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Effect of Processing Methods on Nutritional Quality of *Solanum aethiopicum* and *Colocasia esculenta* Leafy Vegetables Commonly Consumed in Ebonyi State, Nigeria

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ABSTRACT

Background: Green leafy vegetables provide many health and nutritional benefits to mankind. Processing to prolong the shelf-life of vegetables goes through several stages, though it might affect the nutrient composition.
Objective: This study evaluated the effect of the processing method on the nutrient, anti-nutrient, and phytochemical composition of commonly consumed green leafy vegetables in Ebonyi state, Nigeria.
Methodology: The study adopted an experimental design. Three hundred grams (300 g) of each of the leafy vegetables (*Solanum aethiopicum* and *Colocasia esculenta*) were cleaned, washed, and divided into three equal portions (100 g, each). One portion each was retained raw (served as a control); the others were processed by steaming and shade-drying methods and were later analyzed in the laboratory for nutritional, anti-nutrient, and phytochemical content using standard methods. One-way analysis of variance was used to compare the data obtained. $P < 0.05$ was considered significant.
Result: The steamed samples had higher moisture content than a shade-dried sample. Similarly, steamed *Colocasia esculenta* had the highest vitamin C among the processed leaf samples. Also, steamed *Solanum aethiopicum* had the highest value of vitamin E when compared to other processed samples. Shade-dried samples of *Solanum aethiopicum* had higher values of mineral content than its steamed counterpart while steamed *Colocasia esculenta* had higher potassium/magnesium content and lesser sodium/phosphorus than shade-dried *Colocasia esculenta* leaf. Steamed leaf samples had higher carotenoids and flavonoids with lesser alkaloid levels than shade-dried samples. Steamed *Colocasia esculenta* leaf had higher saponin and oxalate content than shade-dried *Colocasia esculenta* leaf, while shade-dried *Solanum aethiopicum* leaf had higher oxalate, phytate, and saponin level than the steamed *Solanum aethiopicum*.
Conclusion: The study showed that leafy vegetables contain appreciable levels of nutrients and the different processing methods either increased or reduced the nutrient present in the leaves.

Keywords: *Solanum aethiopicum*, *Colocasia esculenta*, *Leafy Vegetables*

INTRODUCTION

A large percentage of undeveloped nations rely on starch-based foods as their primary source of energy as well as other nutrients. This act of relying on starch-based foods as the primary source of energy has contributed to other nutrient deficiencies and inadequacy – a leading cause of anemia among vulnerable populations, as acknowledged by the Food and Agricultural Organization (1). In Nigeria, the burden and incidence of anemia are high, especially for the vulnerable and disadvantaged population (pregnant women and children) in most rural communities (2). Considering this, various plants, including green leafy vegetables, have been identified and investigated for a variety of nutritional benefits and values to humanity, particularly in Africa, where many of these plants' traditional uses and therapeutic properties are unknown (3). Green leafy vegetables play a vital role among food crops because they deliver significant, accessible, and inexpensive supplies of micronutrients (vitamins and minerals) and health-promoting phytochemicals for mankind (4, 5, 6). As a result, they can serve a dual purpose of giving needed nutrients while also defending and protecting the body from a range of biological, physiological (7), and metabolic problems including anemia (8).

The entire South-east and South-south Region of Nigeria is blessed and endowed with a plethora of nutritive and medicinal leafy vegetables. These vegetables are either wild or domesticated, particularly in rural areas. Nevertheless, nothing is known about the majority of them because their nutrient compositions have yet to be thoroughly researched and exploited. Poor nutrition knowledge and inadequate nutrition information dissemination has resulted in the non-popularity of green leafy vegetables in some contemporary Nigerian traditional diets, despite their important role to household food security (9). Fresh leafy vegetables are known to be highly perishable due to the high moisture content and can deteriorate over a short period of time if not properly handled (10). Processing (steaming and drying) halt the growth of spoilage microorganisms, as well as stop the occurrence of enzymatic reactions (11). Though it affects the nutrient content, processing prolongs the shelf-life of vegetables (12). Processing methods, therefore, allows one to choose the best and tastiest varieties of vegetables that can be picked or bought fresh from the garden during the rainy season and preserve them for off-season use, bringing enjoyment when these are not available in the gardens, groceries or markets (13).

The leafy vegetables investigated were *Solanum aethiopicum* leaf commonly known as garden egg leaf, and *Colocasia esculenta* leaf also known as cocoyam leaf. *Solanum aethiopicum*, African eggplant, also referred to as garden egg (Dauta in the Hausa language; Anara in the Igbo language; Igbagba in the Yoruba language), is a popular ingredient in Nigerian culture and cuisines (14). Eggplants are a prominent and commonly cultivated vegetable crop throughout the subtropic and tropical regions (15). In Nigeria, there are around 25 different types of eggplants, among these are the *S. aethiopicum L.* (Ethiopian eggplant) and *S. macrocarpon L*. (Gboma eggplant), both of which are widely farmed in Nigeria and throughout the African continent (16,17). The leaves and fruits of *Solanum aethiopicum* are eaten fresh, steamed, pickled, cooked, or combined with other veggies or meats to make soups or stews (18).

Colocasia esculenta L. is a tropical plant farmed largely for its edible corms, which are a root vegetable known as taro (19). Taro is a significant root crop of the Araceae family, subfamily Aroideae. It is a swamp perennial shrub native to tropical and subtropical climates, most notably in Southeast Asia, where it is known by various common names such as Arbi, Arvi, and Eddode (20). Furthermore, the leaves and leaf stalks are consumed as vegetables. It is recognized by various local names and is frequently referred to as "elephant ears" since it may expand to be up to 1-2 m tall during the growth phase (21).

Even though leafy vegetables are recognized to contain many micronutrients that are good to health and wellness, it is crucial to expand the list of these health-promising and potential plants to generate more variety in the menu of food of Nigeria's rural inhabitants. Therefore, the objective of this study was to evaluate the effect of processing method on the nutrient, anti-nutrient and phytochemical composition of commonly consumed green leafy vegetables in Ebonyi state as possible remedy for nutrient deficiency diseases.

MATERIALS AND METHODS

Study design

This study adopted an experimental design to evaluate the effect of different processing methods on the nutritional quality of commonly consumed green leafy vegetables in Ebonyi state.

Procurement of raw materials

Freshly harvested leafy vegetables; *Solanum aethiopicum* (African eggplant) leaf, and *Colocasia esculenta* (cocoyam) leaves were obtained from a local market in Obeagu Isu of Ebonyi State, Nigeria.

Identification of samples

Solanum aethiopicum (African eggplant), and *Colocasia esculenta* (cocoyam) leaves were identified at the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Enugu state, Nigeria.

Sample preparation

Three hundred grams (300 g) of each of the leafy vegetables were cleaned, washed to remove dust and sand, and divided into three equal portions (100 g, each). One portion each was retained raw (served as a control); the others were processed with two different methods, as described below.

Steaming of vegetables

A 100 g each of the fresh vegetables was separately steamed in a domestic closed vessel using a stream basket suspended above a small amount of boiling water (100 °C). Cooking time was set at 5 min starting from when the sample was suspended above boiling water. Next, the sample was cooled at room temperature (20-25 ^{0}C) and stored in a refrigerator until further analysis.

Shade-drying of vegetables

A 100 g of each of the vegetables was subjected to open-air under low temperatures for about four days until the vegetables were brittle and considered dry. After shade-drying the vegetables were packaged until further used

Moisture content determination

The moisture content of the sample was determined using the hot air oven method by AOAC (22).

Vitamin determination

Vitamin C (Ascorbic acid) was determined using standard method by AOAC (22). Vitamin E (tocopherol) was determined using the method described by Pearson (23). Vitamin K was determined using the solvent extraction method by Jakob and Elmadfa (24).

Mineral determination

Sodium and potassium were determined following the method of AOAC (25). Magnesium content was determined by atomic absorption spectrophotometer as described by AOAC (22).

Phytochemical analysis

Flavonoids were determined using the Boham and Kocipai-Abyazan (26) method. Alkaloid content was determined by the alkaline precipitation-gravimetric method described by Harborne (27). Determination of carotenoids was done using the method described by Onyeka and Nwambekwe (28).

Anti-nutrients composition

The phytate content in the sample was determined as described by AOAC (22). The total oxalate in the sample was assayed using the method of AOAC (25). Total Saponin content was determined by using the spectrophotometric methods described by Pearson (23).

Statistical analysis

Chemical analysis was carried out in triplicate and data obtained were statistically analyzed using IBM SPSS Statistics Software version 23. The data were analyzed using means and standard deviation. One-way analysis of variance (ANOVA) was used to compare the mean. Duncan's multiple range test was used to separate the mean. The significance level was accepted at ($P < 0.05$).

RESULTS

Moisture composition of the samples

The moisture content of the raw, steamed, and shade-dried leaves of *Colocasia esculenta* and *Solanum aethiopicum* is shown in Table 1. According to the data, the moisture content of the leaves ranges from 63.38 to 89.07 percent, with Raw *Colocasia esculenta* leaf (RCEL) having the highest value (89.07%) and Steamed *Colocasia esculenta* leaf (SDSAL) having the least moisture content (63.38%). The moisture content of RCEL is greater (89.07%) than that of its counterpart leaves, there was a significant difference ($p<0.05$) between the mean values of the leaves.

Vitamin composition of the samples

The vitamin content of the raw, steamed, and shade-dried leaves of *Colocasia esculenta* and *Solanum aethiopicum* is shown in Table 1 (mg/100 g). The vitamin C content in the table ranged from 1.14 to 4.51 mg/100 g, with SDSAL having the lowest (1.14 mg/100 g) and RCEL having the highest (4.51 mg/100 g) vitamin C content. There was a significant variation ($p<0.05$) in vitamin C concentration in the samples. The vitamin E concentration of the samples ranged from 1.77 to 7.39 mg/100 g, with SCEL containing the least (1.77 mg/100 g) and RSAL containing the most (7.39 mg/100 g). Furthermore, the vitamin K content of the sample ranged from 0.00 to 0.71mg/100 g, with RCEL having a negligible or minute quantity of vitamin K (0.00 mg/100 g) and SDSAL having the most though negligible amount of vitamin K (0.71 mg/100 g). The differences in vitamin K content within the group were statistically significant at $P<0.05$.

Mineral composition of the samples

The mineral content of the raw, steamed, and shade-dried leaves of *Colocasia esculenta* and *Solanum aethiopicum* is shown in Table 1. The phosphorus (P) concentration of the plants ranged from 3.65 to 30.80 mg/100 g, with RSAL having the lowest (3.65 mg/100 g) and SDCEL having the highest (30.80 mg/100 g) phosphorus content. The magnesium (Mg) content of the leaves ranged from 2.26 to 62.04 mg/100 g, with SDSAL having the lowest (2.26 mg/100 g) magnesium content and SCEL having the highest (62.04 mg/100 g). There was significant variation ($p<0.05$) in magnesium content throughout the row. The sodium (Na) content of the leaves ranged from 24.46 to 182.49 mg/100 g, with SSAL having the lowest (24.46 mg/100 g) sodium content and SDSAL having the highest (182.49 mg/100 g). The sodium concentration has a significant difference at $p<0.05$ across the row. The potassium (K) content of the leaf samples ranges from 676.95 to 1297.70 mg/100 g, with SSAL having the lowest (676.95 mg/100 g) and SCEL having the highest (1297.70 mg/100 g) potassium content. In the same row, there was a significant difference between SCEL and its counterpart leaves in potassium content ($p<0.05$).

Table 1: Moisture, vitamin and mineral composition of raw, steamed and shade-dried *Colocasia esculenta* and *Solanum aethiopicum* leaves

Parameters	RCEL	SCEL	SDCEL	RSAL	SSAL	SDSAL
Moisture composition (%)						
Moisture	89.07[a] ± 0.18	86.45[c] ±0.18	66.50[e] ±0.22	87.02[b] ± 0.13	69.72[d] ±0.16	63.38[f] ±0.00
Vitamin composition (mg/100 g)						
Vitamin C	4.51[a] ± 0.08	3.36[b] ± 0.01	1.14[d] ± 0.01	3.36[b] ± 0.03	3.10[c] ± 0.10	1.14[d] ± 0.00
Vitamin E	2.19[d] ± 0.14	1.77[d] ± 0.21	3.63[c] ± 0.08	7.39[a] ± 0.48	5.14[b] ± 0.49	3.84[c] ± 0.03
Vitamin K	0.00[f] ± 0.00	0.10[e] ± 0.00	0.15[cd] ± 0.00	0.14[de] ± 0.01	0.19[b] ± 0.00	0.71[a] ± 0.03
Mineral composition (mg/100 g)						
P	12.04[c] ± 0.06	10.31[d] ± 0.01	30.80[a] ± 0.28	3.65[f] ± 0.35	4.65[e] ± 0.35	15.20[b] ± 0.14
Mg	53.23[b] ± 0.21	62.04[a] ± 0.06	6.70[c] ± 0.13	4.58[d] ± 0.12	4.45[d] ± 0.28	2.26[e] ± 0.05
Na	79.78[c] ± 0.22	54.23[d] ± 0.19	121.55[b] ± 0.30	34.68[e] ± 0.40	24.46[f] ± 0.05	182.49[a] ± 0.23
K	1235.58[ab]±101.99	1297.70[a]±28.96	823.48[ab]±22.83	963.52[ab]±120.24	676.95[ab]±394.28	937.22[ab]±185.8

Values are Means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at p<0.05

RCEL = Raw *Colocasia esculenta* leaf; SCEL = Steamed *Colocasia esculenta* leaf; SDCEL = Shade-dried *Colocasia esculenta* leaf; RSAL = Raw *Solanum aethiopicum* leaf; SSAL = Steamed *Solanum aethiopicum* leaf; SDSAL = Shade-dried *Solanum aethiopicum* leaf

Phytochemical composition of samples

The quantitative study of the phytochemical composition of raw, steamed and shade-dried leaves of *Colocasia esculenta* and *Solanum aethiopicum* is shown in Table 2. The alkaloid content ranged from 0.48 to 4.37 percent, with SSAL having the lowest (0.48%) and SDCEL having the highest (4.37%) alkaloid content. In the same row, there was significant change in alkaloid content (p<0.05).

The flavonoid content varied from 1.66 to 9.22 percent, with SDSAL having the lowest flavonoid content (1.66 percent) and RCEL having the highest (9.22 %). In the same row, there was significant change (p<0.05) in flavonoid content. The carotenoid concentration ranged from 1.81 to 9.02 percent, with SDSAL having the lowest (1.81%) and RCEL having the highest (9.02%) carotenoid content. Significant difference (p<0.05) was observed in the carotenoid concentration in the same row.

Table 2: Phytochemical composition of raw, steamed and shade-dried *Colocasia esculenta* and *Solanum aethiopicum* leaves

Parameters (%)	RCEL	SCEL	SDCEL	RSAL	SSAL	SDSAL
Alkaloid	2.47[b] ± 0.01	1.44[c] ±0.01	4.37[a] ±0.00	1.41[c] ± 0.01	0.48[d] ±0.01	2.46[b] ±0.01
Flavonoid	9.22[a] ± 0.18	3.55[c] ±0.13	1.94[d] ±0.00	6.03[b] ± 0.01	1.84[d] ±0.12	1.66[d] ±0.29
Carotenoids	9.02[a] ± 0.01	4.92[c] ±0.04	3.92[d] ±0.05	5.81[b] ± 0.02	1.90[e] ±0.00	1.81[e] ±0.02

Values are Means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at p<0.05

RCEL = Raw *Colocasia esculenta* leaf; SCEL = Steamed *Colocasia esculenta* leaf; SDCEL = Shade-dried *Colocasia esculenta* leaf; RSAL = Raw *Solanum aethiopicum* leaf; SSAL = Steamed *Solanum aethiopicum* leaf; SDSAL = Shade-dried *Solanum aethiopicum* leaf

Anti-nutrient content of the samples

Table 3 shows the anti-nutrient composition of the raw, steamed, and shade-dried leaves of samples. From the table, the oxalate content of both leaf samples ranged between 0.00 to 0.01 mg/100 g, having SDCEL and SSAL being the least (0.00 mg/100 g) and RCEL, SCEL, RSAL, and SDSAL having the highest (0.01mg/100 g) content of oxalate with a significant difference at P<0.05. Phytate content ranged from 0.01 to 0.07 mg/100 g with SSAL and SDSAL as the least (0.01 mg/100 g) and RSAL as the highest (0.07 mg/100 g) phytate content respectively. A significant difference (p<0.05) existed in the phytate content in the same row.

The Saponin content of the samples ranged from 0.33 to 2.23 mg/100 g with SSAL as the least (0.33 mg/100 g) and RCEL as the highest (2.23 mg/100 g) saponin content respectively. A significant difference (p<0.05) exists in the saponin content in the same row.

Table 3: Anti-nutrient content of raw, steamed and shade-dried samples

Parameters (mg/100 g)	RCEL	SCEL	SDCEL	RSAL	SSAL	SDSAL
Oxalate	$0.01^{c} \pm 0.00$	$0.01^{b} \pm 0.00$	$0.00^{d} \pm 0.00$	$0.01^{ab} \pm 0.00$	$0.00^{e} \pm 0.00$	$0.01^{a} \pm 0.00$
Phytate	$0.03^{c} \pm 0.00$	$0.02^{d} \pm 0.00$	$0.03^{b} \pm 0.00$	$0.07^{a} \pm 0.00$	$0.01^{f} \pm 0.00$	$0.01^{ef} \pm 0.00$
Saponin	$2.23^{a} \pm 0.02$	$0.98^{c} \pm 0.00$	$0.66^{e} \pm 0.00$	$1.32^{b} \pm 0.01$	$0.33^{f} \pm 0.00$	$0.67^{d} \pm 0.01$

Values are Means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $p<0.05$

RCEL = Raw *Colocasia esculenta* leaf; SCEL = Steamed *Colocasia esculenta* leaf; SDCEL = Shade-dried *Colocasia esculenta* leaf; RSAL = Raw *Solanum aethiopicum* leaf; SSAL = Steamed *Solanum aethiopicum* leaf; SDSAL = Shade-dried *Solanum aethiopicum* leaf

DISCUSSION

Moisture composition of the samples

Table 1 shows the mean moisture content of the studied raw, steamed and shade-dried leaves of *Colocasia esculenta* and *Solanum aethiopicum* vegetables. The moisture composition was in consistence with the findings of Azubuike et al. (29) who found a high moisture content of fresh (83%) and boiled (88%) *Colocasia esculenta* leaves that decreased during drying, as well as the findings of Lester and Seck (30) who discovered a high moisture content of 82.1% for *Solanum aethiopicum.* Furthermore, the results were similar to the findings of Adeniyi, Ehiagbonare and Nwangwu (1), who found that other popular leafy vegetables consumed in the Eastern part of Nigeria had high moisture content (79.98, 87.84, 89.47, and 83.46 percent for *Corchorus olitorius, Ocimum gratissimum, Talinum triangulare,* and *Telfaria occidentalis,* respectively). The result of this work can be compared favourably to the work conducted by Ossamulu, Akanya, Jigam, and Egwim (31) who reported moisture content ranging from 88.31 - 91.94% for fresh leaves of *Solanum aethiopicum*. However, Achadu et al. (32) Reported a lower value for shade-dried *Colocasia esculenta* leaf (11.77%). The moisture content of steamed *Solanum aethiopicum* leaf (69.72%) recorded in this work was ten times higher than the value of steamed *Solanum aethiopicum* fruit reported by Ndife et al. (33). These values are greater than those previously reported for several Nigerian green vegetables (34), indicating that these two samples studied are very rich source of water-soluble vitamins that aid digestion and metabolism of ingested food, as well as controlling hidden hunger and dehydration. Moisture, often known as water, is unquestionably the most important nutrient and the most abundant material in the human body, accounting for around three-quarters of total body mass and playing a vital role in every cell. Furthermore, water is required to remove (through a process known as hydrolysis) a phosphate group from adenosine triphosphate (ATP) or guanosine triphosphate (GTP) in order to obtain energy (35). Water is also the holding medium for electrolytes and all other ions throughout the human body, according to Mepha, Eboh, and Banigbo (36). Some of the changes in % moisture composition might be attributed to factors such as climate, soil species and type, growth circumstances, the application of natural or artificial manure, and the time period of study (1). On the contrary, Studies have implicated moisture content in deteriorative activities in vegetable and is used as a measure of stability and the susceptibility to microbial contamination (13).

Vitamin composition of the samples

The presence of vitamins C, E, and K in these vegetable samples, as shown in Table 2, suggests that the leaves might be utilized to promote healthy living by strengthening and promoting tissue, bone, and tooth maintenance, as well as protection against scurvy and other vitamin deficiency associated illnesses (37). The vitamin C content of raw, steamed, and shade-dried leaves of *Colocasia esculenta* and *Solanum aethiopicum* were low compare to vitamin C contents (316.80, 241.06, 215.63 and 356.11 mg/100g) of fresh *C. olitorius*, *O. gratissimum*, *T. triangulare*, *T. occidentalis* respectively as reported by Adeniyi, Ehiagbonare and Nwangwu (1). The low Vitamin C concentration (4.51 mg/100g) of the raw *Colocasia esculenta* sample tested was consistent with the findings of Temesgen and Retta (38), who found 7-9 mg/100g of Vitamin C in *C. esculenta.* Hedges and Lister (39) found 14.3 mg/100g of vitamin C in raw *C. esculenta*, which is also in accord. The value of vitamin C contents of steamed leaf of *Solanum aethiopicum* (3.10 mg/100g) studied, was lower compared to the raw sample studied because vitamin C is heat labile and diminishes on the shelf with time. This was in line with the value reported for steamed *Solanum aethiopicum* fruit by Ndife et al. (33). Studies have indicated that the amount of Vitamin C content of fresh leaves is high, ranging from 8-15mg/100g (40) but maintaining such a high content can be challenging especially while using the rudimentary methods of processing. In this current study, there was a significant reduction in vitamin C when the vegetables were steamed and shade-dried with a significantly greater reduction in the sample that was shade-dried (33).

Natural ascorbic acid (vitamin C) is essential for proper bodily function (41). Ascorbic acid deficiency affects the proper production of intercellular substances such as collagen, bone matrix, and tooth dentine throughout the body. A notable pathogenic effect of this deficiency is the weakening of the capillary endothelial wall owing to a decrease in the quantity of intercellular substances (42). As a result, the clinical symptoms of scurvy, such as bleeding from the mouth and gastrointestinal system, anemia, and joint aches, might be linked to the connection between ascorbic acid and proper connective tissue metabolism (41). Ascorbic acid's function also accounts for the necessity for proper wound healing. Because ascorbic acid is present in all vegetables, they may be utilized in herbal medicine to cure common colds and other disorders such as prostate cancer (41, 1).

The vitamin E content of raw *Solanum aethiopicum* and *Colocasia esculenta* leaf as indicated in table 1 above are 7.39 and 2.19 mg/100g respectively. Leaf of raw *Solanum aethiopicum* was observed to have more vitamin E than *Colocasia esculenta* from the table 1 above. This was supported by vitamin E value of *Solanum aethiopicum* recorded as 7.34 mg/100ml by a study conducted by Achikanu, Eze-Steven, Ude, and Ugwuokolie, (43). However, Ezeabara, Okeke, and Amadi (44) Reported 1.89 mg/100g as the highest value for *Colocasia esculenta* varieties investigated. Vitamins E and C are antioxidants that help protect the body against cancer and other degenerative illnesses including arthritis and type II diabetes mellitus (45). Vitamin E is a component of cellular membranes whose primary function is to protect the cell from oxidation. It is the initial line of defense against lipid peroxidation within cells and organelles (e.g., mitochondria). This vitamin is also crucial in providing flexibility to Red Blood Cells (RBC) as they travel through the vascular network (46). According to Emeka and Onyechi, (47), lipid peroxidation was considerably decreased in animals fed a vegetable diet due to the high quantity of vitamins contained in this vegetable. This finding backs up the antioxidant effect of *Telfairia* extracts reported by (48). Vegetables' antioxidant properties have been ascribed to the presence of phenolic substances such as flavonoids, polyphenols, and vitamins (49).
Vitamin K content of the raw leaf samples as seen in table 1 ranged from 0.00 to 0.14 mg/100g with *Solanum aethiopicum* leaf having negligible or insignificant amount of vitamin K (0.00 mg/100g) and raw *Colocasia esculenta* leaf having (0.14 mg/100g) vitamin K respectively though negligible too which suggest that the both samples studied are not good source of vitamin K. According to Hedges and Lister, (39), vitamin K is found in insignificant amounts in *Colocasia esculenta* vegetables and functions as a co-enzyme in synthesis of protein, blood clotting (prothrombin and other factors), bone formation, energy and calcium metabolism.

Mineral composition of the samples
Minerals and vitamins play a very important role in energy metabolism as well as function in lending Red Blood Cells (RBC) flexibility as they make their way through the arterial network (46). The mineral composition of the two samples studied as presented in table 1 reveals that the phosphorus (P) content of raw, steamed and shade-dried leaves of *Colocasia esculenta* are 12.04, 10.31 and 30.80 mg/100g while that of *Solanum aethiopicum* are 3.65, 4.65 and 15.20 mg/100g respectively with raw *Solanum aethiopicum* leaf having the least (3.65 mg/100g) and shade-dried *Colocasia esculenta* leaf having the highest (30.80 mg/100g) phosphorus content respectively. The phosphorus content of the samples studied were very small when compared with those reported by Otitoju, Ene-Obong, and Otitoju, (3) for other green leafy vegetable such as *Psychotria*, *C. aconitifolius* and *T. occidentalis* having 243.70, 80.59, 58.34 mg/100g respectively. However, a study by Iheanacho and Udebuani, (50) reported a small amount of phosphorus in *Amaranthus hybridus*, *Curcubita pepo* and *Gnetum africana leaves* (8.57, 1.12 and 0.18 mg/100g).
The magnesium (Mg) content of raw, steamed and shade-dried leaves of *Colocasia esculenta* are 53.23, 62.04 and 6.70 mg/100g while that of *Solanum aethiopicum* are 4.58, 4.45 and 2.26 mg/100g respectively with shade-dried *Solanum aethiopicum* leaf having the least (2.26 mg/100g) and steamed *Colocasia esculenta* leaf having the highest (30.80 mg/100g) magnesium content respectively. This was not in consonance with that posited by Inyang (51), who reported a higher value of magnesium (109.28 mg/100g) for *Colocasia esculenta.* High amount of potassium, calcium and magnesium have been reported to reduce blood pressure in human (7,52). The magnesium result of *C. esculenta* studied (53.23 mg/100g) was in line with the study done by Hedges and Lister (39), who reported 71 mg/100g of C. *esculenta.* However, another study by Achikanu et al. (43) noted 29.46 mg/100g for magnesium content of *Solanum aethiopicum* which is higher to that gotten from table 1 above. The differences observed in the magnesium values might be due to soil compositions and the rate of uptake of minerals by individual vegetables (53).
Sodium (Na), mostly found in the body fluid plays a major role in maintaining blood volume and blood pressure (54). The result of the sodium level study was similar to that conducted by Achadu et al. (32), who

reported 77.07 mg/100g for shade-dried *Colocasia esculenta* leaf. It is also in accordance with the study by Inyang (51) who reported sodium content to range from 29.59 mg/100g for *Ipomea batatas* leaf to 75.69 mg/100g for *Lasianthera africana* leaf as well as 70.15 mg/100g for *Colocasia esculenta* leaf. Furthermore, in line with the sodium content of *Colocasia esculenta* of this study, Hedges and Lister, (39) reported a lower value of 4.2 mg/100g for *Colocasia esculenta* taro.
As recorded in the table 1, the potassium (K) level of the *Solanum aethiopicum* leaf studied was not in consonance with the investigations by Achikanu et al. (43) who reported a small amount of sodium (2.26 mg/100g) for *Solanum aethiopicum*.

Phytochemical composition of the samples
The results of this research work showed the presence of alkaloid and flavonoid in *C. esculenta*. This was in accordance with the qualitative analysis of *Colocasia esculenta* done by Al-Kaf, Al-Deen, Alhaidari and Al-Hadi, (55) that stated the presence of alkaloids and flavonoids in *C. esculenta* leaves. The result was also in agreement with the of work of Ezeabara, Okeke, and Amadi (44) who investigated the phytochemical assay of different variety of *Colocasia esculenta* leaf and revealed that the greatest level of Alkaloid and flavonoid present in *C. esculenta* were 0.19 and 0.31% respectively. These results were higher than the flavonoid (0.63%) and alkaloid (0.74%) content of *Pterocarpus santolinoides* reported by Ndukwe and Ikpeama (56). A similar study done by Achadu et al. (32), recorded 62.62 mg/100g flavonoids for shade-dried *Colocasia esculenta* leaf. Flavonoids have been shown to have anti-bacterial, anti-inflammatory, anti-allergic and anti-tumor and protect organisms from free radicals' attack. Pure isolated alkaloids and their synthetic derivatives are used as basic medicinal agents for their analgesic, antispasmodic and bactericidal effects (41). The presence of carotenoid in *S. aethiopicum* and *C. esculent* leaves respectively was in accordance with the work of Mibei et al. (57) that equally indicated the presence of carotenoids ranging from 996.2-1049.4 microgram/gram. Several Carotenoid and alkaloids isolated from natural herbs exhibit anti-proliferation and anti-metastasis effects on various types of cancers both in vitro and in vivo (58). Furthermore, highest quantity of alkaloids (56%) and flavonoids (162%) were found in quantitative analysis of crude extract of *Solanum aethiopicum* by Abdullahi, Ibrahim, Sani and Abdullahi, (59). This was also comparable to the result of qualitative analysis of phytochemicals present in *Solanum aethiopicum* reported by another study done by Eze and Kanu, (60). However, it was in contrast with outcome produced by other researchers on qualitative analysis of phytochemical present in *Solanum aethiopicum* (61, 62). In addition, largest quantity of non-polar compounds such as flavonoids and steroids were found in polar residual aqueous fraction of *Solanum aethiopicum* extract (59).

Anti-nutrient composition of the sample
From the table 3 above, oxalate content of both raw leaf samples studied are very small and read between 0.00 and 0.01 mg/100g. This was in line with the study done by Abdullahi, Ibrahim, Sani and Abdullahi, (59) who recorded nothing in oxalate content of *Solanum aethiopicum.* It also agreed with the work done by Ezeabara, Okeke and Amadi (44) who reported 2.32 mg/100g as the highest oxalate level in various *Colocasia esculenta* investigated. Oxalate content of leaves below the toxic levels of 2-5g staled by Edeoga, Omosun and Uche, (63) is unlikely to pose toxicity problems to man. Phytate content ranged from 0.03 to 0.07 mg/100g for raw sample with raw *Solanum aethiopicum* leaf as the least (0.03 mg/100g) and raw *Colocasia esculenta* leaf as the highest (0.07 mg/100g) content respectively. This was in line with the study done by Ezeabara, Okeke and Amadi, (44) who stated 0.82 mg/100g as the highest phytate content among the different variety of raw *Colocasia esculenta* studied.
Saponin content of the samples ranged from 0.33 to 1.32 mg/100g for *Solanum aethiopicum* leaf and 0.66 to 2.23 mg/100g for *Colocasia esculenta* leaf respectively. This was in accordance to the preliminary qualitative phytochemical screening of *Solanum aethiopicum* crude extract and fractions by Abdullahi, Ibrahim, Sani and Abdullahi, (59) revealing the presence of saponins, tannins, flavonoids, alkaloids, steroids and cardiac glycosides. Similar outcome was obtained by other researchers (18, 61, 60, 64, 65). Report by Eze and Kanu, (60) posited high value of 14% saponin content of *Solanum aethiopicum* fruit as was observed in the quantitative analysis of the said fruit which was comparably high to the outcome of this study. Furthermore, Ezeabara, Okeke, and Amadi, (44) reported 0.63 mg/100g as the highest saponin level from his investigation on phytochemical assay of different species of *Colocasia esculenta.* Some of the differences in the percentage composition might be linked to factors like climate, species, and nature of soil, growing conditions, application of natural or artificial manure and the period of analysis (1).

CONCLUSION
In conclusion, the study has shown that the leafy vegetables contain appreciable level of nutrients and the different processing method either improves or reduces the nutrient present in the leafs. They could be consumed to enhance variety and supplement the scarce or non-available sources of nutrients, thereby

averting malnutrition. As was observed from the above result, steaming a leafy vegetable especially *Solanum aethiopicum* has a better effect on the anti-nutrients than shade drying, thereby suggesting steaming as a better processing method than shade-drying. More research on the effect of these green leafy vegetable on non-communicable diseases are recommended.

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