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Research Article
Comparative Study of the Nutritional Composition of Three Leafy Vegetables from the Flora of Côte d'Ivoire: The Case of *Euphorbia moringa* and *Manihot esculenta*

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Abstract

Background and Objectives: Leafy vegetables are perennial species that play an important role in the diet. However, very little research has been devoted to them in Côte d'Ivoire. The aim of the present study was to determine the nutritional composition of three leafy vegetables (*Euphorbia hirta*, *Moringa oleifera* and *Manihot esculenta*), in order to increase their nutritional value against malnutrition. **Methodology:** The nutritional composition of these leafy vegetables was analyzed in accordance with standard methods. **Results:** The results recorded for three species (*Euphorbia hirta*, *Moringa oleifera* and *Manihot esculenta*) were as follows: Moisture content (59.06±0.08%, 70.5±1%, 66.26±3.26%), proteins (14.41±0.02%, 26.12±0.18%, 29.09±0.11%), carbohydrates (35.43±5.30%, 14.37±1.3%, 14.89±0.01%), lipids (3.8±0.13%, 6.8±0.13%, 5.93±0.31%), dietary fibers (37.16±1.55%, 43.2±0.51%, 43.83±1.53%), ash (9.2±0.13%, 9.5±0.67%, 6.20±0.11%), polyphénols (368.66±50.75 mg EAG/ g MS, 375.5±4.78, 381±4.24 mg EAG/g MS), flavonoïdes (290.66±48.36 mg EQ/g MS, 283.78±3.9 EQ/g MS, 283±1.41 mg EQ/g MS) and energy value (193.44±1.68 kcal/100g, 283 78±3.9 kcal/100 g, 171.96±4.29 kcal/100 g, 173.75±0.01 kcal/100 g). **Conclusion:** Leafy vegetables have a generally high nutritional composition. Their consumption could sustainably improve the nutritional status of vulnerable groups in Côte d'Ivoire and thus malnutrition could be effectively combated. Nevertheless, further studies are needed to assess the nutritional contribution of the leafy vegetables studied in combination with other foods.

Key words: Euphorbia hirta, malnutrition, *Manihot esculenta* , *Moringa oleifera* , nutritional composition

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

All age groups in Côte d'Ivoire are affected by a poorly diversified diet, which affects 20.5% of the population in 2014. More than 65% of the daily dietary energy intake is derived from tubers, roots and cereals in this poorly diversified diet[1]. According to the WHO, a balanced diet should include: 50-55% carbohydrates, 30-35% lipids and 10-15% proteins[2]. Poor eating habits, such as the consumption of fat, salt and sodium, sugar, sugary foods and sweetened beverages, contribute to overweight. Moreover, the adoption of Western-style diets and the development of fast-food outlets have degraded the traditional diet in Côte d'Ivoire[3]. An increase in sedentary lifestyles and changing diets (25.5% of the population aged 15 and over) are contributing to an increase in overweight and obesity at an alarming rate, with a consequent rise in chronic diseases[2]. There is a high prevalence of infectious diseases, aggravating the nutritional situation. These diseases are the breeding ground for malnutrition and vice versa. Their interaction tends to create a vicious circle. Climate change, illiteracy and the decade of politico-military crises (2000-2010) marked by growing poverty are all factors that negatively affect nutrition. The proportion of the population living below the poverty line rose from 33.6% in 1998 to 48.9% in 2008. In 2012, 53% of women of childbearing age had no formal education. In addition, with rapid urbanization and industrialization, sedentary lifestyles and changing diets are becoming more common, leading to an increase in overnutrition. The negative effects of malnutrition on the development of human capital and its productivity at work limit economic and social development[3]. An analysis of the consequences of malnutrition in Côte d'Ivoire has revealed an economic loss of over 972 million US dollars, or nearly 486 billion euros, due to a drop in labor productivity[2]. In Côte d'Ivoire, this double burden of malnutrition represents a challenge in itself, as the country needs to find solutions that can resolve problems of undernutrition as well as address the emergence of obesity and metabolic overload. In order to reduce malnutrition in all its forms, interventions should focus more on prevention activities. Access to healthy, diversified and nutritious food is still limited: diversifying agricultural production and reducing post-harvest losses and catches will have to be accompanied by measures to strengthen household resilience to shocks, particularly for the most vulnerable households. It is also necessary to implement a system to guarantee food safety. At the family and community level, nutrition practices and care are suboptimal: To solve this problem, we must take vigorous measures to promote good nutrition, hygiene and community care practices. Among these are traditional Leafy Vegetables (LFT) play a major role in agriculture and food production, generating significant income in both rural and urban areas[4-6]. They are important sources of vitamins (especially A, B and C), trace elements, proteins, fibre and as such, could contribute to improve the nutritional status of populations in both rural and urban areas[7]. Despite the economic, nutritional and medicinal importance of leafy vegetables, very little research had been devoted to them in Côte d'Ivoire. In this context, this study was designed to determine the composition of three leafy vegetables of the species *Euphorbia hirta*, *Moringa oleifera* and *Manihot esculenta* with a view to enhance their nutritional benefits as preventive and curative remedies against malnutrition.

MATERIALS AND METHODS

Study framework: It is located in the District of Abidjan. The average annual temperature is around 26°C. The Ebrié Lagoon is the only waterway adjacent to the town of Bingerville. It is surrounded by the towns of Alépé, Abidjan, Anyama and Grand-Bassam. Christianity and Islam are the main religions practiced here. Like most of southern Côte d'Ivoire, the town is characterized by forest vegetation. The terrain is not very varied, with numerous plateaus. The flora is varied and contains species that are disappearing due to the development of the habitat. The main agricultural activities are oil palm, cassava and rubber. There are a large number of farmers, planters, poultry and pig breeders. Fishing is carried out using hawks, lines or fixed traps. This traditional fishing provides fish that is eaten fresh, dried or smoked.

Plant material: The plant material used here consists of cassava leaves, moringa and euphorbia hirta, harvested at the Bingerville site, which is a suitable location for these plants.

Sampling

Treatment of *Manihot esculenta*, *Euphorbia hirta* and *Moringa oleifera* leaves: The three leafy vegetables harvested in Bingerville were dried in a clean, dry place away from direct sunlight.

A 3-kilogram batch of each leafy vegetable was made up. Each harvested batch was split into 3 samples of identical mass, with 1 kilogram for each sample. One sample of each vegetable was selected and powdered. Three batches of leafy vegetable powders were obtained after grinding in order to determine biochemical and phytochemical parameters.

Determination of biochemical parameters of powders from three leafy vegetables: Moisture content was determined in an oven (MEMMERT 854 SCHWABACHW, Germany) using the AOAC method[8]. Ash content was obtained by weighing the residue of the sample incinerated at 550°C[9]. Moringa oleifera protein content was estimated using the Kjeldahl method[9]. Total lipids were extracted using the SOXHLET method[9]. Fiber content was determined using the AOAC method[9]. Total carbohydrates and energy values were determined using the method recommended by FAO[10]. Dietary fiber was determined using the AOAC method[9].

Determination of phytochemical parameters of powders from three leafy vegetables: Flavonoid content was assessed using the method of Meda *et al.*[11]. Polyphenol content was determined by the Folin-ciocalteu reaction using the method described by Singleton *et al.*[12].

Statistical processing: Quantitative data were collected using Excel spreadsheets. A NEWMAN-KEULS one-criterion classification test at the 5% threshold was performed to assess the significant difference between means. The test was performed using Statisticat version 7.1 software.

RESULTS AND DISCUSSION

Moisture content is a quality criterion and an important indicator of the food's suitability for preservation[13,14]. Biochemical analysis revealed the water content in the leaves of *Euphorbia hirta* (59.06±0.08%), *Moringa oleifera* (70.5±1%) and *Manihot esculentus* (66.26±3.26%). As a result of these moisture levels observed in this study, powdered foods have a longer storage life by inhibiting the proliferation of microorganisms likely to spoil the food[15]. The lipid content in these three leafy vegetables were 3.8±0.13%, 6.8±0.13% and 5.93±0.31%. The levels observed are broadly similar to those found in the literature for moringa and manioc leafy vegetables[16]. Table 1 shows that lipid contents remain low compared to other contents. However, plant-derived lipids can reduce bad cholesterol levels, a health indicator. This can be a natural means of combating potential cardiovascular disease. The results indicate protein macromolecule contents of 14.41±0.02%, 26.12±0.18% and 29.09±0.11%, respectively for *Euphorbia hirta*, *Moringa oleifera* and *Manihot esculentus*. The results concerning the protein content of *Moringa oleifera* species are consistent with those reported in the literature[17,18]. This would justify the incorporation of this vegetable into dietary supplements to combat malnutrition in general[18]. Proteins are nutrients used in growth and reproductive performance. This justifies the use of foods containing high levels of protein in infant nutrition with a view to combating infant malnutrition. In fact, Moringa leaf powder can be used in much the same way as dried spirulina, a nutrient-rich green algae commonly used as a dietary supplement[19]. The leaf is the most widely used organ, consumed in sauces as a simple vegetable, with moderate medicinal use and lesser use in animal feed. Due to its nutritional qualities, this leaf is used so widely. In fact, this study revealed that *Moringa oleifera* has a wide range of uses, particularly for food. The other organs, such as the seeds, stems and roots, are used in the treatment of pathologies relating to infectious diseases, digestive infections, haematology, neurology and gynaecology. In view of the nutritional and therapeutic potential of *Moringa oleifera*, a number of initiatives should be undertaken to enhance the value of this plant[20]. *Euphorbia hirta* (9.2±0.13%) and *Moringa oleifera* (9.5±0.67%) had statistically identical ash contents, while *Manihot esculenta* (6.2±0.11%) had a higher ash content. In fact, the minerals contained in ash are important for the proper functioning of the organism, as they constitute the metallic cofactors of enzymes and are used in catabolic reactions involving carbohydrate, lipid and protein molecules. Dietary fiber values for the three leafy vegetables were 37.16±1.55%, 43.2±0.51% and 43.83±1.53%, respectively. The values recorded are generally high, in contrast to *Euphorbia hirta*, *Moringa oleifera* and *Manihot esculenta*

Table 1: Nutritional composition (%) of three leafy vegetables

	Leafy vegetables		
Parameters	*Euphorbia hirta*	*Moringa oleifera*	*Manihot esculenta*
Moisture content	59.06±0.08[a]	70.50±1.00[a]	66.26±3.26[b]
Proteins	14.41±0.02[a]	26.12±0.18[b]	29.09±0.11[b]
Lipids	3.80±0.13[a]	6.80±0.13[b]	5.93±0.31[b]
Carbohydrates	35.43±5.30[a]	14.37±1.3[a]	14.89±0.01[b]
Ash	9.20±0.13[a]	9.50±0.67[a]	6.20±0.11[b]
Dietary fibers	37.16±1.55[a]	43.20±0.51[b]	43.83±1.53[b]
Energy value (kcal/100 g)	193.44±1.68[a]	171.96±4.29[a]	173.75±0.01[a]

Table2: Polyphenol (mg EAG/g DM) and flavonoid (mg EQ/g DM) composition of three leafy vegetables

	Leafy vegetables		
Parameters	*Euphorbia hirta*	*Moringa oleifera*	*Manihot esculenta*
Polyphénols	368.66±50.75[a]	375.50±4.78[a]	381.00±4.24[a]
Flavonoïdes	290.66±48.36[a]	283.78±3.9[a]	283.00±1.41[a]

have significantly different values ($p<0.05$). *The Moringa oleifera* plant is believed to induce milk production in nursing mothers, due to its high dietary fibre content. In addition, fiber containing water-soluble fibers, such as pectin, is important due to its anti-diarrheal and anti-cancer properties, as well as its detoxifying properties[21]. The presence of non-water-soluble fibers is also thought to promote digestibility and facilitate intestinal transit[22]. Fiber consumption reduces the risk of cardiovascular disease, colon cancer and obesity. Results obtained about dietary fiber and protein richness in the diet are in agreement with those found by PNN[1]. The respective contents of secondary metabolites in the three species (*Euphorbia hirta*, *Moringa oleifera* and *Manihot esculenta*) are all high and are as follows; polyphenols (368.66±50.75 mg EAG/g DM; 375.5±4.78, 381±4.24 mg EAG/g DM), flavonoids (290.66±48.36 mg EQ/g DM; 283.78±3.9 mg EQ/g DM, 283±1.41 mg EQ/g DM) (Table 2). One of the major originalities of plants lies in their ability to produce highly diversified natural substances. Indeed, alongside the classic primary metabolites (carbohydrates, proteins, lipids, nucleic acids), they frequently accumulate so-called secondary metabolites whose physiological function is not always obvious but which represent a major source of molecules usable by man in the agri-food sector. Phytochemical compounds such as flavonoids and phenols are found in *Manihot esculenta* and *Moringa oleifera*[23,24]. Polyphenols can reinforce our natural defences against antioxidant stress by protecting tissue constituents[25]. They can inhibit the production of free radicals[26]. Polyphenols prevent the oxidation of low-density lipoproteins[27]. They may therefore protect the body against myocardial infarction. Flavonoids are compounds with pronounced antioxidant activity[28]. In some cases, flavonoids act as pro-oxidants. Indeed, several have been described as responsible for auto-oxidation and the generation of active oxygen radicals, such as hydrogen peroxide. Ultimately, some flavonoids may accelerate the onset of oxidative damage to DNA, proteins and carbohydrates *in vitro*. The pro-oxidant potential of these compounds should therefore not be overlooked in the mechanism of action of flavonoids. Numerous studies suggest that flavonoids play a role in the prevention of cardiovascular disease.

CONCLUSION

Leafy vegetables generally have a high nutritional value, although they are specifically richer in protein, dietary fiber and minerals. It would be advisable to encourage the population to consume leafy vegetables, as leafy vegetables have a high nutritional value, they contribute significantly to health and food security. Encouraging the consumption of leafy vegetables could improve the nutritional status of vulnerable groups in Côte d'Ivoire.

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