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Assessment of the effect of heat processing on vitamin composition of selectedstaple green leafy vegetables in Nigeria

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Abstract

This study assessed the effect of the steamed and boiling cooking methods on the vitamin content of six staple green vegetables in Nigeria. Vitamin levels in fresh, steamed and boiled leafy vegetables were determined using spectrophotometric and titrimetric methods. The results of vitamin analysis showed that fresh vegetable of *Amaranthus hybridus* contained the largest amount of ascorbic acid, thiamin and niacin (358.40 mg/100 g), (0.09 mg/100 g) and (0.08 mg/100 g) respectively, while *Talinum triangulare* had the highest level of riboflavin (0.18 mg/100 g). The steamed *Amaranthus hybridus* contained the highest levels of ascorbic acid, thiamin and niacin (322.56 mg/100 g), (0.08 mg/100 g) and (0.73 mg/100 g) respectively, while *Talinum triangulare* had the highest quantity of riboflavin (0.16 mg/100 g). The boiled *Amaranthus hybridus* had the highest amount of ascorbic acid, thiamin and niacin (197.12 mg/100 g), (0.05 mg/100 g) and (0.41 mg/100 g) respectively, whereas the *Talinum triangulare* had the highest level of riboflavin (0.09 mg/100 g). The percentage of vitamin loss in steamed leafy vegetables varies from 9 to 11%, 9 to 17%, 9 to 13% and 9 to 12% in ascorbic acid, thiamin, riboflavin and niacin respectively. Almost 50% of the essential vitamins were lost in boiled leafy vegetables. The results revealed that vegetables could be an improved source of some important vitamins that can help humans meet their nutritional needs. According to vegetable processing results, we advised that steamed vegetables be regularly consumed rather than boiled vegetables, which prevents hypertension-related disorders.

Introduction

The vitamin content of six fresh, steamed and boiled staple green vegetables cultivated in South-Western Nigeria were investigated and compared. Furthermore, the consequence of heat treatment was also emphasized. These six green leafy vegetables, namely, *Amaranthus hybridus, Corchorus olitorius, Ocimum gratissimum, Talinum triangulare, Telfaria occidentalis* and *Vernonia amygdalina* are regularly consumed by Nigerians to acquire the necessary vitamins, like, ascorbic acid (vitamin C), thiamin (vitamin B1), riboflavin (vitamin B2) and niacin (vitamin B3) that are important for human metabolism and protection of human body against diseases.

Generally, herbaceous plants' fresh and edible parts are known as green vegetables. They are a great source of important vitamins [1]. Leafy vegetables contain beneficial ingredients in food which serve as energy sources and also possible to be utilized as body building, regulatory and protection. Leafy vegetables have become regular ingredient in the daily diet of Nigerians in both urban and rural areas because they are readily available and affordable. Leafy vegetables can be consumed raw or cooked, and the majority of their vitamins are water-soluble and heat-sensitive. According to reports, when the leafy vegetables are soaked in hot water, these water-soluble vitamins might drain away [2].

Nevertheless, these leafy vegetables are commonly exposed to various cooking processes in order to increase their palatability [3]. They are extremely vulnerable to vitamins loss during processing [4], hence the contents of water-soluble vitamins can be altered by most of these processing methods, particularly

the thermolabile components, thereby reducing the amount of the water-soluble vitamins required for daily body metabolism [5]. Therefore, this study evaluates and compares the vitamin content and retention in six regularly consumed vegetable species, both fresh and processed. Table 1 lists the local names, botanical names, common names and portions of the plant that were used.

Table 1. Staple Leafy Vegetables, names and parts used

Local name	Botanical name	Common name	Part used
Tete	*Amaranthus hybridus*	African spinach	Leaves
Ewedu	*Corchorus olitorius*	Jute plant	Leaves
Efinrin-nla	*Ocimum gratissimum*	Basil	Leaves
Gbure	*Talinum triangulare*	Water lettuce	Leaves
Ugwu	*Telfaria occidentalis*	Fluted pumpkin	Leaves
Ewuro	*Vernonia amygdalina*	Bitter leaf	Leaves

Materials and methods

Materials

Reagents

Chemicals and solvents of analytical grade were utilized without additional purification. Ethanol, and Petroleum ether, Concentrated Sulphuric acid and hydrochloric acid were obtained from BDH Chemicals, England, while Trichloroacetic acid was obtained from E. Merck, Germany.

Collection of plant materials

Fresh leaves of the six vegetables were bought in the market at Okada, Edo State, Nigeria. The identification and authentication of the plant leaves were carried out at the Taxonomy section, Biological Sciences Department, Igbinedion University, Okada, Nigeria.

Methods

Plant Preparation

Each sample was completely mixed, the stalks were removed and de-ionized water was used to rinsed the samples, which was evaporated at ambient temperature. The residual moisture was evaporated during air-drying process that took place for few weeks on a clean paper with regular turning over to avoid fungal growth. Using pestle and mortar, each air-dried sample was crushed into a fine powder and sieved through a 2.0 mm mesh sieve [6].

Thermal Processing

Also, thermal processing (steaming and boiling) of the samples fresh leaves was carried out following the procedure described by Soni and Brightwell [7] with minor modification.

Steaming

5 g each of fresh vegetable leaves were cooked in a clean stainless-steel pot using an electric cooker, fitted with temperature control for 10 minutes. After that, sample was immersed in a water bath at 4ºC for 30 seconds to stop cooking. Excess water was further removed with desiccant paper. The steamed leaves were air-dried for few weeks on a clean paper with regular turning over to avoid fungal growth. Pestle and mortar were used to crush each air-dried sample into a fine powder, sieved through a 2.0 mm mesh sieve and stored in an air tight container for subsequent use [7].

Boiling

5 g each of fresh vegetable leaves were cooked with distilled water that was brought to boiling for

10 minutes with the lid on. The vegetables were sieved and left to cool at ambient temperature after boiling. Pestle and mortar were used to crush each air-dried sample into a fine powder, sieved through a 2.0 mm mesh sieve and stored in an air tight container for subsequent use [7].

Vitamin analysis

Ascorbic acid (Vitamin C)

In an extraction tube, 5.0 g of the sample was weighed, along with 100 mL of EDTA/TCA (2:1). The extracting solution was combined and shook for 30 minutes before being transferred to a centrifuge tube and centrifuged for roughly 20 minutes at 3000 rpm. The extracting solution was then transferred to a 100 mL volumetric flask and made up to 100 mL mark. 1 percent starch indicator was added to 20 mL of extract pipetted into a volumetric flask. To obtain a dark end point, these were added and titration was done using a 20% $CuSO_4$ solution [8].

Thiamin (Vitamin B1)

A total of 5.0 g of the sample was homogenized in 50 mL of ethanolic sodium hydroxide and filtered into a 100 mL flask. 10 mL of the filtrate was pipetted into a 100 mL flask, along with 10 mL potassium dichromate to develop the colour and the results were read at 360 nm. At the same wavelength, a blank sample was prepared and the colour was established and read [9].

Riboflavin (Vitamin B2)

100 mL of 50% ethanol solution was used to extract 5.0 g of the sample, which was agitated for 1 hour. It was filtered into a 100 mL flask, and 10 mL of the extract was pipetted into a 50 mL volumetric flask. 10 mL of potassium permanganate (5%) and 10 mL of H_2O_2 (30%) were added and allowed to stand for 30

minutes over a hot water bath. Thereafter, 2 mL of sodium sulphate (40%) was added, made up to 50 mL mark and the absorbance was measured in a spectrophotometer at 510 nm [9].

Niacin (Vitamin B3)

50 mL of 1 N sulphuric acid was added to 5.0 g of the sample and agitated for 30 minutes. The sample was filtered after 3 drops of ammonia solution was added. Pipette 10 mL of the filtrate into a 50 mL volumetric flask, then add 5 mL potassium cyanide. This was acidified with 5 mL of 0.02 N H_2SO_4 and the absorbance was measured in the spectrophotometer at 470 nm [9].

Statistical analysis

For each parameter, a triplicate study was performed on each independent replication. Each treatment had three independent replicates (n = 3), with the data displayed tables and expressed as means ± standard deviation (SD). Data were analyzed by ANOVA ($P < 0.05$).

Results

Vitamin composition of fresh and processed leafy vegetables

Table 2a-2c summarizes the evaluated values of fresh, steamed and boiled vegetables. All fresh steamed and boiled green vegetables are particularly high in vitamins, according to the results of the vitamin analysis. For both fresh and steamed leafy vegetables, ascorbic acid (vitamin C) ranges from (358.40 mg/100 g to 215.63 mg/100 g) and (322.56 mg/100 g to 191.91 mg/100 g) in *A. hybridus* to *T. triangulare* respectively, but for boiled leafy vegetables, it ranges from 179.12 mg/100 g in *A. hybridus* to 95.94 mg/100 g in *O. gratissimum*. For both fresh and steamed leafy vegetables, thiamin (vitamin B1) ranges from (0.09 mg/100 g to 0.03 mg/100 g) in *A. hybridus* to *O. gratissimum*, whereas for boiled leafy vegetables, it ranges from 0.05 mg/100 g in A. hybridus to 0.02 mg/100 g in *C. olitorius*. For fresh, steamed and boiled leafy vegetables, riboflavin (vitamin B2) levels range from (0.18mg/100 g to 0.06mg/100 g), (0.16 mg/100 g to 0.05 mg/100 g) and (0.09 mg/100 g to 0.03 mg/100 g) in *T. triangulare* to *C. olitorius* respectively. Niacin (vitamin B3) levels in fresh, steamed and boiled leafy vegetables range from (0.80 mg/100 g to 0.29 mg/100 g), (0.73 mg/100 g to 0.26 mg/100 g) and (0.40 mg/100 g to 0.15 mg/100 g) in *A. hybridus* to *O. gratissimum* respectively.

Table 2a. Vitamin composition of fresh leafy vegetables on mg/100 g dry weight

Vegetable	Vitamin			
	Ascorbic acid	Thiamin	Riboflavin	Niacin
Amaranthus hybridus	358.40 ± 0.20	0.09 ± 0.01	0.12 ± 0.01	0.80 ± 0.01
Corchorus olitorius	316.80 ± 0.22	0.03 ± 0.01	0.06 ± 0.01	0.61 ± 0.02
Ocimum gratissimum	241.06 ± 0.21	0.03 ± 0.02	0.08 ± 0.02	0.29 ± 0.01
Talinum triangulare	215.63 ± 0.11	0.06 ± 0.01	0.18 ± 0.02	0.56 ± 0.02
Telfaria occidentalis	356.11 ± 0.20	0.07 ± 0.01	0.09 ± 0.01	0.74 ± 0.01
Vernonia amygdalina	285.92 ± 0.21	0.06 ± 0.01	0. 07 ± 0.01	0.66 ± 0.01

Results are mean of triplicate determinations on a dry weight basis ± standard deviation.

Table 2b. Vitamin composition of steamed leafy vegetables on mg/100 g dry weight

Vegetable	Vitamin			
	Ascorbic acid	Thiamin	Riboflavin	Niacin
Amaranthus hybridus	322.56 ± 0.11	0.08 ± 0.02	0.11 ± 0.01	0.73 ± 0.01
Corchorus olitorius	288.29 ± 0.21	0.03 ± 0.02	0.05 ± 0.01	0.54 ± 0.02
Ocimum gratissimum	216.95 ± 0.18	0.02 ± 0.01	0.07 ± 0.02	0.26 ± 0.01
Talinum triangulare	191.91 ± 0.12	0.05 ± 0.02	0.16 ± 0.02	0.50 ± 0.02
Telfaria occidentalis	316.94 ± 0.21	0.06 ± 0.02	0.08 ± 0.01	0.65 ± 0.01
Vernonia amygdalina	257.33 ± 0.20	0.05 ± 0.01	0. 06 ± 0.01	0.60 ± 0.01

Results are mean of triplicate determinations on a dry weight basis ± standard deviation.

Table 2c. Vitamin composition of boiled leafy vegetables on mg/100 g dry weight

Vegetable	Vitamin			
	Ascorbic acid	Thiamin	Riboflavin	Niacin
Amaranthus hybridus	197.12 ± 0.20	0.05 ± 0.01	0.06 ± 0.01	0.41 ± 0.02
Corchorus olitorius	158.40 ± 0.22	0.02 ± 0.01	0.03 ± 0.01	0.31 ± 0.02
Ocimum gratissimum	95.94 ± 0.21	0.02 ± 0.01	0.04 ± 0.01	0.15 ± 0.01
Talinum triangulare	107.82 ± 0.11	0.04 ± 0.01	0.09 ± 0.01	0.29 ± 0.01
Telfaria occidentalis	178.06 ± 0.20	0.04 ± 0.01	0.05 ± 0.01	0.37 ± 0.01
Vernonia amygdalina	145.82 ± 0.21	0.04 ± 0.01	0. 04 ± 0.01	0.34 ± 0.01

Results are mean of triplicate determinations on a dry weight basis ± standard deviation.

Percentage Loss of vitamin composition of fresh and processed leafy vegetables

The impact of heat processing on the vitamin contents of the vegetables was also investigated. Table 3a and 3b show the estimated percentage loss of vitamin composition of fresh and processed vegetables. For steamed leafy vegetables, the percentage loss of ascorbic acid (vitamin C) varies from (9 to 11 %) in *C. olitorius* to *T. triangulare* and *T. occidentalis*, whereas the percentage loss of ascorbic acid (vitamin C) in boiled leafy vegetables varies from (45 to 50 %) in *A. hybridus* to *C. olitorius, T. triangulare* and *T. occidentalis*. For steamed leafy vegetables, the percentage loss of thiamin (vitamin B1) varies from (9 to 17 %) in *T. occidentalis* to *O. gratissimum*, whereas the percentage loss of thiamin (vitamin B1) in boiled leafy vegetables varies from (48 to 50 %) in *A. hybridus* and *O. gratissimum to C. olitorius, T. triangulare*

and *V. amygdalina*. For steamed leafy vegetables, the percentage loss of riboflavin (vitamin B2) varies from (9 to 13 %) in *T. triangulare* to *C. olitorius*, whereas the percentage loss of riboflavin (vitamin B2) in boiled leafy vegetables varies from (49 to 50 %) in *C. olitorius* and *V. amygdalina to A. hybridus, T. triangulare, O. gratissimum* and *T. occidentalis*. For steamed leafy vegetables, the percentage loss of niacin (vitamin B3) varies from (9 to 12 %) in *V. amygdalina* and *A. hybridus* to *T. occidentalis*, whereas the percentage loss of niacin (vitamin B3) in boiled leafy vegetables varies from (48 to 50 %) in *V. amygdalina to C. olitorius, T. occidentalis* and *O. gratissimum*.

Table 3a. Percentage loss of vitamin composition of steamed leafy vegetables

Vegetable	% Loss of Vitamin			
	Ascorbic acid	Thiamin	Riboflavin	Niacin
Amaranthus hybridus	10	11	10	9
Corchorus olitorius	9	14	13	11
Ocimum gratissimum	10	17	11	10
Talinum triangulare	11	10	9	10
Telfaria occidentalis	11	9	10	12
Vernonia amygdalina	10	11	12	9

Table 3b. Percentage loss of vitamin composition of boiled leafy vegetables

Vegetable	% Loss of Vitamin			
	Ascorbic acid	Thiamin	Riboflavin	Niacin
Amaranthus hybridus	45	48	50	49
Corchorus olitorius	50	50	49	50
Ocimum gratissimum	49	48	50	50
Talinum triangulare	50	50	50	49
Telfaria occidentalis	50	49	50	50
Vernonia amygdalina	49	50	49	48

Discussion

Vitamin composition of fresh and processed leafy vegetables

The results revealed that vegetables contain significant amounts of vital vitamins with fresh vegetables having higher concentrations, followed by steamed vegetables and boiled vegetables having the lowest. The disparity in the vitamin levels in fresh leafy vegetables could be as a result of soil profiles in which the vegetables were planted, impacts of human activities and varied climatic factors, while that of steamed and boiled leafy vegetables could be credited to changes in analytical protocols, processing time and conditions [8, 10].

In generally, leafy vegetables are high in vitamins, which are required for variety of daily biological processes, including cell reproduction [11], growth and cellular energy processing [12]. The result for this

study signified that the fresh, steamed and boiled *A. hybridus* had the highest quantity of ascorbic acid, thiamin and niacin, indicating that *A. hybridus* can be consumed on regular basis, as ascorbic acid is crucial for biosynthesizing collagen in human body [13], protein metabolism [14] and increasing the body's resistance to infections [15-16]. Thiamin also allows the body to use carbohydrates as energy, which it does mostly in muscles, brain, liver and kidney. It also has an impact on glucose metabolism [17]. Niacin is also essential in cells for energy transfer and to repair DNA [18]. Meanwhile, the maximum amount of riboflavin was found in the fresh, steamed and boiled *T. triangulare*, which is crucial for growth and overall health. It also helps the human body in breaking down carbohydrates, proteins and fats to produce energy, in addition, allowing the body to use oxygen [19-20].

Percentage Loss of vitamin composition of fresh and processed leafy vegetables

According to the findings, boiling had the most adverse impact on the vitamin content of the vegetables, accounting for nearly 50 % loss, while steaming accounted for approximately 17 % loss. This is in agreement with Oladejo's [21] findings. To obtain the necessary daily intake of the aforementioned vitamins, we recommend that steamed vegetables rather than boiled vegetables be consumed on a regular basis.

Conclusions

The findings of this study revealed that leafy vegetables studied are high in vitamins that are required for cell reproduction, growth and energy utilization. The study found that *A. hybridus* had the highest quantity of ascorbic acid, thiamin and niacin of fresh, steamed and boiled vegetables assessed, implying that regular consumption of *A. hybridus* will aid during the biosynthesis of the collagen in the body and increase the body's resistance to infections. Furthermore, the results of the impact of heat treatment on the vitamin content of the green vegetables revealed that boiling had the greatest detrimental effect on the vitamin content of the vegetables, accounting for nearly 50% loss, while steaming accounted for about 17% loss.

Declarations

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Author contributions

All authors contributed immensely for both the laboratory work and analysis carried out.

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Availability of data and materials

All data either generated or analyzed during this study are included in the manuscript.

Competing interests

No competing interests have been declared by the authors.

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