Phytochemistry, mineral content, and acute general toxicity of *Daniellia oliveri (Rolfe) Hutch. & Dalziel* and *Cassia tora* Linn., two plants with nutritional and therapeutic properties in Burkina Faso

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Abstract

Several plants used by local communities have interesting nutritional values and therapeutic properties, but they are not very well known. The aim of this study was to determine the phytochemistry, mineral content, and acute toxicity of *Daniellia oliveri* and *Cassia tora* Linn., which are used for their nutritional and therapeutic benefits. The chemical components and mineral content of the aqueous extracts of *Daniellia oliveri* leaves and *Cassia tora* leaves and stems were determined using thin-layer chromatography and AOAC methods, respectively. Acute toxicity was evaluated at 2000 mg/kg body weight in female Wistar rats according to the guidelines of the Organisation for Economic Co-operation and Development. The results showed the presence of potentially bioactive compounds such as phenolic acids, sterols, and triterpenes. *Cassia tora* had higher levels of potassium (13.44 mg/g) and calcium (2.57

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mg/g) compared to *Daniellia oliveri* (4.42 and 1.69 mg/g, respectively). Iron concentrations were higher in *Cassia tora* (252.2 µg/g) than in *Daniellia oliveri* (137.86 µg/g), while the latter had a higher manganese content (47.92 µg/g versus 28.73 µg/g). These values are comparable to the best local food sources of iron in Burkina Faso. The acute oral toxicity test showed no toxic effects, and the LD_{50} is estimated to be over 2000 mg/kg body weight. The results could provide a scientific basis for developing improved traditional medicines and/or dietary supplements.

Keywords: *Daniellia oliveri*, *Cassia tora*, minerals, acute oral toxicity, therapeutic food.

Phytochimie, teneur en minéraux et toxicité générale aiguë de *Daniellia oliveri* (Rolfe) *Hutch.* & *Dalziel* et *Cassia tora* Linn., deux plantes aux vertus nutritives et thérapeutiques au Burkina Faso

Résumé

Plusieurs plantes utilisées par les populations présentent des valeurs nutritionnelles et des propriétés thérapeutiques intéressantes, mais elles ne sont pas très connues. L'objectif de ce travail était de déterminer la phytochimie, la teneur en minéraux et la toxicité aiguë de *Daniellia oliveri* et *Cassia tora* Linn., utilisées pour leurs vertus nutritives et thérapeutiques. Les composants chimiques et la teneur en minéraux des extraits aqueux des feuilles de *Daniellia oliveri* et des feuilles et tiges de *Cassia tora* ont été déterminés respectivement par chromatographie sur couche mince et les méthodes AOAC. La toxicité aiguë a été évaluée à 2000 mg/kg p.c. chez des rats Wistar femelles selon les directives de l'Organisation de Coopération et de Développement Economiques. Les résultats ont montré la présence de composés potentiellement bioactifs tels que les acides phénoliques, les stérols et les triterpènes. *Cassia tora* présentait des teneurs plus élevées en potassium (13,44 mg/g) et en calcium (2,57 mg/g) que celles de *Daniellia oliveri* (4,42 et 1,69 mg/g, respectivement). Les concentrations en fer étaient plus élevées chez *Cassia tora* (252,2 µg/g) que chez *Daniellia oliveri* (137,86 µg/g), tandis que cette dernière présentait une teneur supérieure en manganèse (47,92 µg/g contre 28,73 µg/g). Ces valeurs sont comparables aux meilleures sources alimentaires locales de fer au Burkina Faso. Le test de toxicité orale aiguë n'a pas montré d'effets toxiques, et la DL_{50} est estimée à plus de 2000 mg/kg p.c. Les résultats obtenus pourraient constituer une base scientifique pour le développement de médicaments traditionnelles améliorées et/ou de compléments alimentaires.

Mots-clés : *Daniellia oliveri*, *Cassia tora*, minéraux, toxicité orale aiguë, aliments thérapeutiques.

Introduction

In developing countries, the nutritional and health situation remains a major concern for local populations. Malnutrition is a public health problem. The main micronutrient deficiencies are vitamin A, iron and iodine deficiencies. Chronic non-communicable diseases, which were once specific to developed countries, are becoming increasingly prevalent in developping countries. According to the World Health Organization (WHO), this situation will worsen in the coming years without appropriate solutions (1). In Burkina Faso, between 2013 and 2021, the prevalence of overall obesity increased from 4.5 % to 7 %, overweight from 13.4 % to 14.5 %, high blood pressure from 17.6 % to 18.2 %, and diabetes from 4.9% to 7.6%. The risk of cardiovascular disease is very high among 8.4% of the population over 40 years old (2,3). In children, malaria, acute respiratory infections and diarrhea are among the main fatal pathologies (3). In a context marked by persistent food insecurity, micronutrient deficiencies, and limited access to modern healthcare, local plant resources are essential alternatives for improving people's health and nutrition. Plant genetic resources constitute the biological basis of global food security (4). Plants occupy a very important place in the lives of populations, both in food and in the treatment or prevention of many diseases (5). They are particularly rich in minerals, vitamins, carbohydrates, lipids and proteins, which can significantly contribute to improving human health and preventing certain chronic diseases (6,7). Among these resources, *Daniellia oliveri (Rolfe) Hutch. & Dalziel* (Caesalpiniaceae) and *Cassia tora* Linn. (Fabaceae-Caesalpinioideae), respectively called Aoga and Sogoda in the local Mooré language, hold an important place due to their food and therapeutic uses. *Cassia tora* is a seasonal herb, native to tropical regions. It is widely consumed for its laxative properties, and is included in the World Health Organization's "List of Essential Medicines" (8,9). This plant is also used in many traditional medicine recipes to treat diabetes, dermatitis, constipation, coughs, colds and fever (10). Indeed, several studies have highlighted the antiproliferative, hypolipidemic, immunostimulant and anticancer properties of the plant (11). It is traditionally used to treat skin diseases, digestive issues, and certain infections. Phytochemical studies have shown that this plant contains flavonoids, alkaloids, tannins, saponins, glycosides, and phenolic compounds, which could explain its biological and pharmacological properties (12,13).

As for *Daniellia oliveri* (Rolfe) Hutch. & Dalziel, it is widely distributed in the Sudanian and Guinean savannahs of tropical Africa, particularly in West and Central Africa (14). Different parts of the plant, including the leaves, stem bark, roots, seeds and resin, are extensively used in traditional human and veterinary medicine, while the wood is valued for timber and the resin is commonly used as incense and for cultural purposes (14). Ethnobotanical surveys indicate that the leaves and stem bark are traditionally used for the management of gastrointestinal disorders, fever, wounds, infectious and inflammatory diseases (14). Phytochemical investigations have demonstrated that the leaves contain several bioactive constituents, including flavonoids, tannins, saponins and alkaloids, and possess antimicrobial activity, supporting some of their traditional uses (15).

However, despite their socio-economic importance and various traditional uses, scientific information on the phytochemical composition, mineral content, and safety of *Daniellia oliveri* and *Cassia tora* remains limited, as far as we know, in Burkina Faso. Yet, measuring the mineral elements and the acute safety level of these species is essential to better understand their nutritional and therapeutic potential and to guide their use (16). So, studying the phytochemistry, mineral content, and acute toxicity of *Daniellia oliveri* and *Cassia tora* in this study will help generate reliable scientific data that can support their use in nutrition, traditional medicine, and food safety in Burkina Faso.

Material and methods

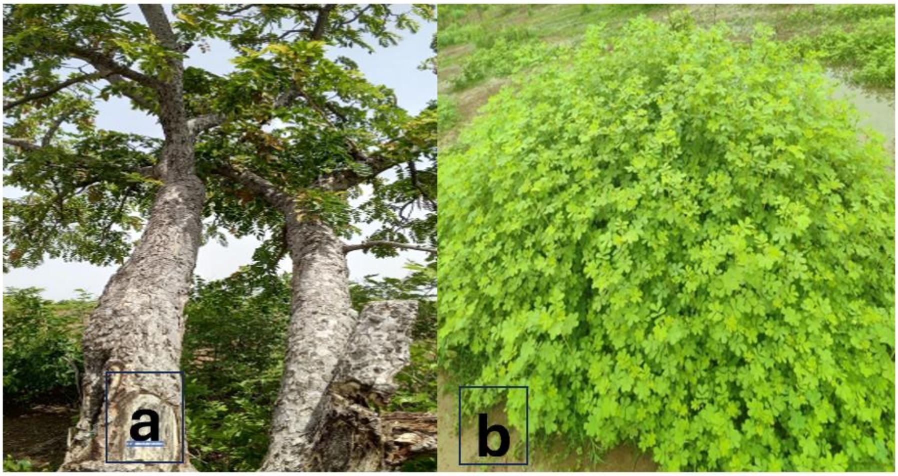
Sampling areas

The leaves of *Daniellia oliveri* were harvested in Toeghin, a locality away 56 km from the capital Ouagadougou. Toeghin is administratively composed of eighteen villages with an area of 189,3 km^2 and a tropical Sudano-Sahelian climate characterized by an average rainfall of 700 mm. There are a dry season of eight (08) months and a rainy season of four (04) months. The commune has shrubby savannah vegetation with discontinuous grassy cover. Toeghin is characterized by mostly tropical ferruginous leached soils developed on Precambrian granite and gneiss formations (17). It had 22,144 inhabitants (18). The economy is based on agriculture (food production), livestock, trade and crafts.

The leafy stems of *Cassia tora* were harvested in Gaskay, a commune in the department of Pabre in the Kadiogo province, central Burkina Faso. In 2019, the department had a population of 40,387 (18). The Pabre commune is part of the Central Plateau soil zone. The soils in this area are mainly leached tropical ferruginous soils developed on granite and gneiss materials (19).

Plant material and extraction

Figure 1 shows the two plants, *Daniellia oliveri* (a) and *Cassia tora* (b) which were collected in June 2023. The leaves of *Daniellia oliveri* were collected east of Toéghin village (GPS coordinates: N12°48′43.3″; W001°41′24.9″), Burkina Faso. Leaves and stems of *Cassia tora* were collected from Gaskay village (GPS coordinates: N12°39′01.0″; W001°36′25.3″), Burkina Faso. Voucher specimens were identified and registered at the National Herbarium of Burkina Faso (HNBU), National Center for Scientific and Technological Research (CNRST), under accession numbers 2285 for *Daniellia oliveri* and 1944 for *Cassia tora*. The collected samples were washed with potable water, dried, and then ground into a fine powder using a *Retsch SM 200* grinder. They were packaged in transparent bags, labeled, and then stored at room temperature for future analyses.



(**a**) : *Daniellia oliveri* (Photo Goubgou, 2024) (**b**) : *Cassia tora* (Photo Goubgou, 2024)

Figure 1: Presentation of *Daniellia oliveri* and *Cassia tora*

An aqueous decoction was prepared by introducing 50 g of plant powder from each plant into a flask containing 500 mL of distilled water. The mixture was homogenized and boiled under reflux for 30 min. After cooling, the contents of the flask were poured into tubes and centrifuged. The supernatants of the extracts obtained were dried in an oven at 37 °C. Another preparation with organic solvent of increasing polarity (ethanol) was carried out. In fact, 50 g of plant powder from each plant was used for extraction under stirring for 24 h in 500 mL of solvent. After each extraction, the residues were dried, weighed and the new mass was measured before extraction with the next solvent. The extracts obtained were centrifuged and concentrated in a rotary evaporator, then dried in an oven at 37 °C. At the end of each extraction, the yields were determined using the following formula:

$$R = \frac{\text{mass of the extract}}{\text{Masse of plant powder}} x100$$

Animal material

These are female WISTAR rats weighing between 180 and 230 g from the animal facility of the Institute for Research in Health Sciences (IRSS) in Ouagadougou, where they are fed wheat cake (29 % protein). Their drinking water is tap water. They are raised under air conditioning with alternating night/day lighting and 75 % humidity and raised at a temperature of 22°C (±3) in the animal facility of the Phytomedicines and Medicines Research and Development Laboratory of the Health Sciences Research Institute.

Residual humidity rate

A test sample of 5 g of dry plant powder (m) was placed in a *MB35 halogen* desiccator. This mass was reweighed (m') after drying and the residual moisture content was calculated using the following formula:

$$THR(\%) = \frac{\mathrm{m} - \mathrm{m}'}{\mathrm{m}} x100$$

With m: initial mass; m’: mass after drying

Ash rate

The ash content was determined by incinerating the sample at 550 °C. A quantity of 5 g of each sample was taken and placed in the previously tared crucible. The whole was placed in the muffle furnace (P SELECTA) at 550 °C for 4 h. At the end of the incineration time, and after cooling in a desiccator, the ash content was determined by the following formula:

$$\text{Ash content } (\%) = \frac{\text{Mass of ash}}{\text{Mass of vegetable powder}} x100$$

Crude fiber content

The determination of crude fiber content consisted of quantifying the soluble lignin and insoluble lignin content according to the method of Ayeni et al. (20). Thus, 0.3 grams of each sample were weighed into glass tubes and 3 mL of sulfuric acid (72%) was added. The resulting solution was vortexed every 30 min for two hours at room temperature to allow complete hydrolysis. Then, 84 mL of distilled water was added and the mixture was autoclaved at 121 °C for one hour. Cooling for one hour was carried out at room temperature and the hydrolysate was filtered. Insoluble lignin was determined by drying the residues on the filter at 105 °C, followed by ashing the filtrate at 575 °C. The fraction of acid-soluble lignin was determined by measuring the absorbance of the acid-hydrolyzed samples at 320 nm. Crude fiber content was calculated by summing insoluble lignin (1) and acid-soluble (2) according to the following formulas:

$$(1) \qquad Insoluble\ lignin = \frac{a-b}{c} * 100$$

$$(2) \qquad Soluble\ lignin = \frac{A}{110} * \frac{Dilution}{m} * 100$$

With: a: residue on the filter (g); b: weight of the ash of the residue (g); c: weight of the sample (g); A: Absorbance; m: mass of the sample (g)

Thin layer chromatography

The different extracts of *Cassia tora* and *Daniellia oliveri* were developed in thin layer chromatography using the eluent system ethyl acetate, formic acid and water (16 /2/2). After diagnosis of the spots in the visible, UV 254 and 366 nm, the reagents of NEU and PEG 4 000 were used to reveal certain compounds.

Mineral dosage

The mineral contents of the leaves and stems of *Cassia tora* and leaves of *Daniellia oliveri* were determined using Optima 8000 ICP-OES Spectrometer according to AOAC methods (21). Thus, 5 g of each sample was weighed in a crucible of initial weight (Pv). The whole was introduced into a muffle furnace for 48 h at 550 ˚C for mineralization. The crucible was cooled and weighed (Pf1) after mineralization. Then, successively 1 mL of HNO_3 (nitric acid) at 63% and 0.5 mL of H_2O_2 (Hydrogen peroxide) were added. The nitric acid was evaporated by heating on a hot plate at 80 °C. The crucible was then put back in the furnace for 24 h at 550 °C, then weighed (Pf2) after cooling in a desiccator. 5 mL HCl (concentrated) was added to the calcined sample and the whole was stirred well, heated again until the acid had completely evaporated on a hot plate set at 80 ˚C. The residue thus obtained was dissolved in 2 mL of HCl (concentrated) and covered with a watch glass, then placed again on the hot plate set at 80 °C for 5 min. The residue was transferred into a 10 mL tube, then stirred well with a vortex. 0.5 mL of this solution was then introduced into another 10 mL tube, to which 0.5 mL of hydroxylamine hydrochloride solution (H_2NOH/HCl) was added. This mixture was left to stand for 5 min, then 2.5 mL of sodium acetate was added and the whole was stirred. Then, 0.5 mL of the o-phenanthroline solution was added to the previously obtained mixture, which was made up to the gauge line. This mixture was left to stand for 30 min. The spectrophotometer reading was taken at 510 nm and then compared to a blank. The minerals elements determined include Calcium (Ca), Potassium (K), Sodium (Na), Magnesium (Mg), Iodine (I), Iron (Fe), Manganese (Mn), Silicon (Si), Antimony (Sb), Mercury (Hg), Lithium (Li), Arsenic (As), Zinc (Zn), Selenium (Se), Boron (B), Silver (Ag), Cobalt (Co), Lead (Pb), Copper (Cu), Cadmium (Cd), Barium (Ba), Chromium (Cr), Titanium (Ti), Tin (Sn), Bismuth (Bi), and Molybdenum (Mo). The concentration of a mineral sample was determined from a simultaneously prepared calibration range established from solution of each mineral between 0 and 4.5 µg/g. The mineral content is calculated by the following formula:

$$\%\, mineral\ (\frac{mg}{g}) = \frac{Abs\ ech - b}{a} * \frac{10}{PE}$$

Abs ech: absorbance read on the spectrometer

PE: test sample: slope of the standard curve

b: intersection of the standard curve with the y-axis

Acute toxicity

Acute toxicity was assessed according to OECD Guideline 423 (22). Female rats with body weights between 180 and 230 g were divided into three groups of three female rats for each plant. Each animal was identified by a tail mark. The rats were fasted for 24 h, then their weight was measured before treatment. They received an aqueous extract of *Daniellia oliveri* or *Cassia tora* at a dose of 2 000 mg/kg body weight in physiological saline water (NaCl 0.9 %). The control group received physiological saline water. The extract was administered orally in a single dose using an oesophageal probe.

The animals were observed during the first four hours after administration of the extracts. Lethality was assessed after 24 h, 48 h, 72 h and the animals were kept under observation for two weeks. The weights of the rats were measured on the first day (D1), three days (D3), one week (D7) and two weeks (D14) after treatment. After 14 days, the animals were sacrificed by cervical dislocation and then autopsied. The organs (liver, spleen, kidney, lung and heart) were weighed and their relative weights were calculated using the following formula:

$$Relative\ Organ\ Weight\ (\%) = \frac{\text{Weight of the Organ}}{Weight\ of\ the\ animal\ on\ the\ day\ of\ slaughter} \times 100$$

Ethical consideration

The acute oral toxicity study was conducted at the Toxicology and Ecotoxicology Laboratory of the Health Sciences Research Institute, Ouagadougou, Burkina Faso, following the Organisation for Economic Co-operation and Development (OECD) Test Guideline 423 for acute oral toxicity. All experimental procedures involving animals were performed in accordance with internationally accepted ethical principles and guidelines for the care and use of laboratory animals.

Statistical analysis

The study parameters were examined using descriptive statistics (means, standard deviations). The data were subjected to analysis of variance (ANOVA) using SPSS™ Statistics software version 20.0 (IBM, USA) and the comparison of means was carried out according to the Newman-Keuls test at the 5% level. Differences were considered statistically significant at the level of 5% ($p < 0.05$). The RStudio software, version 4.0.4, was used to carry out the principal component classification test of minerals based on the two plants.

Results and discussion

Extraction Yields

The aqueous extraction yields ranged from 20.81% to 36.07%, while hexane extraction yielded 2.41% and 1.58%, respectively. Ethanol extraction resulted in yields of 5.05% and 3.99%, respectively, for *Daniellia oliveri* and *Cassia tora*.

The best yield of the extractions is that of the aqueous decoction, obtained with the leafy stems of *Cassia tora*, i.e. 36.07%. This means that this plant contains more water-soluble compounds than the leaves of *Daniellia oliveri*. Other authors had also shown that the yield of the decoction was better than that of the maceration (23). However, ethanol extraction yields were better for *Daniellia oliveri* than for *Cassia tora.*

Residual moisture content, total ash and crude fiber contents

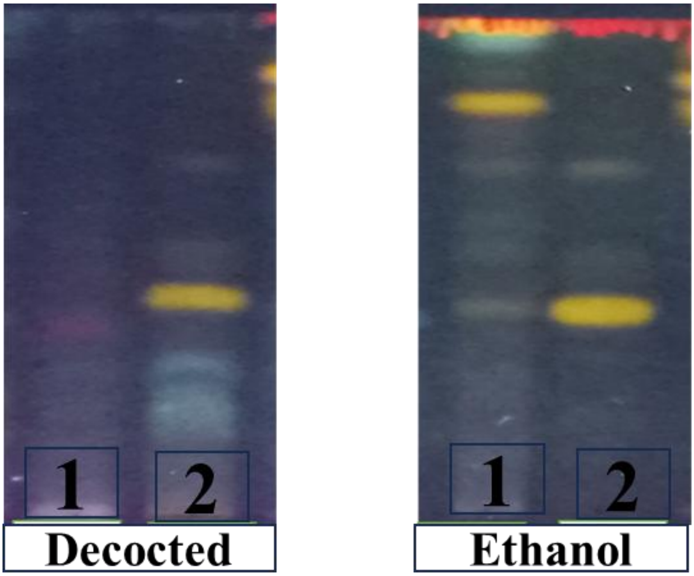
No significant difference was observed in the residual moisture content of the two plant species, with values of 8.20 ± 0.71% for *Daniellia oliveri* and 8.41 ± 0.25% for *Cassia tora*. The residual humidity levels of both plants remain within the range of the value recommended by the WHO for medicinal plants. Indeed, a residual humidity between 8 % and 12 % is recommended for good conservation of bioactive compounds while limiting the risk of biological degradation (24). Dried plant powders with moisture contents below approximately 10% generally exhibit improved storage stability when maintained under appropriate packaging and low water activity conditions (25–27).

The total ash content of *Daniellia oliveri*, 8.54 ± 0.31 %, is less than 10 % and therefore acceptable according to the standards of the European Pharmacopoeia (28). However, that of *Cassia tora* was 12.69 ± 0.09 %. This could be explained by the fact that for this plant, it was the leafy stems that were used.

The crude fiber content of *Daniellia oliveri* was 27.38 %. This value is higher than the 13.11% reported Alagbe (29) but lower than the 32.04% reported by Adamu et al (30) another study on dried leaves. This difference could be explained by climatic variations and sample processing conditions.

Chromatographic profile

The chromatographic profiles of samples from both plants are shown in Figure 2.



1 : *Daniellia oliveri*; **2**: *Cassia tora*

Figure 2: Chromatographic profile of *Daniellia oliveri* and *Cassia tora*

The chromatographic profiles of both plants showed the presence of various compounds. Indeed, ethanol, as an intermediate polar solvent, allowed the extraction of many compounds in *Daniellia oliveri*, represented by colorful, fluorescent and well-separated bands (Figure 2).

For *Daniellia oliveri*, the chromatograms show a relatively limited number of fluorescent bands, indicating a less complex phenolic composition compared to what's seen in *Cassia tora*. The presence of a yellow fluorescent band, especially prominent in the ethanolic extract, is characteristic of flavonoids, while the weak light blue fluorescences observed could correspond to certain phenolic acids or hydroxycinnamic derivatives (31). Phytochemical investigations of *Daniellia oliveri* have shown that it mainly contains flavonoids, tannins, saponins and alkaloids (14). The ethanol extract shows stronger bands than the decoction, indicating better extraction of phenolic compounds by ethanol. The work of Dai and Mumper also showed that hydroalcoholic or alcoholic solvents allow for more efficient extraction of flavonoids and other polyphenols than water alone (32).

As for *Cassia tora*, the chromatograms show a greater number of fluorescent bands as well as higher signal intensity, which could indicate a greater diversity of phenolic compounds. The bright yellow bands observed are characteristic of flavonoids (31). The work of Ahonsou and Sarwa et al. on the phytochemical characterization of *Cassia tora* described it as a species rich in flavonoids, anthraquinones, naphthopyrones, and other phenolic compounds (33,34).

Comparing the two plants shows that *Cassia tora* has a richer chromatographic profile than *Daniellia oliveri*, with more fluorescent bands and greater intensity. This difference suggests a higher diversity of extractable secondary metabolites in *Cassia tora*. In both species, the ethanol extracts show clearer and more intense bands than the decoctions, confirming that ethanol is better at extracting phenolic compounds of intermediate polarity (32).

The chromatograms obtained confirm that both plants are important sources of phenolic compounds, with *Cassia tora* showing an apparently greater chemical richness.

Mineral content

Table I below shows the results of the macroelement contents (mg/g) and microelements (in µg/g) measured in the leaves of *Cassia tora* and in the leaves and stems of *Daniellia oliveri*.

For the macroelements, *Cassia tora* had the best Ca (2.57 mg/g) and K (13.44 mg/g) contents. However, *Daniellia oliveri* had the high Mg content (1.69 mg/g). Sodium (Na) contents were relatively low for both plants.

Among the trace elements analyzed, both plants showed higher levels of iron compared to the other micronutrients. Thus, *Cassia Tora* and *Daniellia oliveri* had iron contents of 252.2 µg/g and 137.86 µg/g, respectively. Beryllium was absent in *Daniellia oliveri*, and antimony, mercury, and beryllium were not found in the leaves of *Cassia tora*.

The iron content is high in both plants (25.2 mg/100 g for *Cassia tora* and 13.8 mg/100 g for *Daniellia oliveri*. According to ANSES, the iron requirement for adults is around 11 mg/day for men and can reach 16 mg/day for women of childbearing age (35). Therefore, a 100 g serving of dried and powdered *Cassia tora* leaves could fully cover the daily iron requirement, purely from a quantitative perspective.

Compared to local foods in Burkina Faso, *Cassia tora* ranks among the best sources of iron listed in the composition table of commonly consumed foods in Burkina Faso. Indeed, this table lists soumbala (fermented néré seeds, 36.5 mg/100 g), dried okra (26.3 mg/100 g), and dried baobab leaves (25 mg/100 g) as the richest iron foods, clearly surpassing grain millet (20.7 mg/100 g), red sorghum (15.6 mg/100 g), and dried cowpea seeds (7.6 mg/100 g) (36). The leaves and stems of *Daniellia oliveri* (13.8 mg/100 g) are close in iron content to red sorghum and fresh cowpea leaves (20 mg/100 g).

Table I: Contents of minerals elements (mg/g)

Minerals	*Cassia tora*	*Daniellia oliveri*
Calcium (mg/g)	2.57	1.69
Potassium (mg/g)	13.44	4.42
Sodium (mg/g)	0.0003	0.054
Magnesium (mg/g)	1.01	1.69
Arsenic (µg/g)	0.01	0.02
Molybdenum (µg/g)	0.48	0.05
Selenium (µg/g)	0.91	2.23
Iodine (µg/g)	0.76	0.41
Bismuth (µg/g)	0.76	0.41
Silicon (µg/g)	87.34	78.97
Zinc (µg/g)	3,86	4.04
Antimony (µg/g)	0.01	-
Lead (µg/g)	0.02	0.16
Cadmium (µg/g)	0.04	0.02
Tin (µg/g)	57.14	29.83
Iron (µg/g)	252.2	137.86
Cobalt (µg/g)	0.08	0.05
Boron (µg/g)	13.25	12.17
Manganese (µg/g)	28.73	47.92
Chromium (µg/g)	0.78	0.42
Vanadium (µg/g)	0.89	0.39
Mercury (µg/g)	0.55	-
Beryllium (µg/g)	-	-
Copper (µg/g)	2.95	1.99
Silver (µg/g)	0.03	0.07
Titanium (µg/g)	5.12	2,35
Aluminum (µg/g)	72.95	68.33
Barium (µg/g)	25.16	12.68
Lithium (µg/g)	0.15	0.36

On the other hand, iodine contents (7.6 and 4.1 µg/100 g) remain low compared to the intake recommended by ANSES, which is 150 µg/day (35).

Unlike iron, the zinc content (0.39 mg/100 g for *Cassia tora* and 0.40 mg/100 g for *Daniellia oliveri* is low compared to the ANSES recommendations (7 to 14 mg/day) (35). These values are also lower than those of zinc-rich foods identified in Burkina Faso, such as fresh amaranth leaves (10 mg/100 g), dried cowpeas (3.8 to 8 mg/100 g depending on the source), Guinea sorrel or pumpkin seeds (8 mg/100 g), and dried okra (4.8 mg/100 g) (36).

The Ca, Mg and K contents of the two plants are higher than those of Okeke et al., which were 0.29 ± 0.00 mg/g; 0.91 ± 0.00 mg/g and 3.69 ± 0.03 mg/g respectively (37). These differences could be partly explained by soil quality. The presence of these minerals in the leaves of *Daniellia oliveri* and in the leafy stems of *Cassia tora* is important for good health. Indeed, minerals are involved in the formation of many organs and the functioning of the body. Indeed, K, Na and Mg are electrolytes that play an important role in osmoregulation for the maintenance of good homeostasis. Ca is important in the formation of bones and teeth (35). *Cassia tora* had the best contents of I (0.76 µg/g), Fe (252.2 µg/g) and Cu (2.95 µg/g) compared to *Daniellia oliveri.*

Considering the limit rates for heavy metals in food, which are 100 mg/kg body weight (b.w.) for Zn; 0.2 mg/kg b.w. for Cd; 0.30 mg/kg b.w. for Lead (Pb); 100 mg/kg b.w. for Cu; 10 mg/kg b.w. for Cr; 50 mg/kg b.w. for Ni (38), the results of our study show that the values of both samples are within the indicated limits and rule out any possible danger for consumers of these plants (38,39).

The leaves and stems of *Cassia tora* and the leaves of *Daniellia oliveri* have a mineral profile that is mainly made up of macrominerals (K, Ca, and Mg) and also contain several essential trace elements (Fe, Mn, Zn, Se, Cu, I), while showing low levels of potentially toxic elements like arsenic, lead, and cadmium. This confirms the nutritional potential of these two species, which is already recognized for many traditional African food plants, whose richness in micronutrients helps fight nutritional deficiencies in low- and middle-income countries (40,41).

The Principal Component Analysis (PCA) of Trace Elements is presented in Figure 3.

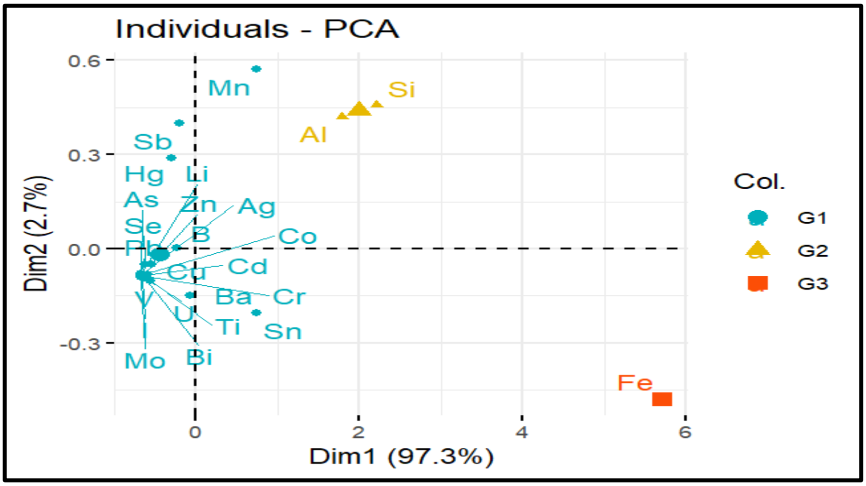


Figure 3: Grouping samples into classes

The figure 3 of Principal Component Analysis shows three clusters. Cluster 1 (blue) strongly present around the origin indicates very little variance between the two plants regarding minerals such as Zn, Cu, Cr, Mn, Sb, Hg, Li, Ag, Se, Cd, Li, B, As, Pb, Co, Mo, Ba, Ti, V, Bi, Sn. Cluster 2 (yellow) composed of Al and Si, and Cluster 3 (Red) which only includes Iron. This means that the contents of Fe, Al, Si and Mn vary differently between the two plants. Considering the importance of trace elements for health, *Daniellia oliveri* is a good source of Si (Group 2) which is a beneficial element for the skeleton and connective tissue (42,43). *Cassia tora*, on the other hand, has a high potential in Fe (Group 3), an essential trace element vital for many physiological functions, including oxygen transport and energy metabolism. Fe is particularly important in human nutrition (44).

Acute toxicity of Cassia tora and Daniellia oliveri extracts

Single doses of 2000 mg/kg body weight of each extract from the two plants given to Wistar rats didn't cause any deaths in the different tests.

The organ weights of the tested rats and the control group are presented in Table II.

Table II: Weight (g) of organs of tested rats and control group

Organs	Animals from the control group	Animals that received *Cassia tora* extract	Animals that received *Daniellia oliveri* extract
Liver	3.31 ± 0.65	2.70 ± 0.17	2.74 ± 0.22
Heart	0.32 ± 0.01	0.33 ± 0.01	0.33 ± 0.02
Spleen	0.32 ± 0.033	0.27 ± 0.05	0.26 ± 0.05
Lungs	0.65 ± 0.05	0.57 ± 0.03	0.57 ± 0.056
Kidneys	0.79 ± 0.06	0.62 ± 0.08	0.62 ± 0.06

The results show that there was no significant variation between the organ weights of rats treated with plant extracts and those of the control group (P>0). Figure 4 presents the weight evolution of rats during the acute toxicity test.

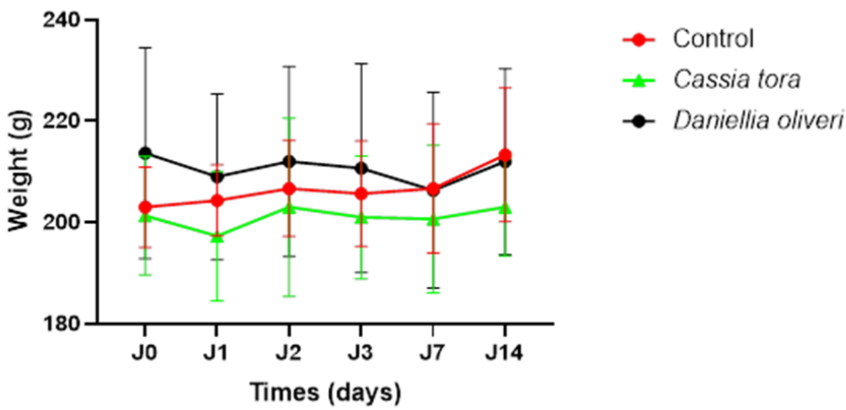


Figure 4: Weight evolution of rats

Body weight evolution, a fundamental parameter in the assessment of acute toxicity, showed stability in the treated animals, comparable to that of the control group. Indeed, the administration of *Daniellia oliveri* and *Cassia tora* extracts at doses of 2 000 mg/kg did not induce significant weight loss in rats monitored for 14 days (P > 0). The weight profile is similar to that of the controls. So, the median lethal doses (LD_{50}) of both extracts were estimated to be over 2000 mg/kg of body weight. The results obtained with *Cassia tora* corroborate those of previous authors regarding the acute toxicity of *Cassia tora* (45,46). These authors also reported good tolerance of the extract, without significant alteration of body weight. Indeed, according to OECD guidelines, plants with an LD_{50} greater than 2,000 mg/Kg of body weight are classified in category 5 of the Globally Harmonized System of Classification (22). The leaves of *Cassia tora* and the leafy stems of *Daniellia oliveri* can therefore be classified in this category.

Conclusion

This study showed that *Daniellia oliveri* and *Cassia tora* are plants that contain important phytonutrients, potentially bioactive. The leaves and stems of *Cassia tora* and the leaves of *Daniellia oliveri* have a mineral profile that is mainly made up of K, Ca, Mg, Fe, Mn, Zn, Se, Cu, I), while showing low levels of potentially toxic elements like arsenic, lead, and cadmium. The acute toxicity analysis showed that the median lethal dose of the two plants is above 2000 mg/kg and therefore they could be low-toxicity plants. The results obtained open up research opportunities aimed at further characterizing the bioactive compounds of *Daniellia oliveri* and *Cassia tora*, assessing their nutritional bioavailability, pharmacological activities, and long-term safety. Subchronic and chronic toxicity studies will be necessary to confirm their safety for use. Additionally, utilizing these plants in standardized food or herbal formulations could help fight nutritional deficiencies and contribute to the development of high-value local resources in Burkina Faso.

Conflict of interest

All authors have declared that no conflict of interest exists.

Author contributions

MG and ART designed the study; MG, DB, and VR performed the analyses; MG, VR, SC, and BMB collected the samples; MG, VR, and ART wrote the manuscript; BO, JO, LTSO, MC, FK, and MK revised the manuscript.

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