

Comparative Evaluation of the Nutrient Composition and Phytochemical Content of Selected Vegetables Consumed in Nigeria

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Abstract. This study evaluated the phytochemical and nutrient composition of four selected vegetables consumed in Nigeria, namely, bush mallow (*ahihara*), garden egg leaf (*okpokwa*), African spinach (*inine*), and bush okro (*ewedu*). They were analyzed for proximate, minerals, vitamins and phytochemical contents. Proximate values maintained the following ranges: moisture 6.73% to 91.22%, protein 7.05% to 32.12%, crude fiber 2.75% to 6.36%, ether extract 3.15% to 6.81%, ash content 2.81% to 6.81% and carbohydrate 48.75% to 72.62%, while energy value ranged from 340.54kcal to 363.07kcal. The vitamin content for these vegetables ranged as follows: vitamin A 0.13mg/100g to 370.64mg/100g, thiamin (vit B₁) 3.12mg/100g to 7.45mg/100g, riboflavin (vit B₂) 0.08mg/100g to 3.96mg/100g, vitamin B₃ (niacin) 0.17mg/100g to 1.91mg/100g, and vitamin C 39.84mg/100g to 98.75mg/100g. The mineral content, namely, calcium ranged from 45.61mg/100g to 430.69mg/100g, magnesium 11.05mg/100g to 198.14mg/100g, potassium 49.82mg/100g to 708.28mg/100g, sodium 2.36mg/100g to 22.98mg/100g. Also the phytochemical content of the vegetables for phytate ranged from 0.47mg/100g to 3.04 mg/100g, tannin from 0.10 mg/100g to 1.01 mg/100g, saponin from 0.16 mg/100g to 2.56 mg/100g and oxalate from 0.63 mg/100g to 0.72 mg/100g. Result obtained from these vegetables show that they can contribute qualitatively to the nutritional need of the Nigerian population, especially among the rural dweller where vegetables are major food source.

Introduction

Vegetables are edible parts of leaf, stem and roots of plant [1]. They are usually cooked or eaten raw. They include those plant parts that are used in making soup which serve as an integral part of the people's meal [2]. As a food source, they supply fiber, minerals and vitamins to the diet of majority of people in the developing countries, where they are frequently consumed as side dish or relish with staple foods [3]. Vegetables are important protective food for the maintenance of health and prevention of diseases. They contain valuable phyto-nutrients like carotenoids, polyphenolic compounds and dietary fibre that can be utilized for the physiological needs of the body and inhibit disease conditions such as cancer, heart attack, stroke, hypertension, birth defects, cataracts and diabetes. Edible vegetables are grouped into leafy vegetables (lettuce), stem vegetables (asparagus), root vegetables (carrot), flower vegetables (broccoli) and bulbs (garlic and onions). Certain fruits such as tomatoes and beans are used as vegetables [4]. They may grow wild or cultivated as trees, herbs, shrubs or erect plants that cut across the plant world.

In Africa, and especially Nigeria, green leafy vegetables are consumed as soup complements of major staples like cassava, cocoyam, guinea corn, yam, maize, millet, rice and unripe plantain. Vegetables contribute to food security and add spice and variety to the starchy staples either as soups or porridge. In fact, eating these staples is considered incomplete without a generous serving of cooked vegetables. Broadly, green leafy vegetables are good sources of micronutrients, non-volatile acids, organic acids, mineral salts, volatile sulphur compounds and tannin, which impart flavor in diets and antioxidant compounds like polyphenols, flavonoids and arrays of carotenoids especially, β -carotene and ascorbic acid which boost the body immunity [5]. Vegetables also consist of carbohydrates mainly as indigestible fibrous materials such as cellulose, hemicelluloses and

lignin and small quantities of sugars such as glucose, fructose, sucrose and high moisture content that ranges from 75% to 95%.

The micronutrient content of leafy vegetables can potentially address the problem of micronutrient deficiency among the rural dwellers in Nigeria. In contribution to health, reasonable amount of vegetable intake has been reported to reduce the risk of degenerative diseases like cancer, diabetes mellitus and cardiovascular diseases [6].

The major anti-nutrients in green leafy vegetables are phytic and oxalic acids. These are important because of their significant adverse effect on nutritional value of vegetables [5]. High level consumption of either phytate or oxalate from plant foods inhibits the absorption and utilization of minerals especially iron, zinc and calcium. Pamploma-Rogers [7] stated that fruits and vegetables have been linked to the management of anemia, because they are rich in vitamins and minerals. In Nigeria, especially among the rural population, there is limited information on the nutrient profile of staple vegetables, which are abundant during the rainy season (and are consumed in large amount), but are scarce in the dry season. This situation can lead to protein and micronutrient deficiency among the rural population. Information and advocacy on the nutritional value of vegetables will go a long way to guide consumers on the choice of vegetables to use for food preparation, since different kinds of vegetables are readily available in every locality, especially during the rainy season. This study will add information on the nutrient and anti-nutrient composition of vegetables grown and consumed in Nigeria for use especially by researchers and consumers of vegetables for improved nutrition. In this study, we investigated the chemical and anti-nutritional composition of some staple vegetables consumed in Nigeria, as a major objective.

Materials and Methods

Vegetable materials: The vegetables used in this study were obtained from a farm in Obingwa LGA, Abia State and Oyingbo Market, Lagos State, Nigeria. They were identified by the University Herbarium of Michael Okpara University of Agriculture, Umudike.

Clean black polyethylene bags were used to collect and store the vegetable samples in a refrigerator to avoid heat, contamination and wilting for a day prior to processing.

The local names, botanical names, common names and parts of the plant used are listed in Table 1.

Table 1. Staple vegetables, names and parts used

Local names	Botanical names	Common names	Parts of the plant
1 <i>Ahihara</i> (Igbo)	<i>Corchorus capsularis</i>	Bush mallow	Vegetable
2 <i>Okpokwa</i> or <i>Anara</i> (Igbo)	<i>Solanum macrocarpon</i>	Giant garden egg leaf	Vegetable
3 <i>Inine</i> (Igbo)	<i>Amaranthus hybridus</i>	African spinach or Green	Vegetable
4 <i>Ewedu</i> (Yoruba)	<i>Corchorus olitorius</i>	Bush okro	Vegetable

Material preparation

The vegetable leaves were handpicked to remove unwanted materials. They were washed with clean tap water and were allowed to drip off on a perforated tray. Edible portions of the vegetables were sliced and oven dried at 50 °C. They were cooled and milled into powder with a local attrition mill and then stored in an air tight container for subsequent use.

Chemical analysis

The proximate analysis: moisture, crude protein, crude fat, fibre and carbohydrate (by difference) were determined by the methods of AOAC [8]. Energy content was determined by the method of Kanu et al. [9]. The mineral elements: calcium and magnesium content of the samples was carried out by versanate EDTA compleximetric titration described by James [10]. Flame photometry was used to determine the concentration of potassium and sodium as described by James [10]. Vitamin

A, thiamine (B1), riboflavin (B2), niacin (B3) and vitamin C content of each vegetable sample was determined by the method of AOAC [8]. Phytate was determined by the method described by Oberlease [11], while the method described by Obadoni and Ochuko [12] was used to determine the saponin content. Tannin was determined by the method of Pearson [13] and oxalate content was determined using the method of Iwuoha and Kalu [14].

Results and Discussion

Proximate composition of vegetables

Data Analysis

Mean and standard deviation were calculated for triplicate determinations using the Statistical Package for Social Sciences (SPSS) version 10 Statistic Software Package. Data were expressed as mean \pm standard deviation (SD). Comparisons between groups were performed with analysis of non-parametric test. A value of $P < 0.05$ was considered statistically significant.

Table: 2 show the result of the proximate composition of the vegetables. The percentage dry matter varied from 91.22% to 93.27%. The highest value was obtained in garden egg leaf (93.27%), while the least was obtained in African spinach leaf (91.22%). Percentage moisture content ranged from 6.73% to 8.78% with the highest value obtained in African spinach and the least value recorded in the garden egg leaf.

Table 2. Proximate composition of some vegetables consumed in Nigeria (%)

Sample	Dry matter	Moisture	Crude protein	Crude fibre	Crude fat	Ash	Carbohydrates	Ev (k/cal)
Bush mallow	91.70 ^c \pm 0.14	8.30 ^a \pm 0.14	7.05 ^d \pm 0.03	4.81 ^b \pm 0.04	4.02 ^a \pm 0.01	3.21 ^c \pm 0.01	72.62 ^a \pm 0.12	354.84 ^b \pm 0.72
G. Egg Leaf	93.27 ^a \pm 0.33	6.73 ^c \pm 0.33	32.12 ^a \pm 0.02	2.75 ^d \pm 0.03	2.85 ^d \pm 0.49	6.81 ^a \pm 0.01	48.75 ^d \pm 0.36	349.05 ^c \pm 1.21
Afr. Spinach	91.22 ^c \pm 0.14	8.78 ^a \pm 0.04	15.53 ^c \pm 0.03	6.36 ^a \pm 0.03	3.72 ^b \pm 0.03	4.35 ^b \pm 0.03	61.24 ^b \pm 0.02	340.54 ^d \pm 0.23
Bush okro	92.55 ^b \pm 0.21	7.45 ^b \pm 0.21	24.40 ^b \pm 0.01	2.91 ^c \pm 0.04	3.15 ^c \pm 0.04	2.81 ^d \pm 0.01	58.28 ^c \pm 0.10	363.07 ^a \pm 0.83

Values are mean \pm standard deviation of duplicate deviations. Data with the same superscripts along the same row are not significantly different at ($P \geq 0.05$). N/B Ev = Energy value

Crude protein of the vegetables ranged from 7.05% to 32.12%. Garden egg leaf was the highest value. These findings are in agreement with the values of 20.5% in *Amaranthus caudatus* and 13.1% in *Lesianthera africanas* reported by other researchers [15-17]. Protein is vital for growth, maintenance and repair of worn out tissues. It is known that animal protein is expensive and the use of vegetable source to supply cheap protein especially among the rural poor population in developing country such as Nigeria cannot be over-emphasized. The results show that these vegetables especially garden egg leaf (Okpokwa) are good sources of protein. Thus, the protein content of these vegetables will go a long way in meeting the protein need of the rural poor who supplement their food with vegetables.

The highest percentage crude fiber was obtained in African spinach (6.36%), while the least was recorded in the garden egg leaf (2.75%). These values are in accordance with the report of Akindahunsi and Salawu [18] and Anita et al. [19] in percentage crude fiber of *P.guineensis* (6.4%) and *corchorus olitorius* (7.0%). Dietary fiber is important in intestinal health and in prevention of excess cholesterol absorption. Dietary fibre, mainly cellulose and hemicellulose add bulk to the diet, ease waste elimination and prevent absorption of excess starchy diets which protects metabolic conditions against hypercholesterolemia, diabetes mellitus [20] and other related health complications.

Percentage crude fat shows a significant difference in the vegetables. The values obtained in this study (2.85% to 4.02%) are higher than those reported on raw and cooked *T. triangulare* (1.14% and 1.08%) by Eleazu and Eleazu [21].

The highest ash content (6.81%) was recorded in garden egg leaf while the least (2.81%) was recorded in African spinach. This is in agreement with the findings of Mofunanya et al. [22]. The ash content is indicative of the mineral content of the leafy vegetables.

This study shows that these vegetables contain significant quantities of carbohydrates. The values ranged from 48.75% to 72.62% with the highest content obtained in bush mallow while the least was observed in garden egg leaf. The carbohydrate content of bush mallow was significantly ($p < 0.05$) higher when compared to other vegetables.

Energy values showed that bush okro was highest while African spinach had the least. Vegetables are low energy food and can be used as slimming diet.

Vitamin composition of vegetables

Table 3. Vitamin Composition of Vegetables (mg/100g)

Sample	Vitamin A	Vitamin B ₁	Vitamin B ₂	Vitamin B ₃	Vitamin C
Bush mallow	0.13 ± 0.04 ^d	7.45 ± 0.08 ^a	0.08 ± 0.01 ^d	0.74 ± 0.01 ^b	98.73 ± 0.04 ^a
Garden egg leaf	370.64 ± 0.05 ^a	5.73 ± 0.03 ^b	0.21 ± 0.00 ^c	0.17 ± 0.01 ^c	39.84 ± 0.01 ^d
African spinach	46.13 ± 0.04 ^b	3.57 ± 0.08 ^c	0.28 ± 0.03 ^b	0.75 ± 0.02 ^b	49.69 ± 0.02 ^b
Bush okro	4.02 ± 0.01 ^c	3.12 ± 0.03 ^d	3.96 ± 0.01 ^a	1.91 ± 0.03 ^a	43.83 ± 0.06 ^c

Values are mean ± standard deviation of duplicate determinations. Means with the same super scripts within the same row are not ($P > 0.05$) significantly different.

The vitamin content of these vegetables is shown in Table 3. The vitamin A content ranged from 0.13 mg/100g to 370.64 mg/100g. Vitamin A content of garden egg leaf was significantly ($p < 0.05$) higher than that of other vegetables. The values are within the range reported by Okwu and Josiah [23] for *Aspilla africana*, *V. amygdalina*, *Bryophyllum pinnatum* and *O. gratissium* K. From the data on vitamin A, consumption of adequate quantity of these vegetables can boost daily requirement of vitamin A for humans. Vitamin A as an antioxidant is known to scavenge free radicals in the body and thus prevents cellular damage. It is important in maintenance of healthy eyes and skin, normal growth and reproduction as well as enhancement of immune function [24].

The thiamine content of these vegetables ranged from 3.12 mg/100g to 7.45 mg/100g. Bush mallow was significantly higher while African spinach was the least. These values are within the range reported by Akubugwo et al. [25]. Thiamine is required for the maintenance of nerve tissue and for the release of energy from carbohydrate metabolism [26].

Vitamin B₃ (riboflavin) content of the vegetables range from 0.08 mg/100g to 3.96 mg/100g, with the highest content obtained in *African spinach* while the least was found in bush mallow.

The values are in agreement with the finding of Akubugwo et al. [25] on the nutritional and chemical analysis of *amaranthus hybridus*, but lower than the value (0.94 mg/100g) reported by Ifon and Bassir [27] in some Nigerian leafy vegetables with the exception of *African spinach* (3.96 mg/100g). Riboflavin is a vitamin that helps in the regulatory functions of some hormones that connect with carbohydrate metabolism.

Niacin (vitamin B₃) content of the vegetables varied from 0.17 mg/100g to 1.91 mg/100g. The bush mallow had the highest niacin content while garden egg leaf was the least.

The ascorbic acid content of these vegetables varied from 39.84 mg/100g to 98.73 mg/100g. The highest concentration was recorded in bush mallow, while the least was in garden egg leaf. These values are higher than the value (29.37 mg/100g) reported by Sobowale et al. [6] in some

leafy vegetables consumed in Nigeria. Vitamin C is essential for healthy teeth, gum and bone. It is also vital for proper functioning of the adrenal and thyroid glands. Scurvy is a deficiency disease of vitamin C and adequate intake of ascorbic acid from these vegetables can be used in the curing of scurvy and also can reduce the formation of carcinogenic nitrosamines [28]. The results show high concentrations of vitamins A and C, riboflavin, thiamine and niacin, enough to meet the Recommended Daily Allowance of 90 mg/day vitamin C and 1.3 mg/day of riboflavin. These vegetables are therefore important in ameliorating micronutrient malnutrition that is encountered among Nigeria's urban and rural dwellers.

Mineral composition of vegetables

The mineral composition of the vegetables is shown in Table 4.

Table 4. Mineral composition of vegetables (mg/100g)

Samples	Ca	Mg	K	Na
Bush mallow	430.69±0.01 ^a	148.92±0.01 ^b	220.03±0.03 ^b	2.36±0.03 ^d
Garden egg leaf	209.61±0.04 ^c	11.05±0.02 ^d	708.28±0.04 ^a	22.98±0.01 ^a
African spinach	241.39±0.01 ^b	120.55±0.02 ^c	210.02±0.03 ^c	3.83±0.03 ^c
Bush okro	45.61±0.01 ^d	198.14±0.04 ^a	49.82±0.02 ^d	7.14±0.01 ^b

Data are means ± standard deviation of duplicate determinations. Means differently super scripted within the columns are significantly different ($P < 0.05$).

The calcium content of the vegetables ranged between 45.61 mg/100g and 430.69 mg/100g. The highest value was obtained in bush mallow while African spinach vegetable was the least.

Calcium is one of the most essential macro mineral required by the body for strong teeth and bones and its deficiency is more prevalent than any other mineral. Calcium, phosphorus and vitamin D help to eradicate rickets in children and osteomalacia as well as osteoporosis among older people [26]. Magnesium content of the vegetables ranged from 11.05 mg/100g to 198.14 mg/100g. The highest value was obtained in African spinach while garden egg leaf had the least value. The values are within the range reported by Eleazu and Eleazu [21] on the bioactive constituent and *in vitro* antioxidant capacity of water leaf. Magnesium functions as an activator of ATPs requiring enzymes such as hexokinase, phosphatase, alkaline, fructokinase and adenylcyclase. Magnesium plays vital role in the structure and the function of the human body such as the skeleton and muscle. The adult human body contains about 25grams of magnesium. The potassium content of these vegetables ranged from 49.82 mg/100g to 708.28 mg/100g. The highest value occurred in garden egg leaf, while the least value was observed in African spinach. These values are within the range reported by Javed *et al.* [29] in some selected vegetables grown in Pakistan. Potassium is an intercellular salt that can combine with sodium to influence osmotic pressure and contributes to normal pH equilibrium in the body [26]. Also, the sodium content of these vegetables ranged from 2.36 mg/100g to 22.98 mg/100g. Garden egg leaf had the highest value while bush mallow had the least value. Sodium plays a significant role in the maintenance of osmotic pressure of the body fluids. Sodium is one of the minerals whose absorption is considered a factor in the etiology of hypertension hence, its low availability in these vegetables can lower the incidence of hypertension. The result obtained in this study is similar to previous reports on some other species of Nigerian vegetables [30, 31]. Of note, the highest concentration of mineral in these vegetables are calcium and potassium and the results further indicate that these vegetables can contribute significantly to the mineral nutrition of the consumers.

*Anti-nutritional content of vegetables***Table 5.** Antinutrient composition of vegetables (mg/100g)

Sample	Phytate	Oxalate	Tannin	Saponnin
Bush mallow	3.04±0.02 ^a	0.80±0.01 ^a	0.10±0.01 ^c	0.16±0.02 ^d
Garden egg leaf	1.94±0.06 ^b	0.72±0.02 ^b	1.01±0.01 ^a	0.31±0.01 ^c
African spinach	0.47±0.03 ^d	0.63±0.02 ^c	0.48±0.01 ^b	2.56±0.01 ^a
Bush okro	1.32±0.03 ^c	0.66±0.01 ^d	0.53±0.03 ^b	1.68±0.02 ^b

Data are means ± standard deviation of duplicate determinations. Means differently super scripted within the columns are significantly different ($P < 0.05$)

The mean values of the anti-nutritional content of the vegetables are presented in table 5.

The phytic acid content ranged from 1.94 mg/100g to 3.0 mg/100g. The highest value was obtained in bush mallow while the lowest value was in African spinach. Our findings are within the range reported by Akubugwo *et al.* [25] on *Amaranthus hybridus*. Phytic acid is a strong chelating agent that can form protein and mineral-phytic acid complex, thereby reducing protein and mineral bioavailability. The saponin content of these vegetables ranged from 0.16 mg/100g to 2.56mg/100g. These values are lower than the finding of Nkafamiya *et al.* [32]. Saponins are glycosides containing polycyclic aglycone moiety of either C₂₇ steroid or C₃₀ triterpenoids attached to a carbohydrate. High saponin level has been associated with gastroenteritis manifested by diarrhea and dysentery [33]. It is also associated with cholesterol lowering activities [34]. The tannins contents of the vegetables varied from 0.10 mg/100g to 1.01 mg/100g. The highest value was recorded in garden egg leaf and the least value in bush mallow. Tannins prevent the activities of digestive enzymes such as trypsin, chymotrypsin, amylase and lipase. The tannin-epigallo-catechin-3-gallate is known to possess hypoglycemic activity [21]. The concentration of these phytochemicals in these vegetables is not high as to constitute health hazard, since they are within safe level.

The oxalate content of these vegetables ranged from 0.63 mg/100g to 0.8 mg/100g. The highest oxalate content was obtained in bush mallow, while the least was in African spinach. Oxalate renders calcium unavailable by binding to the calcium ion complex [35, 36]. Anti-nutrients limit the use of many plant foods due to their occurrence as natural compounds capable of eliciting deleterious effect in man and animals [37]. However, the values recorded in this study were far below the toxic level and cannot cause harm in the vegetables when consumed.

Conclusion

The chemical and phytochemical compositions of some commonly consumed vegetables in Nigeria are highlighted. These vegetables contain macro and micronutrients especially protein, calcium, magnesium, potassium, vitamins A and C, riboflavin, thiamin and niacin in high concentrations. These were specific for protein in Garden egg leaf, in African spinach and Bush mallow, crude fibre in African spinach and ash in Garden egg leaf. For vitamins and minerals, vitamin A was high in Garden egg leaf and African spinach, riboflavin in Bush mallow and Garden egg leaf, while vitamin C was high in all these vegetables. These vegetables do not only have the potential to supply enough nutrients to consumers, but can also contribute to dietary fibre and antioxidant compounds for boosting human immunity. The relative low level of phytochemicals in these vegetables will not hamper mineral absorption and utilization in the body. Therefore, the consumption of these vegetables which are relatively cheap and readily available during the rainy season must be encouraged to maintain balanced nutrition and improve human health. The data of the nutrients recorded in this study can be used for food composition table to improve human health

and ameliorate hidden hunger, especially among the low income groups and rural population. Further research on the bioactive compounds in these vegetables will be undertaken to complement the results obtained in this study towards their nutritional and health benefits.

Conflict of Interest

The authors declare that there is no conflict of interest.

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