Ukom *et al. Journal of Ethnic Foods* (2023) 10:6
https://doi.org/10.1186/s42779-023-00170-x

Journal of Ethnic Foods

ORIGINAL ARTICLE

Open Access

Impact of cooking methods on the chemical and antioxidant composition of some indigenous vegetables used in different food dishes in Southeast Nigeria

Anthony Ukom*, Miracle Albert, Philippa Ojimelukwe, Blessing Offia-Olua and Lilian Nwanagba

Abstract

Background Some wild and domesticated vegetables of Ibo ethnic tribe of Southeast, Nigeria, namely *Piper guineense*, *Ocimum gratissimum*, *Solanum melongena* L., *Gongronema latifolium*, *Gnetum africanum* and *Vernonia amygdalina*, have gained interest in food culinary uses due to its nutritional, antioxidant potentials and health benefits. These vegetables are rich in fiber, minerals and phyto-nutrients and have significant health benefits against degenerative disorders. Due to these facts, cooking methods aimed at better retention of nutrients and antioxidant compounds were exploited.

Methods Carefully selected fresh and shredded indigenous vegetables that are commonly used in different food dishes in Southeast Nigeria were cooked (blanched at 98 °C, 2 min and sautéed at 150 °C, 5 min). They were analyzed on a dry weight basis for minerals, vitamins, phytochemicals and antioxidant activity assayed by DPPH, ABTS and FRAP.

Results Results exhibited wild variations showing that *Ocimum gratissimum* and *Solanum melongena* L had higher concentrations of functional minerals Zn, Fe, K and Ca. Vitamins B_1 and β-carotene had higher concentrations in *Solanum melongena* L, *Gnetum africanum* and *Vernonia amygdalina*. *Ocimum gratissimum* revealed higher concentrations of TPC and TFC and maintains strong scavenging activity in ABTS and FRAP, while %DPPH manifested stronger activity in *Solanum melongena* L. *Vernonia amygdalina* exhibited higher phytochemicals concentrations, especially the alkaloid content.

Conclusion Sautéed cooking retained more nutrients and had stronger antioxidant activity than the blanched method. Overall, these vegetables possess high concentrations of functional constituents that can make them be used to boost human nutrition and benefit the health of consumers.

Keywords Ibo ethnic vegetables, Improved cooking methods, Vegetable food dishes, Nutrient compositions, Phytochemicals and health benefits

Introduction

The daily diet in Southeast Nigeria is dominated by starchy staple foods where indigenous vegetables are the cheapest and most readily available sources of fiber, micronutrients, protein and antioxidant compounds [1]. Indigenous vegetables feature prominently in food security, socio-economy and livelihood activities of our rural

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people. They serve as foods to households and some of their income-generating activities, mostly the women are based on these crops [2]. Common indigenous vegetables include but not limited to *Vernonia amygdalina (onugbu)*, *Gnetum africanum(okazi)*, *Ocimum gratissimum (nchuanwu), Solanum melongena* L. (*anara*), *Gongronema latifolium (utazi*) and *Piper guineense (uziza*) [3]. Indigenous vegetables refer to those vegetable species which are peculiar to a particular region or locality [4].

The Ibo people of Southeast Nigeria (Fig. 1) relishes foods prepared with these vegetables in soups for daily meals and in special occasions like marriages, burials, children dedication or chieftaincy title coronation ceremonies. In most cases, these vegetables are used in combination with other ingredients for soups and sauces like in *Vernonia amygdalina* (*Onugbu)* (bitter leaf) soup, melon seed (*egusi*) soup, *Gnetum africanum* (*okazi*) soup, *Solanum melongena* L. (*anara* leaf) soup or the spices (*Ocimum gratissimum (nchuanwu* leaf*), Gongronema latifolium (utazi* leaf) and *Piper guineense (uziza* leaf) used for fish/chicken/goat meat pepper soup, also called *Ngwongwo* and *Nkwobi* (Fig. 2). As an integral part of the people's meals, the soups are served and eaten with *gari/fufu* (fermented and gelatinized cassava paste), boiled or roasted yam and plantain, rice or just as spices in others like Abacha (tapioca/African salad) and sauces, and have been part of the Southeast Nigeria's cuisine. There are also prepared, sold and served in restaurants and eateries. These vegetables abound along the coastal lines of the West African States like Ghana, Benin, Nigeria and Cameroun. Already, the vegetables are part of local and international commerce involving an estimated millions of dollars, especially among the Southerneast people in

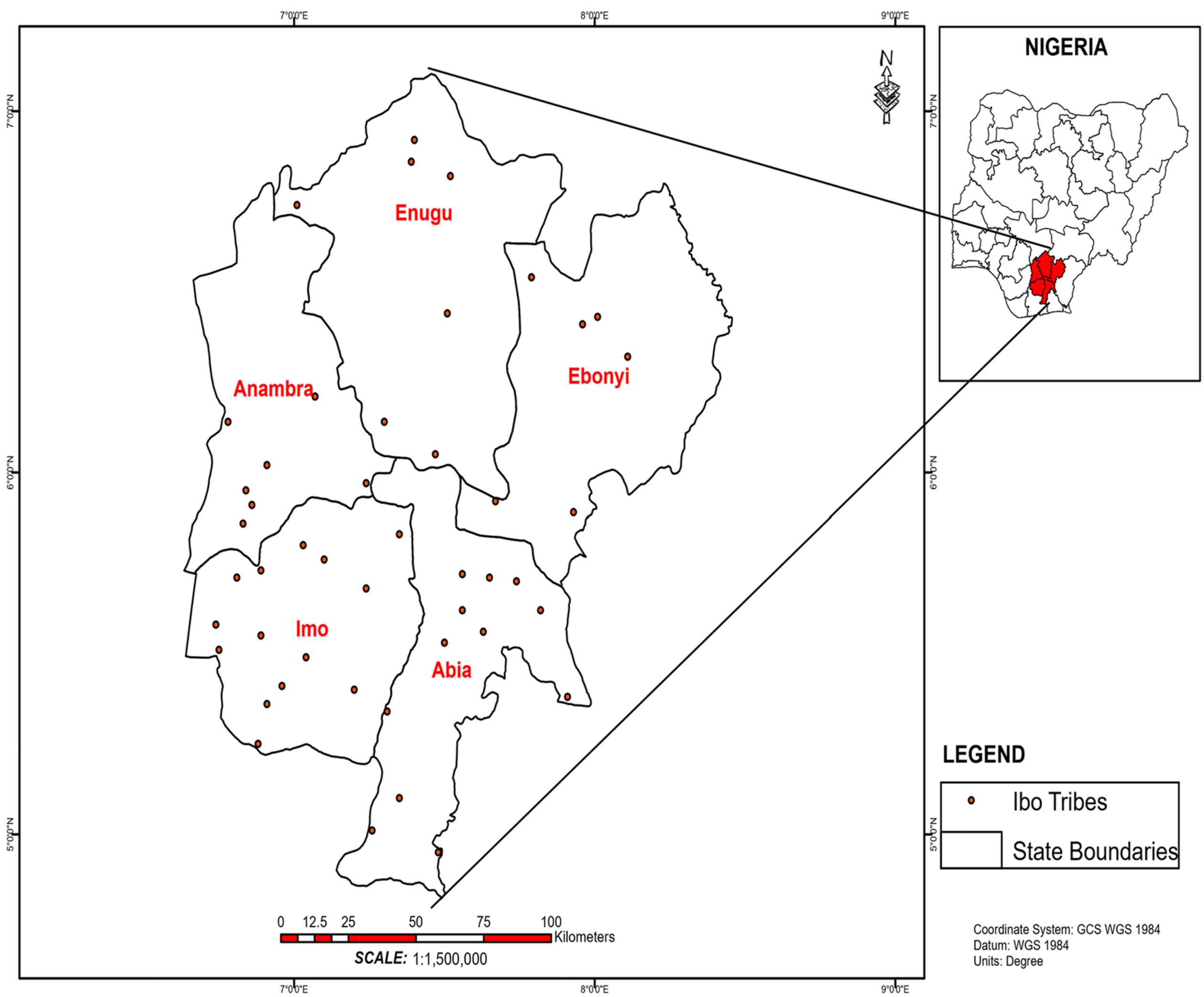

Fig. 1 Map of South Eastern Nigeria

other parts of Nigeria and those in diaspora where they are marketed in dehydrated forms and utilized in diasporan kitchens.

Before now, these indigenous vegetables were harvested mostly from the wild but are nowadays domesticated and grown as garden crops for economic and food safety reasons. A number of these vegetables are consumed cooked or raw as a single or mixed salad, or in soups, sauce, stew and porridge. Others serve as a spice for their aromatic flavor, bitter, hot or pepperish taste. In the light of these, they are in high demand in recent years not only as food, but also as remedial home medicine and for health-promoting benefits. Besides, they are in addition to the diversification of diets rich in vitamins and mineral elements, and to the improvement in functional health. In spite of the value addition to foods among the populous Ibo tribe of Southeast Nigeria (over 70 million people), the nutritional contribution to local diets, and health maintenance and protective properties, these vegetables have not been fully exploited for their biodiverse nutritional and health resources in addressing the complex food, nutritional and health problems of the indigenous population [5].

The eggplant (*Solanum melongena*) is native to Asia (India) where it grows in the wild. As trade routes opened, the eggplant was introduced to Europe by the Arabs and transported to Africa by the Persians. It requires a warm climate [6]. It is a staple in the cuisines of the Mediterranean region. *Piper g*uineense is an evergreen plant found in rainforest edges. It is native to tropical Central and Western Africa. It may be found in the wild or cultivated in countries such as Nigeria Senegal, Southern Sudan, Zambia, and Tanzania. Both the leaves and the fruits are used as spices [7]. *Gongronema latifolium* Benth. belongs to the family Apocynaceae. It is a climber with greenish yellow flowers and heart-shaped leaves that exude white/milky latex when plucked. The vernacular names are utazi (Ibo), Arokeke (Yoruba) and Utasi (Ibibio and Efik). It also has medicinal value and is used extensively in African cuisines [7]. *Ocimum gratissimum* (clove basil) is found in tropical Africa, India, and Southeast Asia. It is cultivated in China, South America, the Caribbean, Australia, New Zealand and many Islands in the Indian and the Pacific region [8]. *Vernonia amygdalina* occurs in the wild in most countries of tropical Africa and can also be cultivated**.** It is a member of the daisy family that typically grows to a height of 2–5 [9]. It is used for the management of various diseases in humans and animals and for special cuisines despite its bitter taste. *Gnetum africanum* is found in the humid tropical forest regions of the Central African Republic, Cameroon, Gabon, Republic of the Congo, Democratic Republic of the Congo and Angola. It is used traditionally in the treatment of many illnesses [10].

Cooking methods have a significant influence on the bioavailability of food nutrients and gastronomy. According to Miglio et al. [11], cooking induces significant changes in the chemical composition, concentration and bioavailability of nutrients and bioactive compounds in vegetables. Cooking methods have both positive and negative effects on the nutrients and antioxidant potential of vegetables. The phenolic content and antioxidant activity of vegetables increased when they were blanched, boiled, fried, steamed or microwaved [11–13]. However, blanching at 98 °C for 2 min reduced the phenolics and antioxidant capacity of some vegetables [14, 15]. The proportion at which nutrients in vegetables are retained after cooking relative to the amount of nutrient present in the raw vegetables before processing is referred to as nutrient retention. The retention of nutrients after processing is important to ensure the consumption of foods with high nutrient density for proper human growth, development and warding off sicknesses [16]. This is important to the indigenous people's nutrition whose major source of micronutrients to enhance their physiological health depends on these vegetables as food. Evaluating the concentration of essential nutrients of these vegetables in cooked form vis-à-vis the uncooked ones for their nutrient retention and health-promoting benefits becomes imperative.

The main objectives of this study were to evaluate some cooked (blanched and sautéed) indigenous vegetable for chemical, phytochemical contents, and antioxidant activity and their contribution to nutrition and health-promoting benefits. Figure 1 shows the map of the Southeast region of Nigeria where the populace utilizes these vegetables extensively for various culinary and medicinal purposes.

Materials and methods

Sources of raw materials

Fresh vegetables: *Vernonia amygdalina (onugbu)* or bitter leaf, *Gongronema latifolium (utazi*), *Solanum melongena* L. (*anara*) or garden egg leaf, *Ocimum gratissimum*

(See figure on next page.)

Fig.2 Photographic images of soups cooked with indigenous vegetables. Each soup is named after the vegetable used in cooking it: **A** (*G. latifolium* (*Utazi) Nkwobi* cow leg), **B** (*P. guineense* (*Uziza)* leaf soup), **C** (*G. latifolium* (*Utazi)Abacha/*African salad), **D** (*G. latifolium* (*Utazi)* leaf goat meat pepper soup), **E** (*G. africanum* (*Ukazi)* soup), **F** (*G. africanum Ukazi* + *Egusi* soup), **G** (*G. latifolium* (*Utazi)* chicken pepper soup), **H** (*S. melongena (Anara)* leaf soup), **I** (Gari), J (*Vernonia amygdalina (Onugbu)* soup). Sources: https://9jafoods.com; https://cookpad.com; https://myactivekitchen.com and https://allnigerianfoods.com

Fig.2 (See legend on previous page.)

(nchuanwu) or scent leaf, *Piper guineense (uziza*) or West African pepper leaf and *Gnetum africanum (okazi*) (Fig. 3) were procured from Ubani main market, Umuahia, Abia State, Nigeria. Standard reagents were obtained from the Biochemistry Laboratory of National Root Crops Research Institute, Umudike.

Processing of vegetable samples

Fresh vegetables were processed using the modified method of Bamidele et al. [17]. The vegetables were separately sorted and washed in potable water manually. They were then picked up from the nodes, shredded with a stainless steel knife and divided into three parts of 100 g each.

Processing treatments

Table 1 shows the cooking methods and conditions. Blanched vegetables were done in a stainless steel pot, after which the water was allowed to drain off. King's brand oil was used for sautéed vegetable samples. The

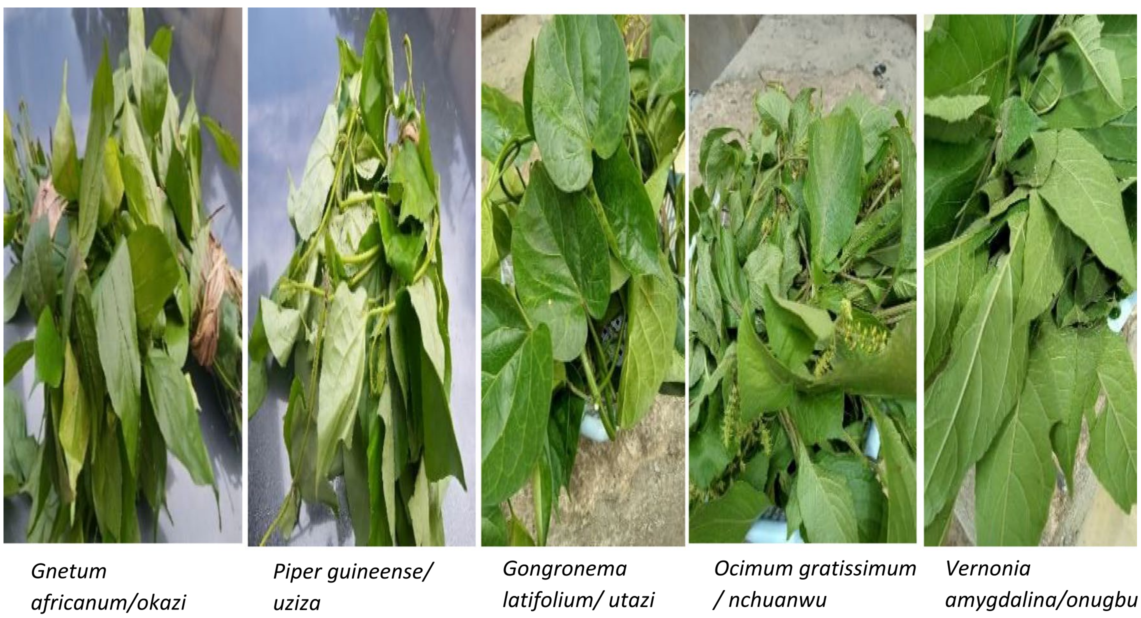

Fig. 3 Indigenous vegetables used in analysis (and in soup preparation)

Table 1 Cooking of vegetables by (a) blanched method, (b) sautéed method

Botanical name Local name	English name	weight (g)	Water (ml)	Temp/Time (min)
(a)				
Piper guineense (*Uziza)*	–	100	250	98 °C /2 min
Ocimum gratissimum	Scent leaf (*Nchuanwu*)	100	250	98 °C /2 min
Solanum melongena L (*Anara)*	Garden egg leaf	100	250	98 °C /2 min
Gongronema latifolium (Utazi)	–	100	250	98 °C /2 min
Gnetum africanum (Okazi)	–	100	250	98 °C /2 min
Vernonia amygdalina (*Onugbu*)	Bitter leaf	100	250	98 °C /2 min
(b)				
Piper guineense	–	100	200	150 °C /5 min
Ocimum gratissimum Nchuanwu	Scent leaf	100	200	150 °C /5 min
Solanum melongena L *Anara*	Garden egg leaf	100	200	150 °C /5 min
Gongronema latifolium Utazi	–	100	200	150 °C /5 min
Gnetum africanum Okazi	–	100	200	150 °C /5 min
Vernonia amygdalina Onugbu	Bitter leaf	100	200	150 °C /5 min

oil was drained off and the vegetables dabbed with clean Whiteman's paper to absorb excess oil. After processing, the vegetables were allowed to cool at room temperature. Both the uncooked and cooked vegetables were further dried at 50 °C and pulverized into powder for subsequent analysis.

Determination of minerals content of vegetables

Calcium, magnesium and potassium contents of vegetable samples were determined by the method described by Onwuka [18], while zinc, iron and phosphorus contents were determined by the method of AOAC [19].

Determination of vitamins content of the vegetables

The spectrophotometric method described by AOAC [19] was used to determine the β-carotene contents of vegetable samples. Five grams (5 g) of milled vegetable was added to 30 mL of absolute ethanol and 3 mL of 5% potassium hydroxide. The mixture was boiled under reflux for 30 min and cooled rapidly with running water and filtered. Thirty milliliters (30 mL) of distilled water was added to the mixture and was then transferred into a separating funnel. Three portions of 50 mL of ether were used to wash the mixture, the lower layer was discarded, and the upper layer was washed with 50 mL of distilled water. The extract was evaporated to dryness and dissolved in 10 mL of isopropyl alcohol, and its absorbance was measured at 325 nm. β-carotene content of the vegetables was then calculated as follows:

$$\beta-\text{carotene}(\text{mg}/100\text{g}) = \frac{100}{w} \times \frac{au}{as} \times \text{c}$$

where: au = absorbance of the test sample, as = absorbance of standard solution, c = concentration of the test sample and w = weight of the sample.

Vitamins B_1, B_2 and B_3 were determined by the method of AOAC [19]. Vitamin C was determined by the method of Okwu and Josiah [20].

Preparation of vegetable extracts

A 50:50 (v/v) acetone/water mixture was the solvent used for extraction according to the modified method of Ukom et al. [21]. About 0.5 g of powdered vegetable samples (triplicate) was mixed with 5 mL of the extraction solvent in a 50-mL BD Falcon tubes using Ultra-Turrax (1Ka T18 basic Staufen, Germany) for 10 s and then capped and remixed in a Vortex mixer (Fisher Scientific, USA) for 1 min. The vegetable samples were placed in a multi-purpose rotator (Barnstead International, USA) for 30 min and then centrifuged at 4 °C for 5 min at 6000 rpm (Eppendorf Centrifuge 5804R Hamburg, Germany). The vegetable extracts (2 mL), each was collected and stored in the dark at 4 °C for determination of total polyphenol, flavonoids, DPPH, FRAP and ABTS.

Determination of total polyphenol content (TPC) of vegetable extract

TPC of the vegetable extract was determined using a Folin--Ciocalteu reagent [22]. A 50 μL of the vegetable extract was added to 0.5 mL Folin--Ciocalteu reagent and vortexed, then 400 μL $NaC0_3$ solution (75 g/L) was added after a 3-min reaction time. Thereafter, the mixture was vortexed thoroughly and the absorbance was measured at 765 nm against a blank after 30 min of incubation at room temperature. All samples were prepared and measured in duplicate. Gallic acid was used as the standard, and TPC was expressed as mg gallic acid (GA) equivalent per 100 g sample.

Determination of total flavonoid (TFC) content of vegetable extract

The total flavonoid content of the vegetable extract was determined using the colorimetric $AlCl_3$ method [23]. Briefly, 250 μL of extract solution was diluted with 1.25 mL distilled water and mixed with 75 μL of 5%$NaNO_2$. After 5 min, 150 μL of 10% $AlCl_3$ was added and then incubated for 6 min and 500 μL of 1 mol/L Na0H was subsequently added. The absorbance was measured immediately at 510 nm. Tannic acid was used as the standard, and TFC was expressed as mg tannic acid (TA) equivalent per 100 g sample.

Antioxidant activity of vegetable extract determined by 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay

DPPH radical scavenging activity of the sample extract was determined according to the method reported by Benzie and Strain [24}. A series of extracts (10, 20, 30, and 40 mg/mL) were prepared using distilled water, and the total volume was maintained at 1 mL. About 250 μL of 0.5 mM methanolic solution of DPPH was added and vortexed. The test tubes were incubated for 30 min in the dark at room temperature. The absorbance was measured at 517 nm. Distilled water was used as control. The scavenging activity of the sample extract was expressed as 50% inhibition concentration (IC50) (mg/mL) and was obtained by interpolation from linear regression analysis.

Antioxidant activity of vegetable extract determined by ferric reducing antioxidant power (FRAP)

The FRAP assay is based on the reduction of the Fe (III)-TPTZ complex to the ferrous form at low pH. This reduction was monitored by measuring the absorption change at 593 nm [25]. One milliliter of the working reagent was mixed with 20 μL of the extract, and the absorbance at 593 nm was recorded after 4 min of incubation at room temperature. The absorption of 1000 μM ferrous sulfate standard was also measured. FRAP values are expressed as mmol of Fe (II) equivalent per 100 g sample.

Antioxidant activity of vegetable extract determined by $ABTS^{+}$ radical cation

For the ABTS assay, the method modified by Ukom et al. [21] was adopted. $ABTS^{+}$ was produced by reacting 38.4 mg ABTS and 6.6 mg potassium persulfate in 10 mL of deionized water. The mixture was allowed to stand in the dark at room temperature for 12 h before use. The $ABTS^{+}$ stock solution was diluted with ethanol to obtain an absorbance of 1.1 + 0.02 at 734 nm. Then, 30 μL of vegetable extract or Trolox standard and 200 μL $ABTS^{+}$ solution was added together and allowed to react for 6 min before taking absorbance at 734 nm (μQuant, Biotech Instruments, USA). Data were expressed as Trolox equivalent dry weight (TE/gdw). The Trolox standard curve was linear between 50 and 400 μM Trolox.

Determination of phytochemical contents of uncooked and cooked vegetables

The spectrophotometric method of AOAC [19] was used for the determination of phytate. The saponin and tannin contents were determined using the methods of AOAC [19]. The phenol content of vegetable samples was determined by using Folin--Ciocalteu reagent according to the method of Odabasoglu et al. [26]. The gravimetric method of Harbone [27] was used to determine alkaloids.

Statistical analysis

One-way analysis of variance (ANOVA) was carried out on the data generated in this study using the SPSS version 22.0 software. The analyzed data were expressed as mean ± SD (standard deviation). The Duncan multiple range test (DMRT) method was used to compare the means of experimental data at a 95% confidence interval.

Results and discussion

Minerals composition of uncooked and cooked indigenous vegetables

Table 2 presents the results of the minerals composition of uncooked and cooked vegetables. As observed in some cases, cooking of fresh vegetables resulted in significant

Table 2 Mineral composition of uncooked and cooked indigenous vegetables (mg/100 g)

Sample	Ca	Zn	P	Fe	K	Mg
Uziza leaf (*Piper guineense*)						
Uncooked	45.56^{e} ± 0.02	1.78^{e} ± 0.01	1.61^{f} ± 0.02	15.12^{c} ± 0.03	7.41^{e} ± 0.04	12.82^{e} ± 0.02
Blanched	40.19^{e} ± 0.02	1.42^{d} ± 0.03	0.91^{f} ± 0.02	10.64^{c} ± 0.01	4.24^{f} ± 0.04	9.52^{e} ± 0.02
Sautéed	42.31^{d} ± 0.02	1.57^{e} ± 0.02	1.14^{f} ± 0.02	12.22^{c} ± 0.04	5.63^{f} ± 0.04	11.11^{e} ± 0.01
Nchuanwu (Scent) leaf (*Ocimum gratissimum*)						
Uncooked	60.45^{c} ± 0.01	19.89^{a} ± 0.01	20.36^{d} ± 0.02	17.67^{a} ± 0.02	70.23^{d} ± 0.04	71.08^{b} ± 0.03
Blanched	41.83^{d} ± 0.04	16.57^{a} ± 0.02	15.41^{d} ± 0.01	13.93^{b} ± 0.03	52.13^{d} ± 0.03	62.47^{b} ± 0.02
Sautéed	45.37^{e} ± 0.04	18.04^{a} ± 0.02	26.75^{d} ± 0.03	19.62^{a} ± 0.01	76.13^{d} ± 0.03	62.47^{b} ± 0.01
Anara (garden egg) leaf (*Solanum melongena*)						
Uncooked	206.63^{a} ± 0.01	8.09^{b} ± 0.01	7.25^{e} ± 0.01	15.73^{b} ± 0.03	715.52^{a} ± 0.02	6.52^{f} ± 0.01
Blanched	196.91^{a} ± 0.01	6.72^{b} ± 0.03	2.92^{e} ± 0.03	14.03^{a} ± 0.01	550.71^{a} ± 0.01	6.52^{f} ± 0.01
Sautéed	200.32^{a} ± 0.01	8.19^{b} ± 0.01	5.57^{e} ± 0.03	16.02^{b} ± 0.01	601.84^{a} ± 0.01	7.82^{f} ± 0.03
Utazi leaf (*Gongronema latifolium*)						
Uncooked	156.36^{b} ± 0.02	2.45^{c} ± 0.02	49.82^{c} ± 0.02	7.66^{d} ± 0.04	355.34^{b} ± 6.39	298.72^{e} ± 0.01
Blanched	143.71^{b} ± 0.02	1.06^{f} ± 0.03	41.27^{b} ± 0.01	4.87^{d} ± 0.01	300.54^{b} ± 0.01	279.46^{a} ± 0.02
Sautéed	144.97^{b} ± 0.01	2.10^{c} ± 0.01	45.92^{b} ± 0.02	6.31^{d} ± 0.01	301.85^{b} ± 0.01	279.98^{a} ± 0.01
Okazi leaf (*Gnetum africanum*)						
Uncooked	60.22^{d} ± 0.01	1.38^{f} ± 0.01	81.57^{a} ± 0.02	2.47^{f} ± 0.03	150.43^{c} ± 0.02	64.07^{c} ± 0.03
Blanched	49.74^{c} ± 0.03	1.21^{e} ± 0.01	72.42^{a} ± 0.02	2.31^{e} ± 0.01	130.27^{c} ± 0.03	40.37^{c} ± 0.01
Sautéed	55.61^{c} ± 0.01	1.28^{f} ± 0.01	75.34^{a} ± 0.01	2.37^{e} ± 0.02	137.57^{c} ± 0.01	60.52^{c} ± 0.03
Onugbu (bitter) leaf (*Vernonia amygdalina*)						
Uncooked	12.98^{f} ± 0.02	2.14^{d} ± 0.01	53.44^{b} ± 0.01	3.53^{e} ± 0.02	9.36^{e} ± 0.01	17.48^{d} ± 0.01
Blanched	10.38^{f} ± 0.02	1.89^{c} ± 0.01	39.65^{c} ± 0.04	2.07^{f} ± 0.03	8.24^{e} ± 0.02	13.45^{e} ± 0.01
Sautéed	12.22^{f} ± 0.01	2.04^{d} ± 0.04	45.10^{c} ± 0.01	1.76^{f} ± 0.02	8.42^{e} ± 0.05	14.26^{d} ± 0.04

Mean ± standard deviation for duplicate determination. Values with different superscripts in the same column are significantly different ($p < 0.05$)

($p < 0.05$) loss of minerals in comparison with uncooked ones. In particular, blanching caused the degradation of soluble minerals in some vegetables probably because of leaching into water and to a high processing temperature. Also, blanched vegetables would have had a minor degree of softening and opening up of the cell matrix, a situation that probably prevented further minerals extraction from the blanched vegetables. Sautéed process lost minimal and/or gained minerals than the uncooked treatment possibly due to better sautéed texture quality. It was considered that sautéed treatment (150 °C for 5 min.) tenderized the vegetables but affected little or no solubilization of minerals. *Anara* (garden egg) leaf possessed the richest source of Ca, K, Fe and moderate concentration of Zn. Following, *utazi* leaf had high concentrations of K, Mg and Ca and a moderate amount of P and Fe, respectively. On the other hand, *nchuanwu* (scent) leaf was the richest source of Zn and Fe. From the study, *onugbu* (bitter) leaf showed the least minerals concentration, followed by *uziza* leaf which was only high in Fe, and *okazi* leaf which was moderate in K and P. The vegetables are of immense minerals nutrition to the indigenous population. They play key functional roles in the human body. Ca, Mg and K act as important regulators of the acid–base balance of the body, Ca and P are essential for skeletal development, while Fe and Zn associate with β-carotene for improved immune function for infants and children. Other researchers support these views on minerals nutrition of vegetables [27–29].

Vitamins composition of uncooked and cooked indigenous vegetables

The results of vitamins composition of uncooked and cooked vegetables are shown in Table 3. Cooking had a significant impact ($p < 0.05$) on vitamins concentration. Looking at the β-carotene, sautéed cooking exhibited the highest retention more than uncooked and blanched methods. This agrees with some findings in the literature. Bernhardt and Schlich [30] and Miglio et al. [11] revealed that cooked leafy vegetables increased the release of β -carotene from the matrix by the disruption of carotenoid--protein complexes, leading to better extractability and higher concentration of β -carotene. In this study, blanching determined the highest decrease (mean 19.1%) of β-carotene concentration. Blanching of vegetables at 98 °C in 2 min caused insufficient softening and

Table 3 Vitamin composition of uncooked and cooked indigenous vegetable (mg/100 g)

Sample	β-Carotene	B_1	B_2	B_3	Vit. C
Uziza leaf (*Piper guineense*)					
Uncooked	$66.22^d \pm 0.01$	$0.03^f \pm 0.01$	$0.02^e \pm 0.01$	$0.06^e \pm 0.01$	$2.54^d \pm 0.00$
Blanched	$45.03^d \pm 0.03$	$0.01^f \pm 0.01$	$0.01^d \pm 0.01$	$0.04^d \pm 0.02$	$2.00^d \pm 0.01$
Sautéed	$70.62^d \pm 0.02$	$0.06^f \pm 0.01$	$0.04^f \pm 0.01$	$0.11^d \pm 0.01$	$2.04^d \pm 0.02$
Nchuanwu (scent) leaf (*Ocimum gratissimum*)					
Uncooked	$20.54^e \pm 0.01$	$0.27^e \pm 0.02$	$0.05^e \pm 0.01$	$0.12^d \pm 0.01$	$15.78^c \pm 0.02$
Blanched	$9.96^e \pm 0.03$	$0.08^d \pm 0.01$	$0.01^d \pm 0.01$	$0.04^d \pm 0.02$	$7.15^c \pm 0.02$
Sautéed	$25.32^e \pm 0.02$	$0.06^e \pm 0.02$	$0.09^e \pm 0.01$	$0.10^d \pm 0.01$	$11.59^c \pm 0.02$
Anara (garden egg) leaf (*Solanum melongena*)					
Uncooked	$312.33^b \pm 0.03$	$10.67^a \pm 0.01$	$0.62^b \pm 0.03$	$0.22^c \pm 0.01$	$2.40^e \pm 0.02$
Blanched	$259.76^a \pm 0.04$	$4.95^a \pm 0.02$	$0.25^{\mathbf{b}} \pm 0.02$	$0.09^c \pm 0.01$	$0.97^e \pm 0.01$
Sautéed	$315.38^b \pm 0.02$	$7.53^a \pm 0.01$	$0.31^b \pm 0.01$	$0.19^c \pm 0.00$	$1.09^f \pm 0.04$
Utazi leaf (*Gongronema latifolium*)					
Uncooked	$3.94^f \pm 0.03$	$0.81^b \pm 0.01$	$0.96^a \pm 0.27$	$1.19^a \pm 0.02$	$20.03^b \pm 0.02$
Blanched	$0.92^f \pm 0.01$	$0.32^c \pm 0.02$	$0.61^a \pm 0.02$	$0.69^a \pm 0.01$	$10.24^b \pm 0.03$
Sautéed	$4.15^f \pm 0.03$	$0.87^b \pm 0.04$	$0.72^a \pm 0.03$	$0.88^a \pm 0.02$	$16.66^b \pm 0.01$
Okazi leaf (*Gnetum africanum*)					
Uncooked	$319.23^a \pm 0.03$	$0.52^c \pm 0.02$	$0.13^d \pm 0.01$	$0.47^b \pm 0.02$	$1.27^f \pm 0.02$
Blanched	$252.97^b \pm 0.03$	$0.44^b \pm 0.04$	$0.80^c \pm 0.03$	$0.31^b \pm 0.01$	$0.92^c \pm 0.01$
Sautéed	$325.32^a \pm 0.02$	$0.61^c \pm 0.01$	$0.19^d \pm 0.02$	$0.62^b \pm 0.03$	$1.20^e \pm 0.01$
Onugbu (bitter) leaf (*Vernonia amygdalina*)					
Uncooked	$220.75^c \pm 0.03$	$0.36^d \pm 0.01$	$0.41^c \pm 0.01$	$0.11^d \pm 0.02$	$62.39^a \pm 0.02$
Blanched	$194.07^c \pm 0.03$	$0.05^{ed} \pm 0.03$	$0.95^c \pm 0.01$	$0.05^d \pm 0.01$	$52.63^a \pm 0.03$
Sautéed	$231.72^c \pm 0.03$	$0.19^d \pm 0.03$	$0.26^c \pm 0.01$	$0.09^d \pm 0.01$	$57.50^a \pm 0.02$

Mean ± standard deviation for duplicate determination. Values with different superscripts in the same column are significantly different ($p < 0.05$)

cellular matrix opening, and thus, a reduction in carotenoids release and extractability. In addition, Pinheiro San'Ana et al. [31] explained that temperature, rather than the presence of water, was a major factor influencing the carotenoids' stability and concentration during the cooking treatment of carrot. This may suggest the higher β-carotene concentration obtained in sautéed vegetables, and without the involvement of water. The highest β-carotene retention was seen in *okazi* leaf, followed by *anara* (garden egg) leaf and *onugbu* (bitter) leaf in comparison with other vegetables. Green leafy vegetables are rich sources of carotenoids. β-carotene is fat-soluble vitamin that is important for normal vision, and immune competence for the good health of the indigenous people.

Uncooked *anara* (garden egg) leaf was significantly ($p < 0.05$) higher than other vegetables in B_1 vitamin irrespective of the cooking method, while blanched *uziza* leaf had the least value. Blanched vegetables retained about 46.2 and 62.7% of the uncooked and sautéed values. Due to cooking, vitamin B_2 showed significant variation with blanched *uziza* and *nchuanwu* (scent) leaves exhibiting the least values, whereas uncooked *utazi* leaf posited the highest value. The same trend was observed in vitamin B_3 where blanched *uziza* leaf was seen to have the least value, whereas uncooked *utazi* leaf manifested the highest value. The clear observation was that *uziza* leaf (possibly due to its texture) and blanched treatment obtained the least concentration of the B-group of vitamins, and in all cases, blanching retained less than 50% of uncooked and sautéed concentrations of B-group of vitamins. The loss of vitamins during the blanching process is consequential in their solubility into the blanching water and high temperature.

From Table 3, vitamin C varied with blanched *okazi* leaf showing the least value, followed by blanched *anara* (garden egg) leaf, whereas uncooked *onugbu* (bitter) leaf exhibited the highest value, followed by sautéed *onugbu* (bitter) leaf and blanched *onugbu* (bitter) leaf, respectively. It showed that *onugbu* (bitter) leaf (52.63–62.39 mg/100 g) possessed the highest concentration of vitamin C, followed by *utazi* leaf (10.24–20.03 mg/100 g) and *nchuanwu* (scent) leaf (7.15–15.78 mg/g) than the other vegetables.

The presence of Fe, Zn, β-carotene and B-groups of vitamins in high concentrations make these vegetables good sources of essential minerals and vitamins for enhanced nutrition and health benefits. Therefore, *anara* (garden egg) and *nchuanwu* (scent) leaves with greater contents of Fe, Zn and β-carotene can be used for effective nutrition in combating the incidence of Fe, Zn and vitamin A deficiency that are frequently the cause of morbidity and mortality in children across the Sub Sahara Africa. Little wonder that these vegetables are intuitively used traditionally to boost health status due to the functional role that Fe, Zn and vitamin A can play in hematopoiesis.

Antioxidant properties of uncooked and cooked indigenous vegetables

The effect of cooking on the antioxidant potential of the vegetables is presented in Table 4. Blanching induced a loss of phenolics than the sautéed treatment. Blanching resulted in %DPPH loss of between 6.4 and 36.2%, ranking in ascending order: 6.4% (*okazi* leaf) < 13.6% *anara* (garden egg leaf) < 14% (*uziza* leaf) < 18.5% *nchuanwu* (scent leaf) < 21.3% *onugbu* (bitter leaf) < 36.2% (*utazi* leaf), whereas, sautéed treatment increased the %DPPH scavenging power by 1.7% (*okazi* leaf) < 2.6% *anara* (garden egg leaf) < 3% *nchuanwu* (scent leaf) < 9% (*uziza* leaf) < 16% (*utazi* leaf) when compared to uncooked vegetables.

ABTS antioxidant activity exhibited greater losses in blanched vegetables and ranked as follows: 9.3% (*utazi* leaf) < 19.6% (*uziza* leaf) < 26% *nchuanwu* (scent leaf) < 26.6% *onugbu* (bitter leaf) < 33.5 (*okazi* leaf) < 41.8% *anara* (garden egg) leaf, whereas, sautéed treatment posited gains in *uziza* leaf (1.7%) < *nchuanwu* (scent leaf) (31.5%), when compared to the uncooked vegetable samples. Sautéed vegetables had a mean ABTS (μmTE/gdw) concentration of 20.3% higher than the blanched vegetables.

In this study, blanched treatment (98 °C, 2 min) applied to the vegetables did change their antioxidant scavenging activity, affecting a significant decrease in ABTS more than the %DPPH. These changes indicate that there were thermal instability and lixiviation of hydrophilic-soluble antioxidant compounds from the vegetable matrix into the blanching water [13].

FRAP is an important assay commonly used to determine the antioxidant properties of different food products. The result showed that vegetables cooked and assayed through this condition presented antioxidant properties starting from 3.42 to 21.89 MmolFeII/100 g. Although blanched treatment indicated the lowest concentration, it revealed minimal losses, retaining a mean concentration of 85% of uncooked and 84.8% of sautéed values. Even at high temperature of processing, the vegetables maintained high levels of FRAP antioxidant activity. This implies that Fe^{3+} was fairly stable in all the treatments as FRAP assay measures the reduction of ferric ion (Fe^{3+}) to the ferrous ion (Fe^{2+}) by donor electron in the samples. The FRAP values of blanched *okazi* leaf were the least, whereas sautéed *nchuanwu* (scent) leaf was the highest. The variation in the FRAP values could

Table 4 Antioxidant properties of uncooked and cooked indigenous vegetables

Samples	% DPPH	ABTS (μmTE/gFW)	FRAP (MmolFeII/100 g)	TPC (GAE/100 g)	TFC (TAE/100 g)
Uziza leaf (Piper guineense)					
Uncooked	60.12^{c} ± 0.03	12.76^{c} ± 0.01	12.75^{b} ± 0.03	20.17^{c} ± 0.03	16.39^{b} ± 0.01
Blanched	51.38^{c} ± 0.02	10.25^{c} ± 0.01	12.21^{b} ± 0.01	19.28^{c} ± 0.01	11.38^{b} ± 0.01
Sautéed	65.66^{c} ± 0.02	12.98^{c} ± 0.02	13.42^{b} ± 0.01	20.23^{c} ± 0.01	16.51^{b} ± 0.01
Nchuanwu (scent) leaf (Ocimum gratissimum)					
Uncooked	74.03^{b} ± 0.03	20.96^{a} ± 0.03	21.18^{a} ± 0.03	115.43^{a} ± 0.03	40.71^{a} ± 0.01
Blanched	60.35^{b} ± 0.01	15.57^{a} ± 0.01	17.20^{a} ± 0.03	89.92^{a} ± 0.03	33.68^{a} ± 0.01
Sautéed	76.16^{b} ± 0.02	27.50^{a} ± 0.01	21.89^{a} ± 0.01	116.74^{a} ± 0.01	41.42^{a} ± 0.01
Anara (garden egg) leaf (Solanum melongena)					
Uncooked	80.25^{a} ± 0.03	9.83^{d} ± 0.02	10.29^{e} ± 0.01	18.94^{e} ± 0.01	2.43^{f} ± 0.04
Blanched	69.32^{a} ± 0.01	5.72^{e} ± 0.01	8.47^{d} ± 0.03	15.62^{d} ± 0.02	2.01^{e} ± 0.00
Sautéed	82.40^{a} ± 0.01	6.57^{d} ± 0.03	10.76^{d} ± 0.02	16.32^{d} ± 0.01	2.42^{f} ± 0.01
Utazi leaf (Gongronema latifolium)					
Uncooked	29.67^{f} ± 0.02	3.31^{f} ± 0.01	4.38^{f} ± 0.01	5.82^{f} ± 0.01	7.49^{d} ± 0.01
Blanched	18.90^{f} ± 0.00	3.00^{f} ± 0.00	3.51^{e} ± 0.01	2.45^{f} ± 0.02	4.62^{d} ± 0.01
Sautéed	34.51^{f} ± 0.01	3.09^{f} ± 0.03	4.16^{f} ± 0.01	4.01^{f} ± 0.01	6.13^{d} ± 0.01
Okazi leaf (Gnetum africanum)					
Uncooked	41.81^{e} ± 0.01	10.41^{d} ± 0.01	5.64^{e} ± 0.01	17.53^{e} ± 0.01	7.60^{c} ± 0.00
Blanched	39.12^{e} ± 0.02	6.92^{d} ± 0.03	3.42^{f} ± 0.03	13.85^{e} ± 0.02	6.82^{c} ± 0.01
Sautéed	42.52^{e} ± 0.02	3.54^{e} ± 0.03	5.24^{e} ± 0.03	17.92^{e} ± 0.03	7.51^{c} ± 0.02
Onugbu (bitter) leaf (Vernonia amygdalina)					
Uncooked	54.22^{d} ± 0.01	15.86^{b} ± 0.02	12.42^{c} ± 0.01	29.83^{b} ± 0.02	2.92^{e} ± 0.02
Blanched	42.65^{d} ± 0.01	11.62^{b} ± 0.02	11.87^{c} ± 0.03	20.70^{b} ± 0.01	2.04^{e} ± 0.01
Sautéed	48.29^{d} ± 0.01	13.15^{b} ± 0.01	12.32^{c} ± 0.02	22.12^{b} ± 0.01	2.98^{e} ± 0.01

Mean ± standard deviation for duplicate determination. Values with different superscripts in the same column are significantly different ($p < 0.05$)

be attributed to the texture and pro-oxidant extractability of the individual vegetables.

The TPC values of the vegetables showed that blanched *utaz*i leaf exhibited the least value, whereas, sautéed scent leaf performed the highest value. The result of the TPC is in line with that of Zhan et al. [32]. Similarly, the TFC of the samples saw blanched garden egg leaf observing the least value, whereas, sautéed scent leaf had the highest value. The TFC values are quite lower than the result reported by Zhan et al. [32], probably due to the hydrophilicity of flavonoids, texture and method of processing. In this study, scent leaf maintained higher concentrations of TPC (89.92 to 116.74 mgGAE/100 g) and TFC (33.86 to 41.42 mgTAE/100 g). As antioxidant compounds, TPC and TFC would have contributed to the strong antioxidant scavenging activity of the vegetable extracts in vitro.

Most sautéed vegetables were found to have higher antioxidant potential compared to uncooked and blanched vegetables. Turkmen et al. [33] and Mwebi and Ogendi [12] showed that several cooking methods caused increases in the phenolic content of vegetables. They attributed the increase to the loosening of antioxidant moieties and the dehydration of food matrix and enhanced extractability of the antioxidant compounds which have minimal or no water added to them during stir-frying. This may explain why higher antioxidant concentration and strong radical scavenging activity were observed in sautéed cooking for most of the vegetables. However, blanching substantially decreased the antioxidant concentration in the vegetables as was observed by [12]. The losses may be attributed to the solubilization of phenolic compounds into the blanching water [34]. Irrespective of the cooking method, the high TPC, TFC and antioxidant activity contents of the vegetables in the current study have significant relevance for health-promoting benefits against degenerative conditions and associated complications.

Phytochemical composition of uncooked and cooked vegetables

The result presented in Table 5 shows the phytochemical properties of uncooked and cooked vegetables. Phytochemicals are substances that interfere with the nutritional value of foods by reducing mineral absorption and protein digestibility and causing toxicity and health disorders when present in high concentrations [35].

Table 5 Phytochemical composition of uncooked and cooked indigenous vegetables (mg/100 g)

Samples	Alkaloid	Tannin	Phytate	Saponin	Phenol
Uziza leaf (Piper guineense)					
Uncooked	$0.96^{d} \pm 0.02$	$0.22^{f} \pm 0.03$	$0.34^{f} \pm 0.01$	$1.19^{d} \pm 0.03$	$0.83^{d} \pm 0.02$
Blanched	$0.50^{d} \pm 0.01$	$0.12^{f} \pm 0.02$	$0.12^{e} \pm 0.04$	$0.19^{d} \pm 0.04$	$0.32^{e} \pm 0.02$
Sautéed	$0.25^{d} \pm 0.03$	$0.10^{d} \pm 0.01$	$0.13^{d} \pm 0.04$	$0.15^{d} \pm 0.04$	$0.22^{c} \pm 0.03$
Nchuanwu (scent) leaf (Ocimum gratissimum)					
Uncooked	$0.72^{e} \pm 0.01$	$4.09^{a} \pm 0.02$	$0.64^{e} \pm 0.03$	$0.24^{f} \pm 0.05$	$0.13^{e} \pm 0.03$
Blanched	$0.54^{d} \pm 0.01$	$3.02^{a} \pm 0.01$	$0.24^{e} \pm 0.04$	$0.13^{d} \pm 0.03$	$0.70^{d} \pm 0.04$
Sautéed	$0.21^{d} \pm 0.01$	$1.20^{a} \pm 0.03$	$0.05^{e} \pm 0.00$	$0.04^{e} \pm 0.00$	$0.62^{b} \pm 0.02$
Anara (garden egg) leaf (Solanum melongena)					
Uncooked	$0.95^{d} \pm 0.01$	$1.05^{e} \pm 0.03$	$1.31^{c} \pm 0.00$	$0.35^{e} \pm 0.01$	$2.02^{b} \pm 0.03$
Blanched	$0.21^{e} \pm 0.00$	$0.58^{e} \pm 0.01$	$0.91^{b} \pm 0.01$	$0.04^{e} \pm 0.03$	$1.32^{b} \pm 0.04$
Sautéed	$0.06^{e} \pm 0.02$	$0.02^{e} \pm 0.01$	$0.42^{b} \pm 0.01$	$0.01^{e} \pm 0.00$	$0.22^{c} \pm 0.01$
Utazi leaf (Gongronema latifolium)					
Uncooked	$2.27^{b} \pm 0.01$	$1.27^{d} \pm 0.02$	$0.98^{d} \pm 0.02$	$1.84^{b} \pm 0.04$	$1.73^{c} \pm 0.03$
Blanched	$2.03^{b} \pm 0.02$	$0.82^{d} \pm 0.01$	$0.45^{d} \pm 0.01$	$0.57^{c} \pm 0.01$	$0.89^{c} \pm 0.21$
Sautéed	$0.83^{b} \pm 0.02$	$0.32^{b} \pm 0.01$	$0.22^{c} \pm 0.01$	$0.21^{c} \pm 0.02$	$0.61^{b} \pm 0.01$
Okazi leaf (Gnetum africanum)					
Uncooked	$2.02^{c} \pm 0.01$	$1.81^{c} \pm 0.01$	$1.77^{b} \pm 0.01$	$1.32^{c} \pm 0.03$	$0.19^{e} \pm 0.02$
Blanched	$1.88^{c} \pm 0.02$	$1.52^{b} \pm 0.01$	$0.71^{c} \pm 0.01$	$1.32^{b} \pm 0.03$	$0.09^{f} \pm 0.01$
Sautéed	$0.51^{c} \pm 0.01$	$0.13^{d} \pm 0.03$	$0.20^{c} \pm 0.01$	$0.86^{a} \pm 0.03$	$0.02^{d} \pm 0.01$
Onugbu (bitter) leaf (Vernonia amygdalina)					
Uncooked	$6.38^{a} \pm 0.01$	$2.01^{b} \pm 0.01$	$2.72^{a} \pm 0.01$	$4.73^{a} \pm 0.01$	$3.20^{a} \pm 0.01$
Blanched	$3.11^{a} \pm 0.01$	$1.21^{c} \pm 0.01$	$1.07^{a} \pm 0.03$	$2.40^{a} \pm 0.01$	$1.88^{a} \pm 0.02$
Sautéed	$0.98^{a} \pm 0.01$	$0.26^{c} \pm 0.01$	$0.52^{a} \pm 0.01$	$0.64^{b} \pm 0.01$	$0.82^{a} \pm 0.02$

Mean ± standard deviation for duplicate determination. Values with different superscripts in the same column are significantly different ($p < 0.05$)

These phytochemicals are mainly found in foods that are consumed in raw forms [36]. Food processing substantially reduced the phytochemical antinutrients to save levels. Results maintained significant variation ($p < 0.05$) in the phytochemical contents of the cooked vegetables. The alkaloid content varied from 0.06 to 6.38%. Sautéed *anara* (garden egg) leaf had the least value (0.06%), whereas uncooked *onugbu* (bitter) leaf had the highest value (6.38%). Also, tannin content varied from 0.02 to 4.09%. Sautéed *anara* (garden egg) leaf had the least value (0.02%), whereas uncooked *nchuanwu* (scent) leaf had the highest value (4.09%). These results agree with the report of Okon and Akpanyung [37]. The phytates content varied from 0.05 to 2.72%, with sautéed *nchuanwu* (scent) leaf having the least value (0.05%), whereas uncooked *onugbu* (bitter) leaf had the highest value (2.72%). The phytates content of the samples is low when compared to the result of Ekpo [38]. Also, the saponin content varied from 0.01 to 4.73%, with sautéed *anara* (garden egg) leaf having the least value (0.01%), whereas uncooked *onugbu* (bitter) leaf had the highest value (4.73%).

The phenol content varied from 0.02 to 3.20%, with sautéed *okazi* leaf having the least value (0.02%), whereas uncooked *onugbu* (bitter) leaf had the highest value (3.20%). Phytochemicals in foods must be rated on their toxicity levels. High contents of phytate and tannin exert negative effects on the bioavailability of protein and some mineral nutrients. According to Codex Alimentarius [39], the lethal dose of phytate is 25 mg/100 g [40], and tannin is 90 mg/100 g [41] which are far above the results in this study. These vegetables will not pose nutritional problems when they are consumed, whether raw or cooked. Accordingly, processing especially sautéed cooking effectively decreased the anti-nutritional factors.

In our modern days of cultural demand for foods, these vegetables that were sometime treated as food for the poor are nowadays sought after by the low and mighty of the society due to their perceived health benefits. Not only the intuitive use of these vegetables by the ethnic locals for nutrition and health benefits for decades, but they are also being recommended for adequate consumption by nutritionists, dieticians and medical professionals with the hope to ameliorate the preponderance of degenerative disorders. For this also, the food products are in high demand in homes, eateries and restaurants. On these grounds, the results of these analysis are a boost to increasing the awareness and show the cultural relevance of their continuous use traditionally as vegetable foods. Furthermore, the results can help advance these ethnic food vegetables in our modern days and an effect to increase their production, marketing and utilization as part of the historical values and preservation of our ethnic food system.

Nutrition and health benefits

Health benefits attributed to these ethnic vegetables are not only for improved nutrition, but also for medicinal purposes mostly due to their antioxidants and free radical scavenging properties. Free radicals are known to be responsible for the pathophysiological of several degenerative diseases such as diabetes, cancer and cardiovascular diseases [42]. Antioxidant and other phytochemicals in vegetables have the potential to dissolve free radicals in the human cells [43]. As evidence based and as well in this study, vegetables are the main sources of some functional minerals, vitamins, antioxidant and phyto-nutrients [44]. We can adduce their association with overall health benefits, reduced risk of diabetes, cancer, cardiovascular diseases, anemia and some other degenerative disorders due to their high content of antioxidants and phytochemicals as evidence [45]. Confirming their quantitative phytochemistry analysis and pharmaceutical interest, these vegetables contain flavonoids, alkaloids, saponins, tannins, phenols and carotenoids, all of which function as therapeutic, pharmacological, antioxidant, antibacterial, anti-inflammatory, hepatoprotective, aphrodisiac, antihypertensive and anticancer agents [46–51]. For example, Oyugi et al. [52] showed that extracts of *Vernonia amygdalina* inhibited the growth of human breast cancer cells and that the ethanolic extracts lowered blood sugar in rats [53]. Ijeh and Obioda [54] and Egedigwe [55] further posited that *Vernonia amygdalina* incorporation in the diet had an effect on the hypo-protection and serum lipid modulation in rats. Likewise, *Gongronema latifolium (utazi*) extract was found to be effective in the treatment of abscesses, boils, bacteremia and entero-infections caused by *Staphylococcus aureus* [56]. Furthermore, the hypoglycemic, hypolipidemic, nephroprotective, anticancer and immunomodulatory activities of *Gongronema latifolium* leaf extract were reported by Balogun et al. [57]. *Ocimum gratissimum (nchuanwu*) leaf was reported to be used in traditional medicine for the treatment of cough, pneumonia, fever, inflammation anemia, diarrhea, pains and fungal/bacterial infections [58]. Moreso, Igwe et al. [59] and De Zoysa et al. [60] did suggest that *Solanum melongena* (garden egg leaf) benefited patients who suffered from raised intraocular pressure (glaucoma), convergence insufficiency and in the treatment of inflammatory disease, heart failure, neuralgia, ulcer in nose and cholera. The positive effect of *Piper guineense* on hypolipidemic activity reduced cholesterol intake and induced body weight gain and increased body's antioxidant defense system [61]. These literature reports validate the efficacy of our indigenous vegetables with regards to the boosting of human nutrition and health benefits, being one of the major reasons for their intuitive use among our ethnic population.

Conclusion

Indigenous vegetables are important sources of income, food security and nutrients to the people as part of their daily meals. However, cooking/culinary methods may either diminish or increase the bioavailability of nutrients. Essentially, vegetables contain antioxidant constituents and fiber which have gained prominence in scavenging free radicals in vivo and thus, boosting the physiological health of consumers. The awareness for the consumption of vegetables as functional foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements is in increasing demand. Therefore, the utilization of vegetables as a source of dietary antioxidant compounds has positioned them as supplements for the amelioration of the incidence of degenerative disorders. Thus, knowledge derived from this study as it affects some cooking methods can be used for advocacy, increase awareness and improve the health status of the indigenous population, as well as retard oxidative stress in cellular tissues and, therefore, the potential health benefits in the context of indigenous food vegetables.

Acknowledgements
The authors acknowledge the Laboratory staff of the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, and Biochemistry Laboratory of National Root Crops Research Institute (NRCRI), Umudike, Nigeria for the analysis of antioxidant activity.

Author contributions
All authors contributed to the manuscript. AU contributed 50%; MA contributed 20%; PO contributed 20%; BO contributed 5%; and LN contributed 5%. All authors read and approved the final manuscript.

Funding
This research work was not funded.

Availability of data and materials
All data generated or analyzed during this study are included in this manuscript.

Declaration

Competing interest
The authors have no competing interest to declare.

Received: 15 May 2022 Accepted: 14 March 2023
Published online: 27 March 2023

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