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Comparative Studies on the Nutritional Composition of Three Commonly Sold Leafy Vegetables in Lafia Modern Market, Nasarawa State, Nigeria

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Abstract

Samples of three healthy, diseases free, commonly consumed vegetables in Nasarawa State, Nigeria were studied for comparative nutritional evaluation with respect to proximate and amino acid compositions. The samples (*Piper guineense, Spinacia oleracea and Gongronema latifolium*) contained moisture in the ranged between 4.19 and 9.25%. Highest values were recorded for *Spinacia oleracea* and *Piper guineense.* Ash value was higher in *S. oleracea* (25.38%) comparable to *G. latifolium* (13.15%) and *P. guineense* (14.25%). The dietary fiber content ranged from 8.52% in *S. oleracea* to 15.18% in *G. latifolium.* The protein content was within the range of 18.61 to 26.12%. The amino acid analysis revealed that all the samples contained nutritionally useful quantities of most of the essential amino acids. Leucine (7.35 to 8.16 g/100 g crude protein) was the outstanding essential amino acid in this research. The total essential amino acids (with His) ranged between 38.67 g/100g cp (52.41%) in *P. guineense* to 40.53 g/100g cp (54.82%) in *G. latifolium.* The limiting AAs were Met + Cys, Thr and Met + Cys for *P. guineense, S. oleracea and G. latifolium,* respectively. The dietary formula based on this report showed that some essential amino acid supplementations such as Lys, Met + Cys, Thr and Val will be required in all the studied samples.

Keywords: Leafy vegetables, proximate, amino acid

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Introduction

Leafy vegetables contain a variety of vital elements that support general health and they are key parts of a diet that are both balanced and healthful [1]. They are abundant in dietary fibers, vitamins, minerals and antioxidants, all of which are essential for preserving health and warding off a number of illnesses [2]. The importance of leafy vegetables in human nutrition cannot be overstated, as they provide essential nutrients that play vital roles in physiological functions [3]. Uziza, spinach, and utazi are widely consumed worldwide and are known for their distinct flavors, textures, and culinary versatility.

Uziza leaf (*Piper guineense*) as shown in Plate 1 is a West African specie of piper, the spice derived from its dried fruit is known as Ashanti pepper. This leaf's flavor, fragrance, and preservation qualities are due to a variety of nutritional and non-nutritional elements [4, 5]. Because of its purported therapeutic qualities, researchers in the modern era may investigate its extracts. Due to the leaf's nutritional and therapeutic qualities [6], it is taken in many nations across the world.

Plate 1: Uziza leaf

Spinach (*Spinacia oleraecea*) has been widely growing throughout Africa. They are used to generate an abundance of seasonal crops. When consumed raw or cooked, spinach is one of the most significant and nutrient-dense vegetables [7]. Plate 2 shows the fresh leafy spinach which offers a high amount of minerals, soluble dietary fiber, riboflavin, folate, niacin, and vitamins B6, C, and E. [3, 8].

Spinach is also rich with iron; its use prevents from some of diseases like osteoporosis, anaemia results of iron deficiency [9, 10]. In addition to its nutritional importance, spinach has a number of medicinal uses. Spinach is used to treat gastrointestinal disorders, blood-generating therapies, children's growth stimulation, hunger stimulation, weariness, and convalescent support. Its application as an antioxidant and anticancer agent has also been proposed [9, 11], and cancer preventative. Additionally, spinach may lessen the impairment of age-related vision due to cataracts and macular degeneration [12]. In which may also interact with anticancer herbs and supplements [13].

Plate 2: Spinach

Utazi leaf also known as bush buck is an indigenous vegetable plant of Tropical Africa. When in season, the plant constitutes an important and most cherished local delicacy. It is consumed after tendering the leaf by either squeezing the leaf extract or by cooking it properly. There are several studies on the African leaf (*Gongronema latifolium*) that focus mainly on the composition of the edible plant that constitutes the mainstay of the economic importance of the leaf [14]. Plate 3 shows the utazi leaf which is of the plant genus. *Gongronema latifolium* is a member of the spice family. It belongs to the genus Gongronema, family Apocynaceae, and species latifolium. With a woody, hollow, glaborous stem beneath, utazi is a climber that goes by various colloquial names, such as Igbo, Hausa, Yoruba, and many more Nigerian tribes. It is distinguished by greenish yellow flowers produced by *Gongronema latifolium*. They are frequently used as a leafy vegetable and as a spice in sauces, soups, and salads. They are sharply bitter and sweet. In tropical Africa, utazi leaves are widely distributed and can be found from Senegal's east to Chad and the South Republic of Congo [4]. The leaf has a lot of nutritional values and it is widely used in West Africa for medicinal purposes. An infusion of the aerial part is taken to treat cough, intestinal worms, dysentery, dyspepsia and malaria. In Sierra Leon, an infusion or decoction of the stems with lime juice is taken as a purge to treat colic and stomach - ache [15]. Little children in Ghana and Senegal are helped to walk by having leaves rubbed on their joints. Soup's cooked fruits are consumed as a laxative. To treat high blood pressure and diabetes, a decoction of leaves or leafy stems is frequently consumed [16, 17]. Additionally, the latex is used for general health management and to prevent weight gain in nursing women. People with asthma can eat fresh leaves to stop sneezing [14]. A cold maceration of the root is also taken as remedy for asthma. A decoction of the roots, combined with other plant species is taken to treat sickle anemia.

Plate 3: Utazi

This study focuses on conducting a comparative analysis of the nutritional composition of three commonly sold leafy vegetables in Lafia modern market, Nasarawa State, Nigeria. Understanding the nutritional profiles such as proximate and amino acid compositions of these vegetables is crucial for making informed dietary choices and optimizing nutrient intake.

Materials and Methods

Samples collection and treatment

The samples of three healthy, diseases free, commonly consumed vegetables were purchased from Lafia modern market, Nasarawa state Nigeria. Edible portion of the plants were separated and washed thoroughly under running tap water and then were rinsed in the distilled water. The vegetables were shade dried free from any contamination for 1 week until completely dried. The dried samples were powdered in a blender (Model: GK 240, UK) and were stored in airtight containers for laboratory analyses.

Proximate composition

Standard methods of AOAC [18] were used to quantify the nutritional composition of the vegetables. Moisture content of the samples was determined by weighing some portion into a Petri dish and dried in an oven (Model-SAP 2200, Gallenkamp, UK) at 105°C until constant weight was obtained. The loss in weight was expressed as percentage moisture content. Ash content was determined by the incineration of a 2 g sample in a muffle furnace at 500°C for 6 h until the ash turned white. Fat content was determined by petroleum ether (Boiling point 60-80°C) extraction in a Soxhlet apparatus.

The fiber content was determined by the acid-base digestion method using 1.25% H_2SO_4 (v/v) and 1.25% NaOH (w/v) solutions. The protein content was estimated by the Kjeldahl method. Total protein was calculated by multiplying the evaluated nitrogen by a factor of 6.25. Soluble carbohydrate (g/100g) was estimated using a different method [19] by subtracting the sum of the percent of protein, moisture, fat and ash from 100. All the analysis was carried out in triplicate for all the samples.

Amino acid analysis

The amino acid analysis was by Ion Exchange Chromatography (IEC) [20] using the Technico Sequential Multisample (TSM) Amino Acid Analyzer (Technicon Instruments Corporation, New York). The period of analysis was 76 min for each sample. The gas flow rate was 0.50 $mLmin^{-1}$ at 60^oC with reproducibility consistent within ± 3%. The net height of each peak produced by the chart recorder of the TSM (each representing an amino acid) was measured and calculated. Amino acid values reported were the averages of two determinations. Nor–leucine was the internal standard. Tryptophan was determined after alkali (NaOH) hydrolysis by the colorimetric method.

Determination of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P–PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo [21]:

$$plm = \sum_{i=1}^{n=1} pliXi \quad ---------(1)$$

Where:

pIm = the isoelectric point of the mixture of amino acids;

Xi = the mass or mole fraction of the amino acids in the mixture.

pIi = the isoelectric point of the ith amino acids in the mixture;

The quality of dietary protein was measured by finding the ratio of available amino acids in the sample protein compared with the needs expressed as a ratio. Amino acid score (AAS) was then estimated by applying the formula [22]:

$$AAS = \frac{mg\ of\ amino\ acid\ in\ 1g\ of\ test\ protein}{mg\ of\ amino\ acid\ in\ reference\ protein} \times \frac{100}{1} \ldots\ldots(2)$$

The predicted protein efficiency ratio (P–PER) of the seed sample was calculated from their amino acid composition based on the equation developed by Alsmeyer *et al.* [23] as stated thus;

P–PER = –0.468 + 0.454 (Leu) – 0.105 (Tyr) - - - (3)

Statistical analysis of the samples

The fatty acid values were obtained by multiplying crude fat value of each sample with a factor of 0.8 (i.e. crude fat × 0.8 = corresponding to fatty acids value). The energy values were calculated by adding up the carbohydrates × 17 kJ, crude protein × 17 kJ and crude fat × 37 kJ for each of the samples [24, 25]. Errors of three determinations were computed as standard deviation (SD) for the proximate composition by using MS Excel Spread Sheet. The mean, standard deviation and coefficient of variation (%) for variability test on the fish samples were also analyzed.

Results and Discussion

Proximate composition includes nutritionally important ingredients such as moisture, ash, crude fiber, lipid, protein and carbohydrate from the edible parts of vegetables as presented in Table 1. Moisture content is a major factor as it determines the shelf life and storage of vegetables. Moisture content of vegetables ranged between 4.19 and 9.25%. Highest values were recorded for *Spinacia oleracea* and *Piper guineense*. The results of the moisture content of the vegetables were lower comparative to the values of [26]. The water content of vegetables when eaten raw helps the body as the body does not need to use some of its own water to digest them [27]. This means that the body uses less energy and resources to digest the greens and can then assimilate all the nutrients of the vegetables much faster. Less pressure is therefore put on the digestive system [28]. The reported values in this study are comparable to the values reported for *Clotropis procera* leaves (17.21%) and fruits (16.83%) by Aremu *et al.* [29]. Here ash value turned out to be higher in *S. oleracea* (25.38%) and lower in *G. latifolium* (13.15%) and *P. guineense* (14.25%). Commonly consumed leafy vegetables like *Amaranthus viridis* and *Alternanthera sessilis* have ash content of 1.85 and 1.5%, respectively. This indicates that the studied leaves have high mineral content compared to the previous findings of leafy vegetables [30].
The dietary fiber content is found to be the highest in *G. latifolium* (15.18%) and lowest in *S. oleracea* (8.52%). The values are comparable with the results of [30] for *P. latifolia* (15.30%) and *C. halicacabum* (7.88%). The higher amounts of dietary fiber contribute significantly to nutrient intakes since fiber lowers the body cholesterol level, thus decreasing the risk of cardiovascular diseases [31]. The protein content is within the range from 18.61% in *P. guineense* to 26.12% in *S. oleracea*. The results are close to the reported protein values of leafy vegetables, *Moringa oliefera* (20.72%) and *Momordica balsamina* (11.29 %) [32]. This suggests that the vegetables under studies are good sources of protein. Low levels of coefficient of variation showed that the results of the analysis were very close. The calculated fatty acids and metabolizable energy obtained for *Piper guineense, Spinacia oleracea and Gongronema latifolium* were 2.58, 2.41 and 2.14%; 1,177.42, 999.62 and 1,200.73 kJ/100g, respectively. The CV% ranged from 9.34 in crude fat to 38.55 in ash content.

Table 1: Proximate composition (%) of *Piper guineense, Spinacia oleracea* and *Gongrenema latifolium*

Parameter	*P. guineense*	*S. oleracea*	*G. latifolium*	Mean	SD	CV (%)
Crude protein	18.61±0.14	26.12±0.08	24.44±0.10	23.06	3.94	17.09
Crude fat	3.23±0.06	3.01±0.01	2.67±0.57	2.97	0.28	9.34
Ash	14.25±0.16	25.38±0.27	13.15±0.11	17.56	6.77	38.55
Crude fibre	11.09±0.35	8.52±0.11	15.18±0.10	11.60	3.36	28.97
Moisture	9.25±0.12	8.85±0.04	4.19±0.11	7.43	2.81	37.82
Carbohydrate	43.62±0.71	26.13±0.43	40.38±0.36	36.70	8.94	24.35
Fatty acid	2.58±0.08	2.41±023	2.14±073	2.38	0.45	9.45
Energy, kJ/100g	1,177.42±0.2	999.62±0.23	1,200.73±1.20	1,125.92	42.20	21.45

SD = Standard Deviation; CV = Coefficient of Variance. All values are the mean ± standard deviation of three determinations expressed in dry weight basis

Table 2: Amino acid (g/100 g crude protein) profile of *Piper guineense, Spinacia oleracea* and *Gongrenema latifolium*

Parameter	*P. guineense*	*S. oleracea*	*G. latifolium*	Mean	SD	CV %
Leucine[e]	7.70	8.16	7.35	7.74	0.41	5.3
Lysine[e]	3.66	3.91	4.01	3.86	0.18	4.67
Isoleucine[e]	4.48	4.56	3.94	4.33	0.34	7.85
Phenylalanine[e]	4.52	4.45	4.06	4.34	0.27	6.22
Tryptophan[e]	0.84	1.16	0.95	0.98	0.16	16.33
Valine[e]	4.32	4.61	4.50	4.48	0.15	3.35
Methionine[e]	1.20	1.29	1.20	1.23	0.52	20.33
Proline	2.94	3.16	3.31	3.15	0.17	6.03
Arginine[e]	4.64	5.31	6.11	5.35	0.74	13.83
Tyrosine	3.10	3.40	3.38	3.29	0.17	5.17
Histidine[e]	2.24	2.30	3.14	2.56	0.50	19.53
Cystine	0.85	1.09	0.76	0.90	0.17	18.89
Alanine	3.94	4.35	3.49	3.93	0.43	10.94
Glutamic acid	10.59	9.36	9.76	9.90	0.62	6.26
Glycine	3.73	3.26	3.06	3.35	0.33	9.85
Threonine[e]	3.33	2.96	3.16	3.15	0.19	6.03
Serine	3.40	3.48	3.24	3.37	0.12	3.56
Aspartic acid	8.31	8.75	8.51	8.52	0.22	2.58
P–PER	3.12	2.87	2.51	2.83	0.62	3.41

[e] = Essential Amino acid

Amino acid analysis (Tables 2) showed the range of sample contents: *P. guineense* between 0.84 to 7.70 g/100g crude protein for the essential amino acids and 0.85 to 10.59 g/100g cp for the non-essential amino acids; *S. oleracea* between 1.16 to 8.16 g/100g cp for essential amino acids and 1.09 to 9.36 g/100g cp for non-essential amino acids; *G. latifolium* has range of 0.95 to 7.35 g/100g cp essential amino acids and 0.76 to 9.90 g/100g cp for non-essential amino acids. Like the report of [33], where leucine is the dominant essential amino acid in pumpkin leaf, spinach, bitter and water leaf, leucine is also the outstanding essential amino acid in this research which content is dominant in all the leafy vegetables investigated viz: *P. guineense* (7.70 g/100g cp), *S. oleracea* (8.16 g/100g cp) and *G. latifolium* (7.35 g/100g cp). The values derived from consumption of these vegetable is attributable to their contents and their importance as explained by [33], some of which are: healing and repair of muscle tissues, clotting at site of injuries, production of growth hormones, regulation of blood sugar, increasing endurance and provision of energy in the body. Other essential amino acids with appreciable contents obtained in the analyzed vegetables include: Arginine *P. guineense* (4.64 g/100g cp), *S. oleracea* (5.31 g/100g cp) and *G. latifolium* (6.11 g/100g cp); phenylalanine *P. guineense* (4.52 g/100g cp), *S. oleracea* (4.45 g/100g cp) and *G. latifolium* (4.06 g/100 g cp) while isoleucine values for *P. guineense*, *S. oleracea* and *G. latifolium* were 4.48, 4.56 and 3.94 g/100 g cp, respectively. Gold [34] explained that phenylalanine is needed in treating brain disorder, normal functioning of the central nervous system, control of symptoms of depression and chronic pain. The most notable non-essential amino acids in this research were: Glutamic acid, *P. guineense* (10.59 g/100g cp), *S. oleracea* (9.36 g/100g cp) and *G. latifolium* (9.76 g/100g cp); aspartic acid, *P. guineense* (8.31 g/100g cp), *S. oleracea* (8.75 g/100g cp) and *G. latifolium* (8.51 g/100g cp). In some circumstances such as illness or non-availability of enzymes, some non-essential amino acids, such as glutamine, tyrosine and cystine, may not be synthesized by the body.

When this occurs, such non-essential amino acids are said to be conditional essential amino acids and thus must be provided through food intake. This is why even the non-essential amino acids from leafy vegetables as understudied are important should such situation arise [33]. The predicted protein efficiency ratio (P–PER) is one of the quality parameters used for protein evaluation [2]. The P–PER values were 3.12, 2.87 and 2.51 for *Piper guineense, Spinacia oleracea and Gongronema latifolium*, respectively. The CV% varied from 2.58 in aspartic acid to 20.33 in methionine.

The nutritive value of a protein depends primarily on the capacity to satisfy the needs from nitrogen and essential amino acids [35]. Total essential amino acid (with His) of *G. latifolium* (40.53 g/100g cp) is greater than that of *S. oleracea* (39.86 g/100g cp) and *P. guineense*, (38.67 g/100g cp). These values satisfied the FAO requirements for the essential amino acids and are comparable to the values of *Prosopis africana* [35]. Essential aliphatic amino acids (EAAA), Ile, Leu and Val, which constitute the hydrophobic region of protein were more abundant in the *S. oleracea* (31.38 g/100g cp) than *P. guineense* (30.90 g/100g cp) and *G. latifolium* (29.71 g/100g cp) (Table 3). The total acid amino acid is found to be greater than the total basic amino acid; this implies that the leafy samples are probably acid in nature [24]. The TSAA of *P. guineense* and *S. oleracea* are lower than the 5.8 g/100g protein recommended for infants [36, 37].

Table 3: Concentrations of essential, non-essential, neutral, sulphur, aromatics, etc of *Piper guineense, Spinacia oleracea* and *Gongrenema latifolium*

Amino Acid Description		*P. guineense*	*S. oleracea*	*G. latifolium*	Mean	SD	CV %
Total Amino Acid (TAA)		73.93	75.56	73.93	74.41	0.98	1.31
Total Non-essential Amino Acid		35.12	29.98	33.40	32.82	2.62	7.98
%TNEAA		47.59	39.68	45.18	44.15	4.05	9.17
Total Essential Amino Acid	with Hitidine	38.67	39.86	40.53	39.69	0.94	2.56
	Without Histidine	36.43	37.56	37.38	37.13	0.61	1.64
%TEAA with Histidine		52.41	52.75	54.82	53.33	1.30	2.43
Without Histidine		49.37	49.71	50.27	49.88	0.62	1.24
Essential Aliphatic Amino Acid		30.90	31.38	29.71	30.63	0.86	2.80
Essential Aromatic Amino acid		13.64	14.47	14.84	14.30	0.61	4.26
Total Neutral Amino Acid		44.35	45.93	39.38	43.22	3.41	7.89
%TNAA		60.10	60.78	53.28	58.06	4.15	8.72
Total Acidic Amino Acid		18.90	18.11	17.94	18.32	0.51	2.78
%TAAA		25.61	23.97	24.27	24.62	0.87	3.53
Total Basic Amino Acid		10.54	11.52	16.60	12.89	03.25	25.21
%TBAA		14.28	15.24	12.51	14.01	6.81	48.61
Total Sulphur Amino Acid		2.05	2.38	22.47	8.97	11.10	123.75
% Cystine in TSAA		41.48	45.79	38.78	42.02	3.54	8.42

Table 4: Amino acid scores of *Piper guineense, Spinacia oleracea* and *Gongrenema latifolium*

EAA	PAAESP g/100g protein	*P. guineense* EAAC	*P. guineense AAS*	*S. oleracea* EAAC	*S. oleracea AAS*	*G. latifolium* EAAC	*G. latifolium AAS*
Ile	4.0	4.48	1.12	4.56	1.14	3.94	0.99
Leu	7.0	7.70	1.10	8.16	1.17	7.35	1.05
Lys	5.5	3.36	0.61	3.91	0.61	4.01	0.73
Met + Cys (TSAA)	3.5	2.05	0.59	2.38	0.68	1.96	0.56
Phe + Tyr	6.0	7.62	1.27	7.85	1.32	7.44	1.24
Thr	4.0	3.33	0.83	2.96	0.48	3.16	0.82
Try	1.0	0.84	0.84	1.16	1.16	0.95	0.95
Val	5.0	4.32	0.86	4.61	0.92	4.50	0.90
Total	36.0	35.96	7.22	35.59	7.63	33.31	7.21

EAA: Essential amino acid composition; AAS: Amino acid score

Table 4 presents the EAA scores of the samples based on the provisional amino acid score pattern [22]. From the result the amino acid scores of the various vegetable samples are less than the reference standard except in Ile, Leu and Phe + Tyr; Ile, Leu, Phe + Tyr and Try; Leu and Phe + Tyr for *P. guineense*, *S. oleracea* and *G. latifolium*, respectively. The dietary formula based on this report showed that some essential amino acid supplementations such as Lys, Met + Cys, Thr and Val will be required in all the studied samples. The limiting AAs were Met + Cys, Thr and Met + Cys for *P. guineense, S. oleracea and G. latifolium*, respectively.

Conclusion

Ultimately, the comparative analyses conducted on the nutritional makeup of three popular leafy greens – Uziza (*Piper guineense*), spinach (*Spinacia oleracea*) and utazi (*Gongronema latifolium*) have provided insightful information about the wide range of nutrients these leaves contain. These leafy greens' complex composition of mineral, crude protein, crude fiber, crude oil and amino acids emphasizes their importance as cornerstones of a diet that promotes health. It became clear from this research that every leafy green has a distinct nutritional profile that adds to the total variety of nutrients found in our diets. In a time when disorders linked to a modern lifestyle are common, the importance of diet in preserving health cannot be emphasized. As this study has shown, leafy greens provide a healthy and natural supply of important nutrients that can help avoid chronic illnesses and improve well-being. The results of this study add to the increasing amount of information about the nutrition of leafy vegetables in the larger context of sustainable and health-conscious eating choices. Future research might focus on particular bioactive chemicals, examine how cooking techniques affect nutrient retention, and look into the possible health advantages of consuming these veggies over an extended period of time.

Conflict of interest: Authors have declared that there is no conflict of interest reported in this work.

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