



Science

AMINO ACIDS AND FATTY ACIDS COMPOSITION OF ABELMOSCHUS ESCULENTUS, VIGNA UNGUICULATA, CORCHORUS OLITORIUS, IPOMEA BATATAS, SOLANUM MELONGENA SOLD ON THE SYPOREX MARKET OF YOPOUGON (COTE D'IVOIRE)

Otchoumou Kraïdy Athanasé ^{*1}, Wognin Légbé Marie Flavienne Raïssa ¹, Zoué Lessoy
Yves Thierry ¹, Yao Konan Franck ¹, Niamké Sébastien ¹

^{*1} Biotechnology Laboratory, Biosciences Faculty, Felix Houphouët Boigny University, 22 Bp
582 Abidjan 22

Abstract

Background: Leafy vegetables (*Abelmoschus esculentus*, *Vigna unguiculata*, *Corchorus olitorius*, *Ipomea batatas*, *Solanum melongena*.) are sold on markets to people who consume them in different forms. Studies have shown their nutritional value but there is little information on the amino acids and fatty acids of these leafy vegetables. The objective of this study was to evaluate the composition in the micronutrients of these leafy vegetables.

Method: These leafy vegetables were washed and dried to determine protein and lipid levels. An evaluation of the amino acid levels and the fatty acid profile was performed on these samples.

Results: Statistical analysis showed that leaves of *Vigna unguiculata* (18.31 ± 0.29 g / 100 g) and *Corchorus olitorius* (19.15 ± 0.32 g / 100 g) contained more protein ($p > 0.05$). The amino acid percentages of *Solanum melongena* leaves were significantly ($p > 0.05$) higher than other leafy vegetables. Overall, the essential fatty acid profiles of the five leafy vegetables studied were characterized by high levels of oleic acid (17.06-22.70%), linoleic acid (15.19-43, 90%) and α -linolenic acid (0.70 - 39.20%).

Conclusion: All these results show that leafy vegetables are excellent sources of micronutrients for both humans and animals.

Keywords: Amino Acids; Fatty Acids; *Abelmoschus Esculentus*; *Vigna Unguiculata*; *Corchorus Olitorius*; *Ipomea Batatas*; *Solanum Melongena*.

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1. Introduction

Africa has a great diversity of plant resources that play a major role in the continent's food, socio-economic and cultural development [1, 2]. Among these resources are the traditional or indigenous leafy vegetables that correspond to wild or cultivated plants (herbs, lianas, shrubs, trees) whose leaves are eaten raw or cooked [3]. They usually come in the form of sauces but are also eaten like spinach. These traditional leafy vegetables help to improve the nutritional status of populations and generate significant income in both rural and urban areas [4]. In fact, they have a high nutritional value because of their contribution to mineral, protein and vitamin elements that are generally deficient in the diet of local populations [4, 5, 6, 7]. In addition to providing essential nutrients, leafy vegetables are involved in the protection of the human body against a number of metabolic, physiological and free radical damage [8,9]. Several of them possess medicinal virtues, notably those of fighting infections, facilitating intestinal transit, and having laxative properties [10]. In Côte d'Ivoire, leafy vegetables are found in the Abidjan markets, particularly at the Syporex market in Yopougon commune. Studies have shown the nutritional value of these leafy vegetables by determining the levels of protein, lipids, fiber, ash, vitamin C, minerals, provitamin A [11, 12, 13]. The presence of secondary metabolites such as polyphenols, flavonoids, tannins and anti-nutritional factors has been highlighted. For a better exploitation of these leaves, it is necessary to evaluate the amino acid and fatty acid content of *Abelmoschus esculentus*, *Vigna unguiculata*, *Corchorus olitorius*, *Ipomea batatas* and *Solanum melongena* sold on the Syporex market of Yopougon commune in the district of Abidjan in Côte d'Ivoire.

2. Material and Methods

Equipment

The work equipment consists of five traditional leafy vegetables purchased fresh from the Syporex market of Yopougon commune in Abidjan District. These are the plants of *Abelmoschus esculentus*, *Corchorus olitorius*, *Ipomea batatas*, *Solanum melongena* and *Vigna unguiculata*.

Treatment of Leafy Vegetables

After their purchase, the five leafy vegetables underwent a treatment that consisted of removing all the impurities (faded leaves, sand grains, and other plant species). The plants were then cleaned with distilled water.

Crude Protein and Fat Composition

The protein content of leafy vegetables and concentrate was determined by the method proposed by Kjeldhal [14] and the fat content by [15]. All analyses were carried out in triplicate.

Fatty Acid Composition

The evaluation of fatty acid composition to consist of extracting lipids from leafy vegetables, to prepare methyl esters for chromatographic analysis The extraction was carried out by the Soxhlet method after steaming the leafy vegetables at 50°C for 24 h. The preparation of the methyl esters and the chromatographic phase were carried out according to the [16] method. 0.10 g of fat containing 2 mL of n-heptane is stirred for 30 seconds before and after the addition of 0, 2 mL of methanolic potassium hydroxide solution and then placed at rest. 1 µl of the phase containing the heptane recovered after decantation is injected into a chromatographic chain using a TDR1 capillary column (60 m x 0.25 mm x 0, 25 µm). The temperature of the column goes from 150 °C

per step of 5 °C/min to 250 °C for 10 min. The injection temperature is 250°C in split mode (1:20). The carrier gas used is nitrogen with a flow rate of 23 mL/min and the detection of fatty acids was carried out using a flame ionization detector maintained at 250°C. The identification of fatty acids is performed by comparing the peak areas and retention times with those of standard solutions. The identified fatty acids are quantified by reference to a standard curve established with an internal standard (erurci acid at 2 µg/µL

Essential Amino Acids Composition

It was determined to [17] methods. The sample (5 g) was hydrolyzed in 6N HCl at 110°C for 24 hours. Hydrolyzates were diluted in 20 ml of 0.2 N sodium citrate; pH 2.3 After evaporation of acid, the sample was recovered in 10 mL of 70% ethanol then filtered on a millipore. Two (2) mL of filtrate were further analyzed using high performance liquid chromatography chain which a Waters Alliance unit, model e2695 equipped with two Lichrocart 125-4 Lichrospher 100 RP-18 columns in serie. Elution was done in gradient mode with a flow rate of 1 mL / min. Detection was carried out using a Waters spectrofluorometer 2475. Excitation and emission were carried out respectively at 340 nm and 450 nm.

Vitamin Analysis

Vitamins content were determined according to the method described by [18] using high performance liquid chromatography (HPLC). Five (5) grams of samples were crushed in 25 mL of methanolic solution. After filtration, alpha-tocopherol and retinol were evaluated by an HPLC system (SHIMADZU SPD 20A) with DAD detector, a high pressure pump and a C18 column ODS, 250 x4.60 mm (Cluzeau, France). The quantification was carried out by comparing the area sample peak with that of the reference standards which are retinol acetate and alpha-tocopherol.

The water-soluble vitamins were analyzed after injection of 20 µL of solution obtained from a mixture of 2 g of sample in 25 mL of 0.1N sulfuric acid in the HPLC system. Chromatographic separation was achieved on a reversed phase (RP) HPLC column through the isocratic delivery mobile phase at a flow rate of 1.5 mL/min. Ultraviolet (UV) absorbance was recorded at 270 nm at room temperature. Statistical analysis: All the data taken from this study were subjected to the analysis of variance (ANOVA) using SPSS 17 software. The variations in means were separated using the Duncan Multiple Range Test [19].

3. Results

The protein and fat content of leafy vegetables was presented in the Table 1. The protein content was significantly highest ($p>0.05$) for *Corchorus olitorius* (18.31 ± 0.29 g/100 g) and *Vigna unguiculata* (19.15 ± 0.32 g/100 g)

Table 1: Protein and fat composition of leafy vegetables

Nutrients (g/100 g of DM)	<i>Abelmoschus esculentus</i>	<i>Corchorus olitorius</i>	<i>Ipomea Batatas</i>	<i>Solanum melongena</i>	<i>Vigna Unguiculata</i>
Protein	10.58 ± 0.64 a	18.31 ± 0.29 e	15.83 ± 0.41 d	12.55 ± 0.24 b	19.15 ± 0.32 e
Fat	4.42 ± 0.20 b	4.76 ± 0.05 c	3.75 ± 0.14 a	3.67 ± 0.12 a	5.29 ± 0.02 d

The values represent the mean \pm the standard deviation of the triplicate trials tested. Values in the same column with different superscripts were significantly different ($P < 0.05$). DM: Dry mater

The essential composition amino acids of the leafy vegetable were indicated in Table 2. *Solanum melongena* leaves had the highest rate of phenylalanine (4.56 ± 0.18 g/100 g), lysine (8.72 ± 0.17 g/100 g) an valine (6.17 ± 0.12 g/100 g). Threonine content was significantly ($p > 0.05$) higher in the leaves of *Abelmoschus esculentus*, *Vigna unguiculata* and *Corchorus olitorius* with mean values ranged from 4.36 ± 0.07 g / 100 g to 4.51 ± 0.07 g / 100 g. The leaves of *Ipomea batatas* recorded the lowest levels of leucine (4.16 ± 0.25 g / 100 g) and lysine (2.56 ± 0.16 g / 100 g).

Table 2: Essential amino acids composition of leafy vegetables

Amino acids (g/100 g of DM)	<i>Abelmoschus esculentus</i>	<i>Corchorus olitorius</i>	<i>Ipomea Batatas</i>	<i>Solanum melongena</i>	<i>Vigna unguiculata</i>
Phenylalanine	38.6 ± 0.24 b	2.84 ± 0.04 a	3.51 ± 0.09 b	4.56 ± 0.18 c	3.65 ± 0.06 b
Leucine	9.33 ± 0.24 bc	8.91 ± 0.14 b	4.16 ± 0.25 a	9.41 ± 0.18 c	9.16 ± 0.15 bc
Threonine	4.40 ± 0.11 c	4.51 ± 0.07 c	3.24 ± 0.20 b	1.83 ± 0.04 a	4.36 ± 0.07 c
Valine	5.21 ± 0.32 b	3.98 ± 0.06 a	4.07 ± 0.11 a	6.17 ± 0.12 c	4.10 ± 0.07 a
Lysine	7.70 ± 0.20 d	4.69 ± 0.07 b	2.56 ± 0.16 a	8.72 ± 0.17 e	5.03 ± 0.08 c
Methionine	0.72 ± 0.04 a	1.42 ± 0.02 c	1.37 ± 0.04 c	0.97 ± 0.02 b	1.40 ± 0.02 c
Tyrosine	4.88 ± 0.14 c	4.70 ± 0.10 c	2.34 ± 0.17 a	3.24 ± 0.06 b	4.88 ± 0.11 c

The values represent the mean \pm the standard deviation of the triplicate trials tested. Values in the same column with different superscripts were significantly different ($P < 0.05$). DM: Dry mater

Table 3 indicates that there are significant differences between the fatty acid compositions of the five leafy vegetables. Analysis of fatty acid profiles of leafy vegetables revealed that leaves of *Solanum melongena* contain more unsaturated fatty acids ($73.88 \pm 1.01\%$) than saturated fatty acids ($25.12 \pm 0.78\%$). The leaves of *Ipomea batatas*, *Solanum melongena* and *Vigna unguiculata* are characterized by significantly higher ($P > 0.05$) percentages of α -linolenic acid and lower linoleic acid while the reverse is observed in the leaves of *Abelmoschus esculentus*. In addition to the four unsaturated fatty acids, leaves of *Corchorus olitorius* also contain other unsaturated fatty acids ($6.41 \pm 2.12\%$).

Table 3: Fatty acids composition of leafy vegetables

Fatty acids (%)	<i>Abelmoschus esculentus</i>	<i>Corchorus olitorius</i>	<i>Ipomea Batatas</i>	<i>Solanum melongena</i>	<i>Vigna unguiculata</i>
C 12:0 (lauric acid)	0.25 ± 0.07 b	7.93 ± 1.03 d	0.86 ± 0.00 c	0.08 ± 0.01 a	0.15 ± 0.07 b
C 14:0 (myristic acid)	0.60 ± 0.00 a	2.06 ± 0.36 c	1.72 ± 0.25 b	0.63 ± 0.16 a	3.03 ± 0.10 d

C 15:0 (pentadecylic acid)	Nd	1.72 ± 0.95 c	0.62 ± 0.40 b	0.71 ± 0.25 b	0.15 ± 0.07 a
C 16:0 (palmitic acid)	22.70 ± 2.12 bcd	3.29 ± 1.66 a	29.09 ± 6.35 d	15.70 ± 2.15 b	20.71 ± 1.27 bc
C 17:0 (margaric acid)	Nd	0.12 ± 0.02 a	Nd	0.71 ± 0.62 a	0.70 ± 0.14 a
C 18:0 (stearic acid)	6.15 ± 0.21 ab	10.20 ± 0.14 bc	4.36 ± 1.12 a	6.10 ± 1.36 ab	12.00 ± 2.82 c
Other saturated fatty acid	1.00 ± 0.00 a	8.36 ± 1.02 d	Nd	1.21 ± 0.20 b	2.48 ± 0.82 c
Total saturated fatty acid	30.70 ± 2.26 ab	33.67 ± 5.19 bc	36.65 ± 4.57 bc	25.12 ± 0.78 a	39.22 ± 1.12 c
C 16:1 (palmitoleic acid)	2.05 ± 0.50 b	0.19 ± 0.06 a	0.46 ± 0.30 a	2.05 ± 0.49 b	0.90 ± 0.42 a
C 18:1 (oleic acid)	22.70 ± 3.81 a	20.61 ± 2.24 a	22.02 ± 6.63 a	17.06 ± 4.16 a	18.72 ± 3.56 a
C 18:2 (linoleic acid)	43.90 ± 0.84 c	33.88 ± 4.86 b	15.19 ± 2.42 a	15.58 ± 5.48 a	22.30 ± 2.12 a
C18:3 (α-linolenic acid)	0.70 ± 0.14 a	5.35 ± 0.78 b	24.07 ± 6.75 c	39.20 ± 2.82 d	20.35 ± 3.89 c
Other unsaturated fatty acid	Nd	6.41 ± 2.12 a	Nd	Nd	Nd
Total unsaturated fatty acid	69.35 ± 2.33 bc	66.43 ± 5.59 ab	61.71 ± 2.01 a	73.88 ± 1.01 c	62.27 ± 2.22 ab

The values represent the mean ± the standard deviation of the triplicate trials tested. Values in the same column with different superscripts were significantly different (P<0.05). Nd: Not detected

Table 4 indicates that vitamin A and vitamin B6 levels are higher in the leaves of *Abelmoschus esculentus* with 197.99 and 155.69 µg / 100 g fresh leaves, respectively. The leaves of *Vigna unguiculata* are characterized by high levels of vitamin B5 (94.99 µg / 100 g of fresh leaves) while those of *Solanum melongena* contain a higher proportion of vitamin B9 (275.2 µg / 100 g fresh leaves).

Table 4: Vitamins composition of leafy vegetables

Vitamins (µg/100 g)	<i>Abelmoschus esculentus</i>	<i>Corchorus olerius</i>	<i>Ipomea Batatas</i>	<i>Solanum melongena</i>	<i>Vigna Unguiculata</i>
Vitamin A	197,99	144,54	143,15	104,86	28,5
Vitamin B5	20,40	35,86	24,70	42,94	94,99
Vitamin B6	155,69	69,09	18,4	15,19	41,7
Vitamin B9	122,75	92,68	101,1	275,2	202,58

4. Discussion

The protein and lipid contents of the five leaf vegetables from this study are different from those obtained by [11, 12, 13]. These variations could be related to the use of whole leaves (limbs + petioles) in this work, contrary to previous studies in which only leaf blades were analyzed. The high levels of protein in the leaves of *Corchorus olerius* and *Vigna unguiculata* indicate that these

leaves could constitute significant sources of protein because, according [20], a plant-based food is considered a source when it contains at least 12% protein. Proteins play a vital role in the growth and development of the body, in tissue formation, in the repair of aging cells and tissues [21]. Thus, these leafy vegetables could play an important role in food security by improving the protein value of diets where animal protein is very often absent. In addition to their benefits in human nutrition, these leaves could be oriented in the field of livestock in the form of fodder to increase the protein content of rations. It is also important to note that *Vigna unguiculata* is one of the 83 forages plants that can be used for rabbit feed [22]. In addition to their low protein content, leaves of *Solanum melongena* have distinguished themselves from other leafy vegetables with higher levels of four essential amino acids. The rates would indicate that the proteins from the *Solanum melongena* leaves would have good biological value. This finding was also made by [23]. The quality of the proteins contained in this leaf vegetable could be an important nutritional asset in both human and animal nutrition. *Solanum melongena* leaves would therefore be a relatively inexpensive source of amino acids that could be used as food supplements, especially when animal proteins become expensive. Apart from their positive impact on humans, several trials have shown that these leaves can also contribute to the improvement of animal feed. According to this work, the addition of *Solanum melongena* leaves not only improves the growth performance of the rabbit *Oryctolagus cuniculus* [24] but also the quality of the meat produced [25]. Of the seven essential amino acids analyzed, leucine appears to be more abundant in leafy vegetables. This abundance in leafy vegetables may explain their use in traditional medicine, particularly for the healing of skin infections [26, 27, 28]. In addition, similarities are observed between the essential amino acid concentrations of leaves of *Corchorus olitorius* and those of [29]. On the other hand, the values obtained with the leaves of *Ipomea batatas* are weak compared to the results of [7]. Despite the significant differences observed, all leafy vegetable species had low levels of crude lipids. These results are in agreement with the work of [30] according to which leafy vegetables are foods containing little lipids. What makes leafy vegetables, foods to advocate in the diets of people suffering from obesity. The lipid contents of *Vigna unguiculata* leaves are lower than those obtained by [31]. Although the high lipid consumption is likely to cause pathologies, the work of [32] showed that lipids are important nutrients for the human body. Indeed, lipids enter the composition of cell membranes and intervene in the metabolism of fat-soluble vitamins. In-depth study of these lipids has shown that they are characterized by higher proportions of unsaturated fatty acids than of saturated fatty acids. In addition, high percentages of polyunsaturated fatty acids including α -linolenic acid and linoleic acid represent essential nutrients for both humans and animals. These polyunsaturated fatty acids being exogenous, they are therefore brought by the diet. As a result, recurring consumption of the five leafy greens could help protect the body from cardiovascular disease. Because α -linolenic acid is the precursor of the C22: 6 n-3 fatty acid (Docosahexaenoic acid or DHA), several studies have shown their positive effect. Thus, DHA intake is thought to be responsible for a reduction in cardiac arrhythmias, myocardial infarction, and some cancers [33]. In the livestock sector, the use of leafy vegetables as fodder could improve the percentages of polyunsaturated fatty acids and the organoleptic characteristics of meat [34]. As for humans, vitamins are also necessary for the proper development of animals, so leafy vegetables could replace vitamin premix in animal feed formulations. A test carried out with the leaves of *Moringa oleifera* by [35] confirms this assertion.

5. Conclusion

These results show that these plants are important food resources for both populations and animals. The richness of amino acids and essential fatty acids is to be exploited in the context of the prevention of cardiovascular diseases and cancers. Applications will be needed especially in the animal feed to obtain specific examples of recovery of leaf vegetables in food formulations used in the livestock sector.

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*Corresponding author.

E-mail address: tchoumou2@ yahoo.fr