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Research Article

Comparative Study of the Phytonutrients Contents of Three Plants Grown as Vegetables in Burkina Faso

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Abstract

Diets with a high proportion of plants are nutritionally challenging. These food and generally medicinal plants certainly contribute to reducing hunger and mortality from diet-related diseases worldwide. The aim of this study is to assess the nutritional potential of *Cleome gynandra*, *Hibiscus sabdariffa* and *Corchorus olitorius*, three food plants widely consumed in Burkina Faso. The phytonutrient content of these three plants was assessed on a comparative basis. The parameters investigated in this study were: total ash and mineral content, total protein and carbohydrate content, total lipid content, vitamin C and provitamin A content. The results show that *Cleome gynandra* had the highest protein content at 160.6 ±0.32 mg EBSA/g. Lipid levels were relatively close for all three leafy vegetables. They ranged from 3.36% to 4.35%, with the highest content obtained with *Corchorus olitorius*. Carbohydrate content values ranged from 0.05 to 0.15 mg/mg Glucose equivalent. The highest value was found in *Hibiscus sabdariffa* (0.15 Glucose equivalent mg/mg). The vitamin C contents of these three plants are relatively close, with the highest vitamin C content obtained with *Corchorus olitorius* (1.91 ±1.9 ug/mg). Provitamin A levels varied from 0.196 to 0.312 betac equivalent mg/g ES. The highest content was obtained with *Cleome gynandra*. Zinc, Calcium, Potassium, Iron, Magnesium and Sodium are also present in all three plants, with varying levels. *Cleome gynandra* stands out with higher levels of Zinc (59.79 mg/kg), Calcium (9517.5 mg/kg), Potassium (5817.5 mg/kg) and Iron (212.1 mg/kg). These different values justify *cleome gylandra*'s highest total ash content. These edible plants are therefore rich in phytonutrients, and their consumption could help ensure good health and prevent various chronic diseases.

Keywords

Leafy Vegetables, Cleome Gynandra, Hibiscus Sabdariffa, Corchorus Olitorius, Minerals, Vitamins

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1. Introduction

According to a recent United Nations report, one-third (1/3) of the estimated 2 billion people in developing countries suffer from vitamin or micronutrient deficiencies [1]. Particularly in sub-Saharan Africa, at least 237 million people are chronically undernourished [2]. However, plant-based diets and diets with a high proportion of plants are nutritionally interesting and 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 [3]. Today, the food sector in many countries, including sub-Saharan Africa, is striving to establish a food system that is sustainable, authentic, respectful of the environment and healthy for the consumer [4]. In recent years, Burkina Faso has been exposed to an increase in extreme sociological and meteorological events, such as massive population displacements due to insecurity, droughts and floods as a result of climate change. Local and regional food systems, which are the main source of nutrition, income and employment, are strongly affected by these factors. The major challenge for this Sahelian country is therefore to ensure food and health security for a growing population, in a context of variability, insecurity and climate change. It is in this context that the Health Sciences Research Institute of Burkina Faso with the help of its partners set up a nutritious garden in the central plateau region for the benefit of a women's cooperative in order to cultivate certain plants for family nutrition and for income-generating activities.

Scientific research has shown that some traditionally-used local plants possess important nutritional and pharmacological properties [5-7]. In fact, edible plants contain active ingredients with a variety of nutritional and medicinal properties that can be used in the treatment of many illnesses. These traditional vegetables are rich in minerals, vitamins, carbohydrates, lipids, proteins, fibers, resins and gums; all of which help to combat hunger, ensure good health and prevent chronic diseases [8]. A preliminary study carried out in the province of Oubritenga in the Central Plateau region of Burkina Faso identified twenty-five (25) local drought-adapted plants with both nutritional and therapeutic virtues and high utilization values [9]. However, the nutritional potential of these plants has not been sufficiently evaluated scientifically, especially as they are little valued, often poorly packaged and sensitive to the actions of biological and physico-chemical degradation agents [10]. Our study focuses on *Corchorus olitorius L. (Malvaceae)*, *Cleome gynandra L. (Brassicaceae)*, and *Hibiscus sabdariffa L. (Malvaceae)*, respectively called Bulvanca, Kiennebdo and Bito in the local Moor élanguage. The aim of the studie was to compare the phytonutrients contents of these three leafy vegetables consumed daily in households in Burkina Faso.

2. Methodology

2.1. Plant Material

The plant material consisted of the leaves of *Cleome gynandra*, *Hibiscus sabdariffa* and *Corchorus olitorius*, harvested from a nutrient garden in Zitenga (figure 1).

Figure 1. *Photo of a nutrient garden in the Central Plateau Region, Burkina Faso.*

The leaves of the three study plants were well harvested, washed and dried in an airy room, protected from sunlight and dust (for 2 weeks), then ground to powder using a blade grinder (Figures 2-4).

Figure 2. *Photo of Cleome gynandra.*

Figure 3. *Photo of Hibiscus sabdariffa.*

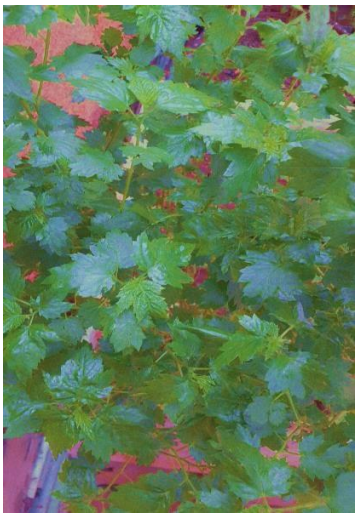

Figure 4. *Photos of Corchorus olitorius.*

2.2. Extraction

The preparation of the extracts consisted of making an aqueous and hydroethanolic decoction of leaf powders of *Cleome gynandra*, *Hibiscus sabdariffa* and *Corchorus olitorius*. The aqueous decoction was obtained according to the following procedure: A test portion of 50 g of the plant powder was dispersed in 500 mL of distilled water. The whole thing was brought to the boil for 30 minutes. After cooling, the mixture was filtered through a fine mesh nylon screen. The filtrate was centrifuged at 2000 rpm for 10 minutes, then dried in a ventilated oven and preserved for further analyses. The hydroethanolic decoction was also obtained according to this procedure:

A test portion of 50 g of the plant powder was dispersed in 500 mL of an ethanol-water mixture in the proportions 70/30 which constitutes the hydroethanolic solvent. The whole thing was brought to the boil for 30 minutes. After cooling, the mixture was filtered through a fine mesh nylon screen. The collected filtrate was centrifuged at 2000 rpm for 10 minutes, then dried in a ventilated oven and preserved for further analyses.

2.3. Nutritional Potential of the Three Plants

2.3.1. Total Protein Assay

Total proteins were determined by the method originally described by Bradford (1976) and used by Zong Liu et al. (2015) [11]. 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).

Table 1. *Total protein assay protocol.*

Reagent	Blank	Test
Extract	250 µL	250 µL
Bradford reagent	_	1250 µL
Tri-base buffer	1250 µL	_
Incubate for 10 min. and read with spectrometer at 595 nm		

2.3.2. Determination of 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 [12]. 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 ℃) 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 ℃ 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:

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

% 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

2.3.3. Total Sugars Determination

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.

Soluble sugars were determined by the Phenol-sulfuric acid

method described by Dubois et al. (2009) [13]. 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 in µg EG/100 mg.

$$T=(C\times D)/Ci\times 100$$

C: sample concentration read, D: dilution factor
Ci: initial sample concentration (mg/mL).

2.3.4. Determination of ß-Carotene (Provitamin A) Content

The β-carotene and lycopene contents were determined by the method of Nagata & Yamashita [14]. 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 and lycopene as mg Lycopene /100 g extract according to the following formulas:

$$\text{Beta carotene (mg/100 mL)} = 0.216 \times A663 - 0.304 \times A505 + 0.452 \times A453$$

2.3.5. Determination of Ascorbic Acid (Vitamin C)

Ascorbic acid quantification was performed according to the method described by Mehta et al. (2018) [15] with minor modifications. This method is based on the decolorization of 2,6-dichlorophenolindophenol (DCPIP) by ascorbic acid. To achieve this, 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 150 µL 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. Ascorbic acid content expressed as µg Ascorbic Acid Equivalent per 100 mg dry matter (µg EAA/100 mg DM) was determined using the formula below:

$$T=(C\times D)/Ci\times 100$$

T: ascorbic acid concentration of sample expressed in µg EAA/100 mg fresh leaves.
C: sample concentration read in µg EAA/mL;
D: dilution factor
Ci: initial sample concentration (mg/mL).

2.3.6. Determination of Total Ash

The percentage of ash was determined by calcining 2 g of the sample [16]. For this purpose, the sample mass was placed in a muffle furnace at 550 ℃ for 6 hours. The ash content was calculated according to the formula:

$$T=(M2/M1)\times 100$$

Where M1: Initial sample mass;
M2: Mass obtained after calcination

2.3.7. Determination of Mineral Content

Minerals were determined wet using an atomic absorption spectrophotometer (Perkin-ElmerModel 3110), Connecticut, USA) according to the method used by Makalao et al. (2015) with slight modifications [17].

For mineralization, 0.2 g of each sample was dissolved in a test tube containing 5 mL of concentrated nitric acid (HNO3). 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. Total Protein, Total Sugar, Lipid, Provitamin A and Vitamin C Content

The contents of proteins, lipids, carbohydrates, provitamin A and vitamin C are given in the following table (table 2):

Table 2. *Protein, fat, carbohydrate, provitamin A and vitamin C contents.*

leafy vegetables	Protein content (mgE BSA/g)	Lipid content (%)	Carbohydrate content Glucose mg/mg	Provitamin A content (betac mg/g)	Vitamin C content ug/mg
Cleome gynandra	160.6 ±0.32	3.36	0.05±0.01	0.312	1.80±0.007
Corchorus olitorius	22.78 ±1.51	4.35	0.05±0.004	0.307	1.91±1.9
Hibiscus sabdariffa	96.63 ±0.61	3.70	0.15±0.002	0.196	1.52±0.01

A difference is observed for the total protein results of the three leafy vegetables according to the Bradford test. *Cleome gynandra* was the highest protein source, with 160.6 ± 032 mgE BSA/g. The lowest levels were obtained with *Corchorus olitorius* at 22.78 ± 1.51 mgE BSA/g. The leafy vegetables studied, *Cleome gynandra*, *Corchorus olitorius* and *Hibiscus sabdariffa*, are significant sources of protein.

Lipid contents vary from one leafy vegetable species to another, ranging from 3.36% to 4.35%, with the highest content for *Corchorus olitorius*. Values are relatively close for all three leafy vegetables.

For sugars, the values found range from 0.05 to 0.15 mg/mg glucose equivalent. The highest value was found in *Hibiscus sabdariffa* (0.15 Glucose equivalent mg/mg). The vegetables studied can be considered a source of carbohydrates, although they contain less than cereals.

Proteins, lipids and carbohydrates are the three macronutrients in the diet that supply calories or energy to our bodies. Eating these leafy vegetables would therefore be beneficial for our bodies [18].

As far as vitamin A and C levels are concerned, the leafy vegetable samples show appreciable levels. The highest vitamin C content was obtained with *Corchorus olitorius* (1.91±1.9 ug/mg), followed by *Cleome gynandra* (1.80±0.007 ug/mg) and *Hibiscus sabdariffa* (1.52±0.01 ug/mg). The vitamin C contents of these three plants are relatively close. Provitamin A levels varied from 0.196 to 0.312 betac equivalent mg/g ES. The highest content was obtained with *Cleome gynandra*. Vitamin C is known for its powerful antioxidant properties. It also plays an important role in the immune system. Provitamin A is a micronutrient essential to the body's vital functions [19]. The combination of provitamin A and vitamin C can be an excellent alliance for boosting immune defenses [20].

3.2. Mineral and Total Ash Contents

The ash and mineral contents of the various plant powders are given in the following table (table 3).

Table 3. *Ash and mineral content of various plant powders.*

Plants	Mineral content (mg/kg)						Total ash (%)
	Zinc	Calcium	Potassium	Iron	Magnesium	Sodium	
Cleome gynandra	59.79	9517.5	5817.5	212.1	750.25	270.67	18.48 ±0.6
Corchorus olitorius	43.96	6276.86	5344.83	94.4	933.25	70.67	10.95 ±0.56
Hibiscus sabdariffa	41.68	5122.44	2630.93	91.13	893.33	640.00	8.23 ±0.92

The total ash content of leafy vegetables ranged from 8.23 to 18.48%. The highest percentage was obtained with *Cleome gynandra* (18.48 ±0.6%). *Hibiscus sabdariffa* had the lowest percentage (8.23 ± 0.92%). The three leafy vegetables also show appreciable levels of the minerals listed in the table below. *Cleome gynandra* has the highest levels of Zinc, Calcium, Potassium and Iron, at 59.79 mg/kg, 9517.5 mg/kg, 5817.5 mg/kg and 212.1 mg/kg respectively.

The highest Magnesium content was obtained with *Corchorus olitorius* at 933.25 mg/kg, and the lowest with *Cleome gynandra* at 750.25 mg/kg. The highest Sodium content is obtained with *Hibiscus sabdariffa* (640.00 mg/kg). Ash is recognized as a source of minerals [21]. Analysis of the table shows that for all three leafy vegetables, ash is rich in Calcium, Potassium and Magnesium. The richness in Iron, vitamins A and provitamin C is particularly significant in countries where there are many cases of anaemia which is caused by malaria, and immune deficiency. The high mineral concentrations

make them recommendable dietary supplements [22]. These three leafy vegetables are veritable mines of phytonutrients. They also contain secondary metabolites of therapeutic interest [23]. Large areas of cultivable land should be devoted to these leafy vegetables in Burkina Faso, to make them available for the population's dietary needs. Their regular consumption could help to cover the nutritional needs of the population, particularly in regions where access to a balanced diet is limited. These plants deserve to be further promoted and integrated into dietary habits, as accessible and sustainable sources of essential nutrients.

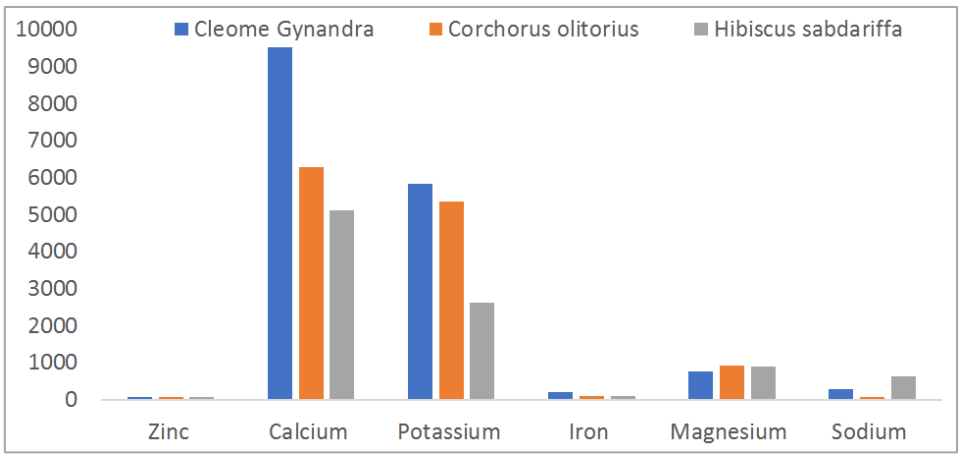

Figure 5. *Histogram of mineral content (mg/kg).*

4. Conclusion

This study assessed the nutritional composition and quality of the leaves of *Cleome gynandra*, *Hibiscus sabdariffa* and *Corchorus olitorius*, three leafy vegetables widely consumed in the Central Plateau region of Burkina Faso.

The results showed that these three plants are important sources of essential nutrients such as proteins, lipids, carbohydrates, minerals and vitamins (vitamins A, C). Of the three, *Cleome gynandra* proved to be the richest in proteins and minerals, particularly Iron, Zinc, Potassium and Calcium. *Hibiscus sabdariffa* stood out for its high carbohydrate content.

Analysis revealed that all three plants contained favorable proportions of vitamin C.

These results underline the nutritional value of *Cleome gynandra*, *Hibiscus sabdariffa* and *Corchorus olitorius*. Their regular consumption could help meet the nutritional needs of populations, particularly in regions where access to a balanced diet is limited. These plants deserve to be further promoted and integrated into dietary habits, as accessible and sustainable sources of essential nutrients.

Abbreviations

ULBO	University Ledea Bernard Ouedraogo
LRD	Research and Development Laboratory
IRSS	Health Sciences Research Institute
BSA	Bovine Serum Albumin
ES	Dry Extract
CNRST	National Center For Scientific and Technological Research
USTTB	University of Sciences, Techniques and Technologies of Bamako, Mali
UCAD	University Cheikh Anta Diop, Dakar, Senegal
UGB	University Gaston Berger, Saint Louis, Senegal
CNRS	National Center for Scientific Research, Paris, France

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Author Contributions

Benjamin Ouédraogo: Investigation, Methodology, Resources, Writing – original draft

Alphonsine Ramdé-Tiendrébéogo: Conceptualization, Funding acquisition, Formal Analysis, Validation, Writing – original draft.

Jules Yoda: Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Félix Kini: Project administration, visualisation, Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

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