Effects of Heat Processing on the Nutritional Compositions of Local Leafy Vegetables Consumed in South-East, Nigeria

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Abstract- The effect of cooking on the proximate composition, energy value, ascorbic acid content and selected antioxidant minerals of four edible leafy vegetables used in preparation of local diets was investigated. In raw samples, moisture content ranged from 71.03±0.21 % in oha leaf (OL) to 83.20±0.23 % in curry leaf (CL). Protein was highest (7.10±0.22 %) in garden egg leaf followed by utazi leaf (5.13±0.12 %) then oha leaf (4.50±0.12 %) and was lowest in curry leaf (3.33±0.21%). Total carbohydrate was low in all the samples and was lowest in garden egg leaf (3.47±0.21%) with the highest value of 16.53±0.25 in oha leaf. Garden egg leaf had the highest ash content of 6.50 ± 0.16 % followed by utazi leaf (4.43±0.22 %) while ash was lowest (1.53±0.16 %) in curry leaf. The low caloric values in raw samples, which ranged from 47.7 kcal in garden egg leaf to 101.8 kcal/100g sample in oha leaf, indicates that these edible leaves are not good sources of crude fat, crude protein and total carbohydrate. Heat processing significantly affected moisture content and generally decreased ash, crude protein, crude fat and the ascorbic acid content of all the edible leafy vegetables investigated at $P<0.05$. Loss in ascorbic acid to the cooking water ranged from 48.78 % in curry leaf to 51.08 % in oha leaf. Results indicate that vegetables analyzed were good sources of iron (Fe), zinc (Zn), copper (Cu), selenium (Se) and manganese (Mn). The study shows that utazi is a better source of mineral than oha leaf. Mineral level were in the order UT>CL>GL>OL. Cooking decreased the level of the minerals Mn, Fe, Zn, Cu and Se.

Index Terms- Proximate composition, Leafy vegetables, Heat processing, Minerals.

I. Introduction

Vegetables are basically any plant that can be eaten. They are herbaceous plants which are grown for food in Nigeria and other parts of the world. Vegetables include leaf vegetable example lettuce; stem vegetable (asparagus), root vegetables (carrot), flower vegetable (broccoli), bulbs (garlic) and fruits such as cucumbers, squashes, pumpkins, capsicums or a combination of these parts of plant depending on one's knowledge of them and their availability. They may be eaten raw or cooked depending on the type but most often are cooked. They provide important nutrients on diets. Their colour, shape, texture and flavor appeal to man's senses (Prior and Cao, 2000). There are hundreds of common vegetables which are eaten in different parts of south east. These include fluted pumpkin, lettuce, cabbage, Greenleaf, waterleaf etc. in south east zone, the use of vegetable leaves in different types of soup and in preparing local diets is a common dietary habit since the leaves may contain appreciable amount of nutrients, especially minerals and vitamins.

Curry leaf (*Murraya kioenigii* sprengel) is the young leaf of the curry tree *Charleas koenigii* a member of the Rutaceae family that grows wild and in garden its leaves are highly aromatic and are used as a herb or spice (Quebedeaux and Elisa, 1990). Curry leaves have a deep/bright green colour and grow to around 4 cm in length. The leaves exude a delightful citrus family. They are directly added to food to improve functioning of the stomach and small intestine and promote their action. They are mildly laxative and thus can tackle multiple digestive problems caused by food intake (Ihekoronye, 1985).

Percularia daemia generally called utazi in Igbo language of south east belongs to the Aspclepiadaceae family. The Aspclepiadaceae are mostly herbs and shrubs with white sap comprising about 250 genera and 2000 species some of which are cactus-like succulents with reduced leaves. The leaves of *Percularia daemia* "utazi" are dark green in colour with net venation and are specially used as a condiment for soup and porridge yam in south-east, Nigeria.

Garden egg leaf (*Solanium melongena*) belongs to the Solanaceae family. The leaves are edible in raw form or in cooked form. The flowers are typically conical in shape and produce fruits. The leaves were reported to contain alkaloidal glycosides that may be irritating to humans. This could also account to its somewhat bitter taste. It is an important source of food condiment and both the leaves and the fruits are used as vegetables for preparation of tapioca, a local diet peculiar to the south east zone.

Oha (*Pterocarpus Soyankii*) belongs to the family Pterocarpaceae. In south east zone of Nigeria, it is known as oha in Igbo language. It is a medium-sized tree having grey, smooth bark; it is propagated by stem cutting. It is planted in family compounds to provide shade and in farmland to demarcate boundaries. The young edible leaves are mainly used in making the popular traditional oha soup (Onyeike *et al.*, 2003).

The nutritional importance of green vegetables as sources of some essential nutrients has been reported (Carlowitz, 1985). The acceptance of some wild plants as food by man has been shown to be a function of their nutritional value (Flags, 1968). The nutrient composition of the edible leafy vegetables analyzed in this study has not been adequately investigated in Nigeria as information, if any, in the literature is very scanty. There is therefore the need for a systematic investigation of the proximate composition, energy value, ascorbic acid concentration and levels of some minerals in these raw edible leafy vegetables and the effect of cooking on these nutrients.

II. MATERIALS AND METHODS

A. *Sample Collection and Preparation*

The fresh leafy vegetables were bought from Afor-egbu market Uli in Ihiala local government area of Anambra State Nigeria and were washed with deionized water and allowed to drain. Each sample was dried at room temperature and further oven dried at 80 ^{0}C for 12 hrs, ground into flour which passed through a 30-mesh test sieve. Each sample was stored in a clean dry air-tight sample bottle in a refrigerator at 4 ^{0}C until required for analyses. The second lot was cooked to tenderness in boiling deionized water for 5 minutes; the cooking solution was discarded. Samples were then oven dried (Model Plus II Sanyo, Gallenkamp Plc, England) at 80 ^{o}C for 12 hours, ground using a food grinder (model Mx491N, National) into flour (30-mesh screen) and appropriately stored as indicated above for the first lot prior to analysis.

B. *Proximate Composition Analysis*

Moisture, crude protein, crude fat, ash was determined by the recommended methods of the Association of official Analytical chemist (AOAC, 1985). Moisture content was determined by heating three 2.0 g portions of each of the samples in an oven maintained at 100 ^{o}C until a constant weight was obtained, crude protein (% N x 6.25) was determined by the Kjeldahl method (Kjeldahl, 1983) of nitrogen determination using three 0.5 g of the sample. Crude fat was obtained by exhaustively extracting three 5.0g samples in the Soxhlet apparatus using petroleum ether with a boiling point range of 40 ^{o}C – 60 ^{o}C as the extractant. The ash content of the samples were determined by incineration of 2.0 g sample in a muffle furnace (LMF4 from Carbolite, Barnford, Sheffield England) at 550 ^{0}C for 3hours. Total carbohydrate was calculated by the difference method (summing the value of moisture, ash, crude fat and crude protein and subtracting the sum from 100). The caloric value was calculated by multiplying the mean values of crude protein, crude fat and total carbohydrate by the. At water factor of 4, 9 and 4 respectively, summing the products and expressing the result in kilocalories per 100 g sample as reported by Onyeike and Omumbo-Dede, (2002).

C. *Mineral Analysis*

Selected mineral levels of the vegetables were determined by the method of AOAC (1984) in which a mixed acid digestion was done before Iron (Fe), zinc (Zn), copper (Cu), selenium (Se), manganese (Mn) and cobalt (Co) were determined by atomic absorption spectrophotometer (AAS) using a bulk scientific atomic absorption/emission spectrophotometer model 210A system. Air/acetylene flame was used. The instrument was calibrated by standard solutions treated in the same way as samples. Aldrich provided the analytical standard used. By comparing the peak of the absorbance of standard with that of the test sample, the concentration of the elements in the test samples was determined.

D. *Ascorbic Acid Content Analysis*

Titration method of Davis and Kramer (1973) as reported by Onyeike and Onwuka (1995) was used to determine the ascorbic acid content of the vegetables. The method was based on the reduction of 2,6-dichlorophenol indophenols dye by an acid extract of ascorbic acid. The ability of the sample extract to reduce a standard solution of the dye was used as a measure of the reduced ascorbic acid level.

E. *Statistical Analysis*

Data were analyzed statistically by one way analysis of variance (ANOVA) and means' were compared by the Duncan's multiple range test significance was accepted at $P \leq 0.05$.

III. RESULTS

The result of nutrient composition and energy value of raw leafy vegetables investigated are shown in (Table I). garden egg leaf (GL) had the highest moisture content of 82.79±0.03 % followed by curry leaf (CL) with a value of 80.75±0.02 % in utazi leaf (UL) had the lowest level of 71.19±0.02 %. The ash content was significantly higher ($P<0.05$) in garden egg leaf (6.50±0.02%) than in other vegetables, the lowest was in curry leaf (1.53±0.03 %). Protein was generally low in all the samples investigated the highest protein level was obtained from GL (7.03±0.08 %) followed by UL (4.45±0.02 %) but was lowest in CL (3.33±0.03%). Crude fat was generally low in all the vegetable but was significantly higher (*P<0.05*) in CL (2.10±0.02%) followed by OL (2.05±0.01%), but was lowest in UL (0.50±0.01 %). Total carbohydrate was low in all the samples studied and ranged from 11.94±0.02 % in GL to 18.73±0.07 % in UL. The energy value was also low in all the samples with the highest value of 99.93±0.50 Kcal/100g in UL followed by 90.57±0.23 Kcal/100g in OL; the lowest value of 81.34±0.29 Kcal/100g was found in GL.

Table 1.Proximate Composition (pc) and Energy levels of Selected Raw Leafy Vegetable

Constituents	Curry leaf	Garden egg leaf	Oha leaf	Utazi leaf
Moisture	80.75±0.02^{b}	82.79±0.03^{a}	76.02±0.22^{c}	71.19±0.02^{d}
Dry matter	19.25±0.02^{c}	17.21±0.03^{d}	23.98±0.21^{b}	28.81±0.22^{a}
Ash	1.53±0.03^{d}	6.50±0.02^{a}	3.90±0.02^{c}	4.45±0.02^{b}
Crude protein	3.33±0.03^{d}	7.03±0.08^{a}	3.51±0.01^{c}	5.14±0.02^{b}
Crude fat	2.40±0.02^{a}	0.61±0.01^{c}	2.05±0.01^{b}	0.50±0.01^{a}
Total carbohydrate	11.95±0.05^{c}	11.94±0.02^{c}	14.52±0.03^{b}	18.73±0.07^{a}
Caloric value (Kcal/100g sample)	82.72±0.43^{c}	81.34±0.29^{d}	90.57±0.23^{b}	99.93±0.50^{a}

Pc: values are means ± standard deviations of triplicate determinations values in the same raw having the same superscript letters are not significantly different at the 5% level.

As can be seen in (Table 2), heat processing (cooking) generally increased the moisture content significantly (*P<0.05*) while decreasing the ash, crude protein and total carbohydrate.

Table 2. The Percentage Proximate Composition (pc) and energy Levels of Selected Cooked Leafy Vegetables

Constituents	Curry leaf	Garden egg leaf	Oha leaf	Utazi leaf
Moisture	86.15±0.03^{b}	86.70±0.06^{a}	82.72±0.01^{c}	77.33±0.01^{d}
Dry matter	8.29±1.20^{c}	13.30±0.06^{d}	17.28 ±0.12^{b}	22.67±0.12^{a}
Ash	0.80±0.01^{d}	4.80±0.01^{a}	2.85±0.01^{c}	3.97±0.01^{b}
Crude protein	1.80±0.02^{d}	6.00±0.02^{a}	2.01±0.01^{c}	4.43±0.02^{b}
Crude fat	2.30±0.10^{a}	0.20±0.02^{c}	1.85±0.01^{b}	0.22±0.01^{c}
Total Carbohydrate	8.95±0.05^{c}	2.30±0.05^{d}	10.56±0.02^{b}	14.07±0.06^{a}
Caloric value (k cal/100g sample)	63.70±0.62^{c}	35.00±0.30^{d}	66.95±0.03^{b}	75.91±0.07^{a}

Pc: values are means±standard deviations of triplicate determinations. Values in the same row having the same supper script letters are not significantly different at the 5% level.

Table 3 showed that the leafy vegetables studied are good sources of trace elements Fe, Zn, Cu, Se, Mn. However cooking significantly (*P<0.05*) decreased the concentration of these trace elements in all the samples investigated as shown in (Table 4). The levels of Fe in raw vegetables ranged between 17.57±0.38 mg/g in oha leaf to 52.88±0.12 mg/g in utazi, Zn: 2.05±0.25mg/g to 12.12±0.02 mg/g in curry leaf, Cu: 0.07±0.01 mg/g to 0.67±0.12 mg/g in oha leaf, Se: 0.12±0.01 mg/g to 0.67±0.03 mg/g in utazi leaf, Mn: 0.12±0.03 mg/g to 8.10±0.10 in utazi.

Table 3: Levels of selected minerals (mg/g) in raw leafy vegetables

Mineral elements	Curry leaf	Garden egg leaf	Oha leaf	Utazi leaf
Fe	46.48±0.30^{b}	18.67±0.23^{c}	17.57±0.38^{d}	52.88±0.12^{a}
Zn	12.12±0.02^{a}	8.21±0.11^{c}	2.05±0.25^{d}	8.75±0.24^{b}
Cu	0.07±0.01^{b}	0.14±0.04^{b}	0.67±0.12^{b}	0.51±0.17^{a}
Se	0.50±0.10^{b}	0.17±0.03^{c}	0.12±0.01^{c}	0.67±0.03^{a}
Mn	0.25±0.05^{b}	0.12±0.03^{c}	0.12±0.03^{c}	8.10v0.10^{a}

Values are means ± standard deviation of triplicate determinations. Values in the same row bearing the same supper script letters are not significantly different at the same 5% level.

Table 4: Levels of selected minerals (mg/g) in cooked leafy vegetables

Mineral elements	Curry leaf	Garden egg leaf	Oha leaf	Utazi leaf
Fe	24.02±0.07^{a}	12.44±0.06^{b}	7.56±0.05^{c}	7.55±0.05^{c}
Zn	9.88±0.18^{a}	4.10±0.10^{c}	1.68±0.20^{d}	7.28±0.08^{b}
Cu	N.D^{c}	0.10±0.32^{a}	0.06±0.01^{b}	0.07±0.01^{a,b}
Se	0.12±0.02^{b}	0.12±0.01^{b}	n.d^{c}	0.62±0.03^{a}
Mn	n.d^{b}	n.d^{b}	n.d^{b}	1.50±0.10^{a}

Values are means ± standard deviation of triplicate determinations. Values in the same row bearing the same super script letters are not significantly different at 5% level. n.d: not detectable.

The ascorbic acid content of raw and cooked samples investigated was presented in (Table 5). The level of ascorbic acid in raw utazi leaf was significantly (*P<0.05*) highest (413.02±1.00 mg/100g) followed by garden egg leaf (375.39±0.54 mg/100g) but was significantly (*P<0.05*) lowest in oha leaf (22.19±0.08 mg/100g). Cooking decreased the ascorbic acid level in all the vegetables samples analyzed. Loss of ascorbic acid content was highest in utazi leaf followed by garden egg leaf, but was least in oha leaf.

Table 5: Ascorbic acid content (mg/100g sample) of selected raw and cooked leafy vegetables

Parameters	Curry leaf	Garden egg leaf	Oha leaf	Utazi leaf
Raw sample	$77.67±0.14^{c}$	$375.39±0.54^{b}$	$22.19±0.08^{d}$	$413.02±1.00^{a}$
Cooked sample	$39.82±0.17^{c}$	$184.71±0.30^{b}$	$10.89±0.11^{d}$	$206.59±0.33^{a}$
Loss of ascorbic acid to the cooking water	$37.85±0.31^{c}$	$190.67±0.83^{b}$	$11.29±0.17^{d}$	$206.46±0.73^{a}$
% Ascorbic acid loss	48.73	50.79	50.88	49.99

Values are means ± standard deviations of triplicate determinations. Values in the same row bearing the same super script letters are not significantly different at the same 5% level.

IV. DISCUSSION

It is observed from (Table 1) that as the moisture content increases, the level of dry matter decreases. The high moisture content in all the samples studied suggests that the leafy vegetables would not store for too long without spoilage, since high moisture content provides for greater activity of water soluble enzymes and coenzymes needed for metabolic activities and could enhance microbial action bringing about food spoilage. It has been reported that vegetables contain as high as 70-90 % water (Onyeike *et al*., 2003) consistent with the range of moisture level of 71.19±0.02 % in utazi to 82.79±0.03 % in garden egg leaf.

The high ash content of the samples investigated may suggest that these leafy vegetables are good sources of minerals. Onyeike *et al*. (2002) reported that when leaves are to be used as food for man, they should contain about 3.0% ash except curry leaf (1.53 ±0.03 %) which are mainly used for flavor in meals, every other leaves investigated met this requirement and hence are good sources of mineral elements for man. The mineral elements serve as inorganic cofactors in metabolic processes. In the absence of these cofactors there may be impaired metabolism (Iheanacho *et al.*, 2009).

The crude protein level of garden egg leaf (7.03±0.08) was significantly higher than other level (ranged between 3.33±0.03 % in CL to 5.14±0.02 % in UL). However, it is discernible from the data shown in (Table1) that there was generally low protein content in all the leafy vegetables investigated. The low level of plant protein in all the samples analyzed does not justify the use of the leafy vegetable in diets as a sole protein source for the alleviation of kwashiorkor due to protein malnutrition. The generally low crude protein levels in the leafy vegetables would require dietary supplementation with animal proteins or complementary proteins from cereals and legumes, especially in diets meant for the kwashiorkor prone target population (growing children and pregnant women) as reported by Onyeike *et al.*, (2002).

The fat content of the vegetable leaves investigated were generally low. Fatty acids play a pivotal role in providing fuel for adenosine triphosphate (ATP) and reducing equivalent and in generating body heat. However, consumption of the vegetables due to the low level of crude fat is a good dietary habit with risk reduction of obesity and recommendable to individuals who would want to reduce weight. The total carbohydrate content of the leafy vegetables was low therefore can be classified as low energy source. Carbohydrate provides a readily available energy source for oxidation metabolism and carbohydrate containing foods are vehicles for many important micronutrient. The very low levels of crude proteins, crude fats and total carbohydrate in these leafy vegetables suggest that they are not good sources of energy. Generally, the low caloric values are due to low crude protein, crude fat and total carbohydrate and relatively high levels of moisture. Cooking increased moisture content and decreased crude protein, crude fats, total carbohydrate as well as ash content due to loss of nutrient to cooking water, but the decrease was not considerable for vegetable leaves that are usually cooked before consumption as a means of destroying natural toxicants and enhancing palatability.

Result presented in (Table 3) shows that the leafy vegetables analyzed are good sources of essential minerals such as Iron, zinc, copper, selenium, manganese and calcium most of these minerals are necessary for energy metabolism where the same as cofactor to different enzymes. Adequately dietary iron intake is essential for infants and young children to prevent iron deficiency. Zinc plays both catalytic and structural role in enzyme activity. It is an antioxidant capable of protecting cells from the damaging effects of oxygen radicals released during lymphocyte activation. Its deficiency impairs immunity and decreases resistance to infectious disease. The levels of Zn in the vegetables analysed are within the recommended dietary allowance of 11 mg/day for men and 8 mg/day for women (Babara and Robert, 2001), copper is a constituent of cytochrome C oxidase. It directly participate in the transfer of electron from reduced cytochrome C to molecular oxygen inadequate supply of copper decreases the enzyme activity and hence affect oxidative phosphorylation in a number of tissue.

Selenium appears in plant as selenomethionine. It is a catalytic component on enzymes or proteins such as glutathione peroxidase thus playing a role in protecting against oxidative damage to erythrocytes. The levels of selenium in vegetables analyzed are within RDA of 40 µg/day for male and 30 µg/day for female (WHO, 1996). Selenium deficiency in human is known as kashan disease characterized by cardiamyopathy (Babara and Robert, 2001). Manganese functions as enzyme activator and is a constituents of several metalloenzymes. The levels of Mn in the vegetable analyzed are below. RDA of 2.3 mg/day for men and 1.8 mg/day for women Mn deficiency causes defect in lipid and carbohydrate metabolism and low dietary manganese has been associated with osteoporosis, impaired wound healing etc (Babara and Robert, 2001).

All the sample analyzed qualify as good sources of ascorbic acid (except oha leaf) since the consumption of only 100 g of each would be more than adequate in meeting the daily requirement of 30-60 mg as recommended by the National Research Council (1974). As a major water soluble antioxidant, ascorbic acid detoxifies reactive radicals in plasma, cytoplasm and mitochondrial of cells. Deficiency of this vitamin causes scurvy, a disease characterized by appearance of holes in the gum, weakness of the collagen structure, fatty infiltration of the liver subcutaneous and intramuscular hemorrhage and failure of wounds to heal easily. Therefore, diet for scurvy patient should be high in leafy vegetables. Cooking decreases the ascorbic acid content of the leafy vegetables analyzed. The percentage losses in ascorbic acid due to cooking were 48.73 %, 50.79 %, 50.79 % and 49.99 % in CL, GL, OL, UL respectively. This was as a result of loss of ascorbic acid to cooking water when discarded. It is therefore recommended that the practice of discarding cooking water after boiling vegetable should be discouraged, as a high percentage of ascorbic acid and nutrients are lost to the cooking water. Edem *et al*., (1989) reported that cooking African yam bean (*phenostylis sterocarpa*) seeds for 3hrs after an overnight soaking in water decreases the ascorbic acid content from 64.2±1.22 mg/100g in raw seeds to 10.2±1.22 mg/100g in the cooked seeds representing an 84.1 % loss of ascorbic acid.

V. CONCLUSION

The four leafy vegetable investigated have been shown to be good sources of moisture and ash but low energy source due to low levels of crude protein, crude fat and total carbohydrate. Cooking generally decreased ash, crude protein and crude fat. Cooking also decreased the ascorbic acid and trace minerals such as iron, zinc, copper, manganese and selenium. The decrease was significant at $P<0.05$.

ACKNOWLEDGMENT

The fact that this work inconvenienced some officials whose services were indispensable to the realization of the goals and objectives of this work cannot be overlooked. Many thanks goes to my research team members especially Egbuna C. for their assistance.

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