nigeria, the seeds of the plant are usually cooked alone or together with other vegetables, grains, roots and tubers. The seeds are reported to contain 20-22% protein, 1.2% fat, 65% carbohydrate and 3.8% ash (Sharma et al., 2011). In addition, they have been found to possess different minerals such as Calcium, Magnesium, Iron and Zinc; and vitamins such as Pro-vitamin A, Thiamine, Riboflavin, Niacin and Ascorbic acid (Karri & Nalluri, 2017). The mineral content and amino acid profile of fio-fio compares closely to those of soy bean except in methionine (Sharma et al., 2011). The seeds of fio-fio contain more minerals, ten times more fat, five times more vitamin A and three times more vitamin C than ordinary peas (James et al., 2020). Besides its nutritional value, fio-fio also possesses various medicinal properties due to the presence of a number of polyphenols and flavonoids. In Africa, different parts of the plant are used in the management of disorders such as ulcer, diarrhea, joint pain, cough, sores, dysentery, hepatitis and measles and also used as a febrifuge (Yang et al., 2020). According to Trinidad

et al. (2010), the presence of dietary fiber in fio-fio provided potential health benefits in the prevention of the risks of chronic diseases and thus has been considered as a functional food. According to Sharma et al., (2011), the leaves of *Cajanus cajan* have been widely used in traditional medicine to relieve pain and in the treatment of wounds, bedsores and malaria. However, there is dearth of information on the nutrient composition of the leaves.

Abelmoschus esculentus also known as okra is a flowering plant which belongs to the Malvaceae or mallow family (Ilodibia et al., 2016). It is an economically important vegetable crop widely grown in the tropical and subtropical regions of the world (Gemede et al., 2014). It is a perennial native plant from Africa which is now grown in many parts of the world such as Thailand, the Middle East, the Caribbean, and the Southern States of the United States (Romdhane et al., 2020). Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seed (Gemede et al., 2014). The immature green pods are consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled. These pods have a unique flavour and texture and release slimy mucilage on cooking, which can be used to thicken sauces and add smoothness to soups. Its seed may be roasted and ground to form caffeine, a free substitute for coffee (Gemede et al., 2015). Okra has been reported to be rich in nutrients which are essential for human nutrition. The seeds of okra have been reported to be rich in dietary fiber and protein especially lysine and tryptophan (Gemede et al., 2014). The amino acid content of okra seed protein can be compared to that of soybean (Adetuyi et al., 2012). The young immature pods have also been reported to be rich in carbohydrates and vitamins such as beta carotene, riboflavin, thiamine, niacin and ascorbic acid (Akintoye, 2011; Gemede, 2014; Ilodibia et al., 2017; Romdhane et al., 2020). Furthermore, the pods are excellent sources of potassium, calcium, phosphorus and magnesium and very low in cholesterol and saturated fat (Romdhane et al., 2020). In Nigeria, the leaves of okra are consumed as vegetables in soups and sauces. However, there is also no comprehensive literature information regarding the nutritive value of the leaves of okra.

Good nutrition is essential for good health. It is the process by which we procure food and utilize it for growth, keeping our bodies working properly and protecting against diseases (Ilodibia et al., 2017). Poor nutrition however has an adverse effect on the body and has been pinpointed as the major factor responsible to the deteriorating the health of individuals. The risk factors of poor nutrition include cardiovascular diseases, kidney failure and diabetes (Chopra et al., 2013; Kumar & Chopra, 2013; Ilodibia et al., 2017). In children, poor nutrition can lead to stunted growth, tiredness and lack of focus in school (Gernede et al., 2015). Akparata, fio-fio and okra leaves maybe helpful to developing countries such as Nigeria, to check malnutrition and food insecurity. This is because they are among the vegetables that are readily available and affordable in the nation. Therefore, the aim of the study was to determine the nutritive value of fresh, sundried and

shade dried *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* leaves.

Objectives of the study

The objectives of the study were to:

1. determine the proximate composition of fresh, sundried and shade dried *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* leaves
2. determine the vitamin (A and C) content of fresh, sundried and shade dried *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* leaves
3. determine the mineral (Iron and Zinc) content of fresh, sundried and shade dried *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* leaves

Materials and Methods

Study design: The study adopted an experimental study research design

Procurement of samples: The leafy vegetables *Afzelia africana* (Sm.), *Abelmoschus esculentus* (L.) Moench, *Cajanus cajan* (L.) used for this study were harvested from family farm in Ogidi, Idemili North Local Government Area of Anambra State, Nigeria. They were harvested tender, during the rainy season.

Preparation of the samples: The leafy vegetables were manually picked to carefully remove spoilt leaves. This was to reduce the microbial load and any adherent contaminants. The vegetables were divided into 3 portions. One portion was analyzed fresh. The other two portions were sun and shade dried and milled into fine powder prior to analysis for various chemical compositions. The surface area of each sample was increased by milling process. The samples were packaged and sent to the laboratory for chemical analysis.

Proximate Analysis: Moisture, fiber, ash, and protein were determined using the standard procedures described by the Association of Official Analytical Chemists (AOAC) method (2010). The fat content was determined using the Soxhlet extraction of Pearson (1976) while carbohydrate content was determined by difference method.

Vitamin analysis: The quantity of Pro-vitamin A in the samples was determined using Harborne method described by Pearson (1976). This was then converted into its vitamin A equivalent. Vitamin C content was determined using the method described by the Institute of Public Analyst of Nigeria (2005).

Mineral analysis: Iron and Zinc content of the samples were determined using the method described by AOAC (2010).

Data analysis: Data obtained coded and analyzed using Statistical Product and Service Solution (SPSS) version 23. Descriptive (means and standard deviation) statistics were used to describe the data. Results were presented in tables.

Results

Table 1 presents the proximate composition of samples of *Afzelia africana* (*a*kparata) leaves. The moisture content was higher in the fresh sample. The values of the protein content ranged from 15.25-20.66% while the values of ash and crude fiber ranged from 2.00-4.00% and 0.95-2.36% respectively. Sundried akparata had the highest value (27.45%) for fat while shade dried akparata had the highest value (58.01%) for carbohydrate.

Table 1: Proximate composition of *Afzelia africana* (akparata) leaves

Sample	% Moisture	% Protein	% Fat	% Ash	% Fiber	% Carbohydrate
Fresh Akparata	55.88±0.01	15.25±0.02	1.99±0.01	3.98±0.02	0.95±0.01	21.95±0.01
Sundried Akparata	14.85±0.02	17.12±0.02	27.45±0.02	4.00±0.01	2.36±0.01	34.22±0.02
Shade dried Akparata	13.46±0.01	20.66±0.01	3.97±0.02	2.00±0.01	1.90±0.01	58.01±0.02

Table 2 shows the proximate composition of *Cajanus cajan* (fio-fio) leaves. The fresh sample had the highest (61.39%) moisture content. The protein value ranged from 25.91-29.76% while the ash and fiber values ranged from 1.99-5.98% and 0.45-2.60 % respectively. The sundried sample recorded the highest value (50.11%) for carbohydrate while the fat value (3.98%) remained the same throughout the samples.

Table 2: Proximate composition of *Cajanus cajan* (fio-fio) leaves

Sample	% Moisture	% Protein	% Fat	% Ash	% Fiber	% Carbohydrate
Fresh fio-fio	61.39±0.01	25.91±0.02	3.98±0.01	2.08±0.01	0.45±0.01	6.27±0.01
Sundried fio-fio	14.71±0.02	26.96±0.02	3.98±0.01	1.99±0.01	2.25±0.01	50.11±0.02
Shade dried fio-fio	12.62±0.02	29.76±0.02	3.98±0.01	5.98±0.01	2.60±0.01	45.06±0.02

Table 3 show the proximate composition of *Abelmochus esculentus* (okra) leaves. The fresh sample had the highest moisture (79.40%) value. The protein, fat, ash and fiber values ranged from 10.53-25.50%, 1.99-3.98%, 1.03-1.99% and 1.03-1.22% respectively. The sundried sample recorded the highest (51.89%) value of carbohydrate in all the samples.

Table 3: Proximate composition of *Abelmochus esculentus* (Okra) leaves

Sample	% Moisture	% Protein	% Fat	% Ash	% Fiber	% Carbohydrate
Fresh Okra	79.40±0.01	10.53±0.01	1.99±0.01	1.98±0.01	1.30±0.01	4.78±0.02
Sundried Okra	14.70±0.02	26.19±0.01	4.00±0.02	1.99±0.01	1.22±0.02	51.89±0.02
Shade dried Okra	24.00±0.01	25.50±0.02	3.98±0.01	1.03±0.02	1.03±0.01	44.2±0.01

Table 4 shows the vitamin and mineral contents of *Afzelia africana*. The shade dried sample recorded the highest values for vitamin C and Vitamin A while the fresh samples recorded the lowest values for vitamins C and A contents. Again, the shade dried sample had the highest (60.85mg) for Iron while the sundried sample recorded the highest (29mg) value for zinc.

Table 4: Vitamin and mineral content of *Afzelia Africana* leaves

Sample	Vitamin C (mg)	Vitamin A (IU)	Iron (mg)	Zinc (mg)
Fresh Akparata	21.30±0.01	50.88.65±0.02	20.92±0.01	23.21±0.01
Sundried Akparata	54.437±0.01	1106.38±0.01	24.49±0.01	29.00±0.01
Shade dried Akparata	85.34±0.02	3314±0.01	60.85±0.02	28.62±0.01

Table 5 shows the mineral and vitamin contents of *Cajanus cajan*. The fresh sample recorded the lowest values (17.32 mg and 578.81 IU) for vitamins C and A respectively. The sundried sample had the highest (51.73 mg) vitamin C content while the shade dried sample had the highest (2620.38 IU) vitamin A values. The Iron and Zinc values ranged from 23.82—45.74 mg and 27.51—51.08 mg respectively.

Table 5: Vitamin and mineral contents of *Cajanus cajan* leaves

Sample	Vitamin C (mg)	Vitamin A (IU)	Iron (mg)	Zinc (mg)
Fresh fio-fio	17.32±0.01	578.81±0.02	23.82±0.01	51.08±0.01
Sundried fio-fio	51.73±0.02	2094.67±0.02	45.74±0.01	27.51±0.01
Shade dried fio-fio	24.72±0.01	2620.38±0.01	37.81±0.01	32.86±0.01

Table 6 presents the vitamin and mineral contents of *Abelmoschus esculentus* leaves. The vitamin C value ranges from 17.42—39.84 mg, with the shade dried sample having the highest value. The fresh sample had the lowest vitamin A value while the sundried sample had the highest vitamin A value. The shade dried sample had the highest (125.28 mg) Iron content while the fresh sample had the highest (51.08 mg) Zinc content.

Table 6: Vitamin and mineral contents of *Abelmoschus esculentus* leaves

Sample	Vitamin C (mg)	Vitamin A (IU)	Iron (mg)	Zinc (mg)
Fresh Okra	17.42±0.01	578.81±0.02	23.82±0.01	51.08±0.01
Sundried Okra	26.67±0.02	2335.36±0.01	57.94±0.02	31.41±0.02
Shade dried Okra	39.84±0.02	2164.10±0.01	125.28±0.02	30.57±0,01

Discussion

Moisture content of a food sample simply refers to the quantity of water contained in the food. The higher moisture content of the three fresh vegetables samples is expected. Fresh vegetables are known to contain more water than either sun or shade dried

vegetables. However, the higher the moisture content, the more susceptible it is to microbial contamination and rapid deterioration. Neela and Fanta (2019) reported the same phenomenon in fresh sweet potato leaves. Drying is one of the most important and cheap methods developed to extend the shelf life of foods and increasing the availability of nutrients to consumers. The lower moisture content observed in the shade dried and sun dried akparata, fio-fio and okra leaves as compared to the fresh samples is a desirable property which according to Raji et al. (2016), will prevent microbial activities and hence increase the storage duration of the leaves.

Proteins are essential organic compounds that help in the building and maintenance of all tissues in the body; it forms an important part of enzymes, fluids and hormones in the body and also helps form antibodies to fight infection and supplies energy (Raji et al., 2016). The present study revealed that shade drying and sun drying has an effect on the protein content of the vegetable samples. The results showed that there was an increase in the protein content of these samples as a result of the drying methods. The higher protein levels of the samples could be attributed to loss of moisture. It is known that the lower the moisture content of foods, the higher are their nutrient density of which protein is one (Igbatin, 2011). Furthermore, according to Pearson (1996), plant food that provides more than 12% of its calorific value from protein is considered good source of protein. Therefore, the shade dried and sun dried akparata, fio-fio and okra leaves met this criterion and thus, can be considered as good sources of protein.

Crude fats refer to the mixture of fat soluble materials present in a sample. Fats nourishes the body with essential fatty acid which the body cannot synthesize. It also provides the body with energy and helps in body building. The results of the study showed that shade drying and sun drying has an effect on the fat content of the three vegetable samples. The increase in the fat content of the samples compared to the fresh samples is in agreement with Odimegwu et al. (2016) who also reported an increase in the fat content of dried akparata seeds. This increase is attributed to the chemical nature of fats of dried samples which during pulverization, ruptures the fat cells and brings it to the surface. Fats and oils aid in blood pressure regulation and is involved in the synthesis and repair of vital cell parts (Ilodibia et al., 2017).

Ash content gives a measure of total amount of inorganic compounds, like minerals, present in a sample. The result shows that drying generally increases the ash content of akparata, fio-fio and okra leaves. The ash values for the three vegetables were controlled by varietals differences and treatments. Shade drying of fio-fio and okra as well as sun drying for akparata appeared to be the food processing techniques to increase ash (mineral) in these vegetables. This increase could be as a result of some inorganic salt trapped in the vegetables during drying. Similar findings have been reported in pumpkin leaves (Raji et al., 2016; Odimegwu et al., 2016). According to Odimegwu et al. (2016), the lower ash content in the fresh samples could be attributed to the presence of anti-nutritional factors that chelates the minerals present in the fresh samples

which have not been inactivated by the loss of moisture.

Dietary fiber refers to the edible parts of plants that are resistance to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. The result of this study showed that the crude fiber content of the three vegetable samples generally increased when dried. This increase in fiber content maybe advantages since the vegetables could enhance digestion and prevent constipation when consumed. High crude fiber according to Gemede et al. (2014) could also help in blood cholesterol and glucose attenuation when consumed. Increasing the fiber content of the diet increases the faecal energy excretion, principally in the form of fats and nitrogen and by virtue, water holding capacity. Fiber also helps in the formation of soft stools with bulk, which can be easily evacuated (McRorie & McKeown, 2017).

Carbohydrates are organic compounds found in foods and drinks which when consumed provides the body with energy. They may also help prevent stomach or intestinal problems such as constipation. The carbohydrate content of the fresh vegetables of fio-fio, okra and akparata is expected because fresh vegetables in general are poor sources of carbohydrates. On the other hand, the varied increases in carbohydrate for the three dried vegetables samples could be due to loss of moisture which precipitated the increases. This increase is also in agreement with reports by Ilodibia et al. (2017) who all reported similar trends. The result therefore indicates that akparata, fio-fio and okra leaves may be considered as a good source of carbohydrates in the dried form, for body growth and development.

Vitamins are essential micronutrients which the body needs in small quantities for proper functioning and metabolism. The vegetables, dried by different methods have a good yield of vitamin A and C. Vitamin C is an essential vitamin involved in the repair of tissues, formation of collagen, and the enzymatic production of some neurotransmitters. It is vital for healthy teeth, guns and bones and is important for proper functioning of the adrenal and thyroid glands (Omokpariola et al., 2021). It is important to note that vitamin C is a water soluble antioxidant which according to Fernandez-Lasaro et al. (2020) stimulates the absorption of soluble iron by reduction process. The vitamin C content obtained in this study was higher than that in Omokpariola et al. (2021). This indicates that sundried and shade dried akparata, fio-fio and okra leaves are potential sources of vitamin C. Similarly, the results showed high levels of vitamin A in the dried samples. The recommended dietary allowance for vitamin A is 3000 IU. This implies that dried samples of akparata, fio-fio and okra leaves can supply up to 73%, 78% and 75% respectively of the required daily vitamin A when consumed in sufficient quantities. Thus, these vegetables are good sources of vitamins A and C and can help check vitamin A and C deficiencies in developing countries.

The result of the mineral content of the plants shows that the mineral compositions of the three samples vary considerably in the iron and zinc content. Iron is essential in the formation of blood in the body. The samples have considerable amount of iron indicating

that they are potential sources of iron when consumed in sufficient quantities. Therefore, they can serve as important tools in fighting iron deficiency most especially in the developing countries. The iron content found strongly agrees with James et al. (2020) who reported similar findings. Zinc is an important trace element which plays vital roles in the body during metabolism it plays important role in the normal growth and development during pregnancy, childhood and adolescence. The result reveals that the vegetables under evaluation are potential food sources of zinc and thus, according to James et al. (2020), are capable of supplying over 50% of the daily human need of zinc.

Conclusion

In conclusion, *Afzelia africana, Cajanus cajan* and *Abelmoschus esculentus* leaves have high moisture content. When sun dried or shade dried, they are good sources of protein, carbohydrates, fats and fiber as well as vitamins such as vitamin C and A, and minerals such as iron and zinc. The two drying methods evaluated in the study can be considered efficient in terms of retained proximate composition, vitamins and minerals.

Recommendations

From the outcome of this work, it is recommended that:

1. The nutritional societies in Nigeria such as the Nutrition Society of Nigeria (NSN) should educate its members as well as the general public on the good nutritional values of these leaves.
2. Agricultural organizations and food agencies such as Food and Agricultural Organization (FAO) and National Agency for Food and Drug Control (NAFDAC) should also educate farmers and food producers on the nutritive value of these vegetables to avoid them been discarded during harvest.

References

Adetuyi, F. O., Ajala, L. & Ibrahim, T. (2012). The effect of the addition of defatted okra seed (*Abelmoschus esculentus)* flour on the chemical composition, functional properties and bioavailability of plantain (*Musa paradisiacal* linn) flour. *Journal of Microbiology, Biotechnology and Food Sciences, 2*(1); 69-82.

Akintoye, H. A., Adebayo, A. G. & Aina, O. O. (2011). Growth and yield response of okra intercropped with live mulches. *Asian Journal of Agricultural Research*, 5; 146-153.

AOAC, (2010). *Official Methods of Analysis of Association of Official Analytical Chemists*. 18th Edition, Washington, DC

Chen, C., Zeng, Y., Xu, J., Zheng, H., Liu J., Fan, R., Zhu, W., Yuan, L., Qin, Y., Chen, S., Zhou, Y., Wu, Y., Wan, J., Mi, M. & Wang, J. (2016). Therapeutic effects of soluble dietary fiber consumption on type 2 diabetes mellitus. *Experimental and Therapeutic Medicine, 12*(2); 1232-1242.

Chopra, A. K., Srivastava, S., Kumar, V. & Pathak, C. (2013). Agro -potentiality of distillery effluent on soil and agronomical characteristics of *Abelmoschus esculentus* L. (Okra). *Environmental Monitoring and Assessment, 185*: 6635-6644,

Fernández-Lázaro, D., Mielgo-Ayuso, J., Martínez, A. C. & Seco-Calvo, J. (2020). Iron and physical activity: Bioavailability enhancers, properties of black pepper (Bioperine) and potential applications. *Nutrients, 12*(6); 1886.

Fuller, D. Q., Murphy, C., Kingwell-Banham, E., Castillo, C. C. & Naik, S. (2019). *Cajanus cajan* (L.) Millsp. Origins and domestication: The South and Southeast Asian archaeobotanical evidence. *Genetic*

Resources and Crop Evolution, 66; 1175-1188.

Gemede, H. F., Haki, G. D., Beyene, F., Woldegiorgis, A. Z. & Rakshit, S. K. (2015). Proximate, mineral and antinutrient compositions of indigenous okra pod accessions: Implications for mineral bioavailability. *Food Science and Nutrition, 4*(2): 223-33

Gemede, H. F., Ratta, N., Haki, G. D. & Beyne, A. Z. W. F. (2014). Nutritional quality and health benefits of okra (*Abelmoschus esculentus):* A review. *Global Journal of Medical Research, 14*(5); 28-37.

Igbatim, C. A. (2012). Chemical composition of processed tender leaves and husks of cowpea and organoleptic attributes of their soups as consumed in Tiv communities, Benue state, Nigeria. [Unpublished Master's thesis] University of Nigeria, Nsukka.

Ilodibia, C. V., Achebe, U. A. & Chiafor, C. (2017). Nutrient characteristics assessment of two variants of okra (*Abelmoschus esculentus* L. Moench.) found in Anambra State, Nigeria. *Archives of Agriculture and Environmental Science, 2*(4): 298-300.

Ilodibia, C. V., Igboabuchi, N. A., & Onwuachu, W.C. (2016). Evaluation of vegetative and yield attributes of okra (Abelmoschus esculentus (L.) Moench) for adaptation in Anambra State, Nigeria. *International Journal of Biological Research, 4*(2): 318-320.

James, S., Nwabueze, T. U., Onwuka, G. I., Ndife, J. & Usman, M. A. (2020). Chemical and nutritional composition of some selected lesser known legumes indigenous to Nigeria. *Heliyon, 6*; 1-8.

Karri, V. R. & Nalluri, N. (2017). Pigeon pea (*Cajanus cajan)* By-products as potent natural resource to produce protein rich edible food products. *International Journal of Current Agricultural Sciences, 7*(7); 229-236.

Kumar, V. and Chopra, A.K. (2013). Ferti-irrigational effect of paper mill effluent on agronomical characteristics of *Abelmoschus esculentus* L. (Okra). *Pakistan Journal of Biological Sciences, 16*(22): 1426-1437.

McRorie, J. W. & McKeown, N. M. (2017). Understanding the physics of functional fibers in the gastrointestinal tract: An evidence-based approach to resolving enduring misconceptions about insoluble and soluble fiber. *Journal of the Academy of Nutrition and Dietetics, 117*(2); 251-264.

Neela, S. & Fanta, S. W. (2019). Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. *Food Science and Nutrition, 7*(6), 1920–1945. https://doi.org/10.1002/fsn3.1063

Odimegwu, E. N., Nwosu, J. N., Umelo, M. I., Olawumi, I. A., Akajiaku, L. O. & Oga, B. N. (2016). Effect of processing on the approximate and functional properties of akparata (*Afzelia africana)* flour. *European Journal of Food Science and Technology, 4*(2); 10-20.

Ogbimi, E. R., Sakpere, A. M. and Akinropo, S. M. (2020). Vegetative propagation of *Afzelia africana* Sm. Ex pers: A multipurpose and threatened tree. *International Journal of Biological and Chemical Sciences, 14*(1), 204-212.

Olorunmaiye, K. S., Apeh, L. E., Madandola, H. A. & Oguntoye M. O. (2019). Proximate and phytochemicalcomposition of African mahogany *(Afzelia africana)* seed and African mesquite *(Prosopis africana)*pod. *Journal of Applied Science Environment Management, 23*(2),249 252.

Omokpariola, D. O., Okechukwu, V. O. & Omokpariola, P. L. (2021). Effects of processing on the nutritive and anti-nutritive properties of *Afzelia africana. Advanced Journal of Chemistry, 3*(2); 188-198.

Pearson, D. (1976) *Chemical analysis of foods*. 7th Edition, Churchhill Livingstone.

Raji, R. A., Adejumbo, B. A. & Obasa, P. A. (2016). Effects of dry methods and storage duration on proximate

composition of fluted pumpkin leaves. *Proceedings of the 37th Annual Conference and Annual General Meeting, Minna 2016*. 39-43.

Romdhane, M. H., Chahdoura, H., Barros, L., Dias, M. I., Corrêa, R. C. G., Morales, P., Ciudad-Mulero, M., Flamini, G., Majdoub, H. & Ferreira, I. C. F. R. (2020). Chemical composition, nutritional value, and biological evaluation of Tunisian okra pods (*Abelmoschus esculentus* L. Moench). *Molecules, 25*, 1-15.

Sharma, S., Agarwal, N. & Verma, P. (2011). Pigeon pea (Cajanus cajan L.): A Hidden Treasure of Regime Nutrition. *Journal of Functional and Environmental Botany, 1*(2); 91-101.

Stagnari, F., Maggio, A., Galieni, A. & Pisante, M. (2017). Multiple benefits of legumes for agricultural sustainability: An overview. *Chemical and Biological Technologies in Agriculture,* 4(2); 1-13.

Trinidad, T. P., Mallillin, A. C., Loyola, A. S., Sagum, R. S. & Encabo, R.. R. (2010). The potential health benefits of legumes as a good source of dietary fiber. *British Journal of Nutrition, 103*; 569-574.

Ukeyima, M. T., Igbabul, B. D. & Peter, O. S. (2019). Physiochemical and sensory properties of cookies produced from brown rice and fermented *Afzelia africana* floor blends. *Food Science and Quality Management, 88*; 39-46.

World Health Organization. (2016). *Global reports on diabetes*. World Health Organization, Working papers https://apps.who.int/iris/handle/10665/204871.

Yang S., Thi, T., Chen, C., Yang, N., Chen, C.& Song, T. (2020). Nutritional composition, bioactive compounds and functional evaluation of various parts of *Cajanus cajan* (L.) Millsp. *Agriculture, 10*; 1-13.


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