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Phytonutrients, Vitamin and Mineral Content of *Adansonia digitata* L. (Malvaceae) and *Moringa oleifera* L. (Moringaceae), Two Medicinal Plants Grown as Leafy Vegetables in Nutritious Gardens in Burkina Faso

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Abstract This study determined the phytonutrients, vitamin and mineral content of *Adansonia digitata* and *Moringa oleifera*, two medicinal plants grown as leafy vegetables in nutrient gardens in Burkina Faso. Both plants have appreciable protein contents with values of 69.68 ± 6.22 mgE BSA/g and 138.27 ± 3.3 mgE BSA/g respectively for *Adansonia digitata* and *Moringa oleifera*. In addition to its best protein content, *Moringa oleifera* also has the highest lipid, β-carotene and vitamin C contents, with respective contents of 13.33%, 0.874 betac equivalent mg/g and 2.38 ± 0.01 ug/mg. In terms of mineral contents, *Adansonia digitata* stood out with the highest contents of Zinc (53.46 mg/kg), Potassium (4510.25 mg/kg), Iron (105.86 mg/kg) and Sodium (153.33 mg/kg). *Moringa oleifera* had the highest content of Magnesium (941.17 mg/kg). The results of this study showed the richness of these two plants in phytonutrients, vitamin and mineral elements, which is an advantage for introducing them into programs to combat malnutrition and associated deficiencies or to improve the health of populations.

Keywords: *Adansonia digitata, Moringa oleifera, protein, Nutraceuticals*

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1. Introduction

Nutrition occupies an important place in social representations and in health management. Indeed, with the emergence of diseases related to food, man has become an actor and author of his own health and tries to feed himself taking into account his state of health, his experience and his achievements. The concept of food has become a means of therapeutic action on the body, "from your food you will make a medicine"[1].

Initially defined as substances produced by plants as repellent, odorous, coloring, protective or regulatory elements, to defend themselves against environmental factors, phytonutrients are also perceived as nutrients present in the natural state in foods of plant origin and which have beneficial effects on health. They must be provided by food because the body cannot synthesize them. There are several categories of phytonutrients including polyphenols (flavonoids, tannins, stilbenes, phenolic acids), Carotenoids (α-carotene, β-carotene, lutein, lycopene, zeaxanthin) and phytoestrogens, which are plant substances close to female hormones (estrogens) [2].

Vitamins are molecules that are essential to life. Initially defined as compounds with an amine function, the term has been extended to all organic molecules that are essential to human health and that humans cannot synthesize in sufficient quantities by themselves. These molecules are catalysts at low doses. Vitamins are classified into two large groups, water-soluble and fat-soluble. Their main functions are coenzyme, proton or electron transfer, membrane stabilizer and hormone [3].

Mineral substances are essential and even indispensable constituents of the tissues of living beings (animals and plants). In infinitesimal doses, they play a plastic and functional role in the teguments, as well as a regulatory role in the processes of ionic exchange. We distinguish between macroelements and trace elements which exist in very small quantities in the parts of plants [4].

Moringa oleifera or miracle tree called Arzantiiga in the local Mooré language is native to northern India. Many medicinal virtues are conferred to this plant (antidiar-rheic, hypotensive, bactericidal, laxative, antiinflammatory, antioxidant, etc.) [5].

As for *Adansonia digitata* or Baobab, called Tohega in the local Mooré language, it is a tree present in its natural state almost everywhere in tropical continental Africa. The plant is used in traditional medicine to treat stomach aches, diarrhea, fever, wounds, malaria, toothache, and amenorrhea in women [6].

Many medicinal plants also have food (vegetables) and condiment (spices) uses. This is the case of these two plants grown in nutritious gardens in Burkina Faso [7]. The technique known as nutritious garden appears as an alternative to increasing the availability of leaves, by encouraging populations to integrate Baobab and Moringa into their market garden crops as vegetables. The choice of these two species is guided by their frequent use by the vast majority of the population. However, there is the problem of the bioavailability of the nutritional constituents of these leafy vegetables which are often poorly packaged before being transported to the markets. Being perishable due to their high water content, they are sensitive to the actions of biological and physicochemical degradation agents [8].

This results in post-harvest losses from a quantitative and qualitative point of view. This raises concerns about the nutritional quality of these leafy vegetables sold, especially since they have a survival of 24 hours. Indeed, at the market level, it happens that these leafy vegetables are not sold in one day. To meet consumer demand, merchants tend to water these leafy vegetables with water, and even with products in order to keep them fresh. The objective of this study is to determine the phytonutrients, vitamin and mineral content of *Adansonia digitata* and *Moringa oleifera*, highlighting their potential to improve the health of populations.

2. Material and Methods

2.1. Plant Material

The plant material consisted of *Adansonia digitata* and *Moringa oleifera* leaves collected from the Boala nutrient garden (Figure 1) in the rural commune of Zitenga. They were well washed and dried away from sunlight in a well-ventilated room for 2 weeks, then ground into powder using a blade grinder.

a. Leaves of *Adansonia digitata*

b. Leaves of *Moringa oléifera* grown in a nutritious garden

Figure 1. Leaves of *Adansonia digitata* and *Moringa oleifera* (photos Benjamin OUEDRAOGO, 2024)

2.2. Determination of Phytonutrients Content

2.2.1. Total Protein Content

Total proteins were determined by the method used by [9]. This is a colorimetric assay based on the change in absorbance (measured at 595 nm), manifested by a change in color of Coomassie Blue G-250 after binding (complexion) with basic amino acids (arginine, histidine, lysine) and hydrophobic amino acid residues present in proteins. The values obtained are directly extrapolated to a bovine serum albumin (BSA) standard curve. Protein contents are expressed in mg BSA Equivalent per g extract (mgE BSA/g) and were obtained according to the formula:

T= c*D*1000/Ci

T: sample total protein concentration expressed in mgE BSA/g dry leaf

C: sample concentration in µg/mL

D: dilution factor

Ci: initial sample concentration (mg/mL)

2.2.2. Total Lipid Content

Lipid content was determined by the soxhlet extraction method in accordance with International Standard ISO 659, 1998 using hexane as the extraction solvent [10]. For this purpose, 200 mL of hexane were introduced into a pre-weighed 250 mL flask (Pv). 5 grams of sample were weighed directly into dehydrated cotton-covered cartridges and placed in Soxhlet extractors. Extraction was carried out at high temperature (65 - 70°C) by soaking followed by rinsing with hexane for 4 h. The steam used to extract the lipids was cooled and condensed using a cryostat. The solvent was separated from the lipids by evaporation using a Rotavapor (Buchi R-3). The flask was then placed in an oven at 103°C for 1h to remove any traces of solvent, then cooled in a desiccator. (Pf) represents the mass of the flask after cooling, and the lipid content is calculated using the following formula:

$$\% L/MS = [\frac{Pf - Pv}{Pe} \times 100] \times \frac{100}{100 - \%H}]$$

% L/MS: percentage of fat in relation to dry matter

Pf: Final weight (drum + fat)
Pv: Empty weight of drum
Pe: Test sample
%H: Moisture content

2.2.3. Total Sugars Content

Soluble carbohydrates were extracted by adding 100 mL ethanol 80% to 100 mg sample, then the mixture was boiled for 30 min. Then cooled to room temperature and centrifuged at 4400 rpm for 10 min. The supernatant was recovered for determination of soluble sugars which were determined by the Phenol-sulfuric acid method described by [11]. In the presence of concentrated sulfuric acid, oses are dehydrated to compounds of the furfuryl derivative family ($C_5H_6O_2$). These products condense with phenol to give yellow-orange complexes. The appearance of these complexes is monitored by measuring the increase in optical density. The reaction medium consisted of 1120 µL of extract at a concentration of 1mg/mL, 560 µL of 5% phenol and 2800 µL of concentrated sulfuric acid. A blank was made with 560 µL of 5% Phenol, 2800 µL of concentrated sulfuric acid and 1120 µL of 80% ethanol. Absorbances were read at 490 nm after 15 minutes incubation in a water bath at room temperature, and the values obtained were directly extrapolated to a glucose standard curve. Soluble sugar contents were expressed using the following formula:

T= (C×D) /Ci×100
T: sugar content in µg EG/100 mg
C: sample concentration read, D: dilution factor
Ci: initial sample concentration (mg/mL)

2.2.4. ß-carotene content

The β-carotene contents were determined by the method of [12].

To 100 mg of dry sample, 10 mL of an acetone-hexane solvent mixture (70: 30) was added. The mixture was vigorously shaken for 1 min and filtered through Wattman No.4 paper. The supernatant was collected and absorbances were read at 453, 505 and 663 nm. Tests were carried out in triplicate. Beta-carotene contents were expressed as mg β-carotene /100 g extract according to the following formula:

Beta carotene (mg/100 g) = 0.216 x A663 - 0.304 x A505 + 0.452 x A453

2.3. Determination of Vitamin C content

Vitamin C (Ascorbic acid) quantification was performed according to the method described by [13] with minor modifications. This method is based on the decolorization of 2, 6-dichlorophenolindophenol (DCPIP) by ascorbic acid. So, 100 mg of dry powder was weighed into test tubes and 2 mL of distilled water was added. The whole batch was then centrifuged at 2000 rpm for 5 min. The supernatant was collected for ascorbic acid assay. Test tubes were filled with 50 µL of supernatant, and 150µL of DCPIP (0.2 mM) was added. Tests were carried out in triplicate, and absorbances were read on a spectrometer at 515 nm. A blank was prepared using 150 µL DCPIP and 50 µL distilled water. A calibration curve was plotted with ascorbic acid which content expressed as µg Ascorbic Acid Equivalent per 100 mg dry matter (µg EAA/100 mg DM) was determined using the formula below:

T= (C×D) /Ci×100
T: ascorbic acid concentration of sample expressed in µgEAA/100 mg dry leaves
C: sample concentration read in µg EAA/mL
D: dilution factor
Ci: initial sample concentration (mg/mL)

2.4. Determination of Mineral Element Content

2.4.1. Total Ash Content

The percentage of ash was determined according to the method described by [14]. So, 2 g of the sample were calcined and placed in a muffle furnace at 550°C for 6 hours. The ash content was calculated according to the formula:

T= (M2/M1) x 100
T: Percentage of ash
M1: Initial sample mass
M2: Mass obtained after calcination

2.4.2. Mineral Content

Minerals were determined wet using an atomic absorption spectrophotometer (Perkin-ElmerModel 3110), Connecticut,USA) according to the method used by [15] with slight modifications. For mineralization, 0.2 g of each sample was dissolved in a test tube containing 5 mL of concentrated nitric acid (HNO_3). The resulting solution was placed in a mineralizer integrated with the absorption spectrophotometer for 2h30 min to ensure digestion. After cooling, the contents of the tube were inserted into a 25 mL volumetric flask, then topped up with distilled water. This mixture was filtered through 0.45 µm Wattman filter paper. Each mineral was assayed according to its wavelength, and the content was expressed according to the formula:

T= CxVxFD/Pe
T : Mineral content ; C : Concentration
V: Volume; DF: Dilution factor
Pe: Test sample

3. Results and Discussion

3.1. Phytonutrients and Vitamin C content

The content of proteins, lipids, sugars, ß-carotene and vitamin C are given in Table 1.

Table 1. Proteins, Lipids, Sugars, ß-Carotene and Vitamin C content

Plants	Protein content (mgE BSA/g)	Lipids content (%)	Sugar content mg/mg	β-Carotene content (mg /g)	Vitamin C content ug/mg
Adansonia digitata	69.68 ± 6.22	4.59	0.06 ± 0.001	0.528	2.22 ± 0.007
Moringa oleifera	138.27 ± 3.3	13.33	0.06 ± 0.003	0.874	2.38 ± 0.01

The results show very good protein contents of both plants, but *Moringa oleifera* leaves are the most important source of protein with a content of 138.27 ± 3.3 mgE BSA/g. Previous studies have also shown that the protein contents of *Moringa oleifera* powder are most often higher than those of several leafy vegetables consumed in Africa, making this plant a real source of vegetable proteins [16]. Both plants contain lipids. However, with a content of 13.33%, the leaves of *Moringa oleifera* presented three times more lipids than those of *Adansonia digitat*a. Protein, fat and carbohydrates are the macronutrients in the diet that provide calories or energy to our body. Both plants also contain carbohydrates. *Moringa oleifera* leaves are richer in β-carotene, with a content equal to 0.874 mg/g. Indeed, also called provitamin A, β-carotene is part of the carotenoid family. It is transformed into vitamin A by the body. The presence of phytonutrients and vitamin C is beneficial for health, particularly at the hormonal, nervous and cardiovascular levels. Phytonutrients also act as antibacterials or antivirals and help limit certain infections [17]. Provitamin A and vitamin C present in both plants are recognized for their powerful antioxidant and immune system protection properties. In addition, provitamin A protects vision and is involved in tissue growth and renewal. It also protects the skin against the effects of solar radiation by activating melanin synthesis and protecting epithelial cells [18]. The combination of provitamin A and vitamin C is therefore beneficial for the body.

3.2. Total Ash and Mineral Contents

The ash and mineral content are given in Table 2.

The results show that both leafy vegetables have appreciable contents of total ash and minerals. However, *Adansonia digitata* has the highest contents of macronutrients (Ca, K, Na) and micronutrients (Zn, Fe). The better Mg content was obtained in *Moringa oleifera* leaves. The World Bank report shows that more than half of developing countries have a food import policy [19]. Meeting the challenge of food and health security requires a systemic approach with the transformation of all food, health, education, social protection, sanitation, drinking water supply and hygiene systems. It is in this sense that the "One Health" concept was developed to adopt a concerted, multi-sectoral and multi-stakeholder approach in order to achieve sustainable change. The study showed that these two medicinal plants are rich in phytonutrients, vitamin and mineral, which is an advantage for introducing them into programs to combat malnutrition and associated deficiencies, particularly anemia, which constitutes one of the greatest public health problems in the most deprived areas of developing countries.

Research along these lines has shown that plant-based diets and plant-rich diets could reduce mortality from diet-related diseases such as stroke, type 2 diabetes, coronary heart disease and cancer by 6% to 10%, and reduce diet-related greenhouse gases by 29% to 70% by 2050 [20]. The challenge remains the

bioavailability of these nutrients for the consumer. Indeed, certain culinary practices, the preparation time, storage and consumption of leafy vegetables can destroy the bioactive elements, essential for health [21]. Indeed, previous work had shown that fresh, unprocessed vegetables contain vitamins, fibers, and minerals that are essential for health, while their modification leads to transformations or the loss of certain nutrients. Similarly, agri-food industrialization often contributes to the degradation of certain foods. This degradation is likely to cause the development of certain pathologies and chronic diseases [22].

Beyond their nutritional properties, it has been scientifically proven that local plants offer benefits for adaptation to climate change. Their short growing season and tolerance to abiotic and biotic stresses offer a great agronomic advantage, as these plants provide a rapid response to the emerging need for year-round nutritious food supply and regular income generation [23].

A key aspect of promoting year-round production and consumption of these therapeutic foods is to increase their share in local market-oriented agriculture by strengthening their food supply and value chains.

4. Conclusion

The objective of this study was to determine the phytonutrients, vitamin and mineral content of two leafy vegetables widely consumed in the central plateau region of Burkina Faso. The results showed that these two plants are important sources of phytonutrients such as proteins, lipids, carbohydrates, β-carotene, of vitamin C and of important minerals. Faced with the challenges of malnutrition and food security, strategies for improving feeding practices recommend a diversity of food sources known and accepted by the population. This requires knowledge of the nutritional value of foods and their sources. It is therefore imperative to integrate these two therapeutic foods, *Adansonia digitata* and *Moringa oleifera,* into diets.

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Table 2. Ash and mineral content in plants

Plants	Mineral content (mg/kg)						Total ash (%)
	Zn	Ca	K	Fe	Mg	Na	
Adansonia digitata	53.46	8842.5	4510.25	105.86	839	153.33	13.05 ± 0.08
Moringa oleifera	32.19	518.5	3486.63	81.13	941.17	139.33	15.09 ± 0.14

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