Ethnobotanical approach of plant diversity and market availability used for diabetes management in Benin and Burkina Faso, West Africa

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Research

Abstract

Background: The management of diabetes in sub-Saharan African countries remains a major challenge for low-income populations. This study provides a comparative analysis of the plants used by herbalists to manage diabetes in Benin and Burkina Faso.

Methods: Market surveys were conducted among 27 herbalists in each country from 2023 to 2024. A semi-structured interview was performed with herbalists who agreed to participate. The main information collected included the local names of the plants sold, the methods of preparation and administration of the recipes, and the recipe prices. Diversity, similarity, market availability indices, and informant consensus factors were determined. The most cited plants underwent phytochemical screening and analysis of chemical compounds.

Results: forty species were identified in each country, but with a very low similarity index (Ij = 0.0256). Shannon, Simpson, and Pielou index revealed comparable diversity structures between the two countries, despite a vastly different floristic composition. The market availability index was not correlated (p = 0.35; p = 0.85) with conservation status (IUCN), suggesting that the presence of species on the markets does not depend on their overall threat level. However, bark is mainly cited (38.5 %) in Burkina Faso, while leaves are dominant (38.3 %) in Benin. The most cited species reveals the presence of chemical compounds of interest for diabetes management.

Conclusions: these results highlight the importance of local knowledge in diabetes management in both countries, while raising sustainability concerns about the exploitation of plant resources.

Keywords: market survey, diabetes, species diversity, management, West Africa

Background

Globally, epidemiological data on chronic diseases reveal alarming trends that have significant health and socio-economic consequences for national health systems (Airhihenbuwa *et al.* 2021; Poku 2023). Among these so-called emerging conditions, diabetes stands out as a public health priority due to its rapid progression and multisectoral impact. According to projections by the World Health Organisation (WHO), the number of people with diabetes worldwide was estimated at 366 million in 2011, with a forecast of 552 million by 2030, representing an increase of more than 50% (Diop & Diédhiou 2015). Sub-Saharan Africa, characterised by low incomes and fragile health systems, is no exception to this trend. In 2015, 19.1 million people with diabetes were recorded, and projections indicate increases of 109 % in 2025 and 143% in 2045 (Dessie *et al.* 2020; Malek 2020). This increase is all the more worrying given that health infrastructure and skilled human resources remain insufficient to meet the growing demand for care.

In Burkina Faso, a national survey revealed that the prevalence of diabetes rose from 4.9 % in 2013 to 7.6% in 2021 (Traoré *et al.* 2024). In Benin, the disease prevalence is 9.2 %, and around 49.3 % of the population is unaware of its seroprevalence, making diagnosis and management of the disease complex (Dramé *et al.* 2018). Furthermore, a study conducted in sub-Saharan African countries, including Benin and Burkina Faso, clearly showed that the costs of diabetes treatment are exorbitant and generally inaccessible to low-income populations, most of whom lack health insurance (Alouki *et al.* 2015). Thus, the use of medicinal plants is an alternative for diabetes management. Like other sub-Saharan African countries, Burkina Faso and Benin have a remarkable diversity of medicinal plants with hypoglycaemic properties (Aloke *et al.* 2023). According to survey results, traditional healers use between 14 and 255 plant species to manage diabetes in Africa (Asong *et al.* 2024). These plants contain bioactive compounds belonging to the flavonoid and terpenoid families, which act by reducing blood sugar levels, stimulating insulin secretion, and improving sensitivity to this hormone (Oguntibeju 2019; Mohammed 2023). Despite this rich flora, the plants specific to these two countries remain poorly studied. Furthermore, although they share some common ecological and cultural characteristics, these two countries also have specific features that may influence phytotherapeutic practices in the management of diabetes.

The study aims to: i) determine the diversity of species used for diabetes management in Benin and Burkina Faso; ii) assess the market availability of plants sold in both countries by herbalists for diabetes management; iii) assess the total flavonoid content in extracts of the most widely sold plants in both countries for diabetes management.

The hypotheses underlying this study stipulate that: i) there is a strong specific similarity between Burkina Faso and Benin in the traditional management of diabetes; ii) the plants most available on the markets are the most threatened according to IUCN data; iii) the most frequently cited plants contain chemical compounds that are of interest for the management of diabetes.

Materials and Methods

Study area

In Burkina Faso, the study was conducted among herbalists working in markets in the provinces of Sanmatenga (Kaya, Boussouma and Korsimoro), Bazèga (Kombissiri, Ipélcé and Toécé) and Zoundweogo (Manga, Béré and Bindé) (Fig. 1).

The province of Sanmatenga, located between latitudes 13° and 14° North and longitudes 1° and 2° West, covers an area of 9,281 km² (MEF 2009). The province of Bazèga is located between latitudes 11°30' and 12°30' North and longitudes 0°50' and 2°10' West and covers an area of 3,963 km². The province of Zoundweogo is located between latitudes 11° and 12° North and longitudes 1°30' and 2°30' West, with an area of 3,604 km². The province of Sanmatenga has a Sahelian climate, with a rainy season that lasts from June to September, and average temperatures ranging from 23.24 °C to 33.20 °C. The province of Bazèga and the northern part of the province of Zoundwéogo have a Sudano-Sahelian climate, with rainfall ranging from 600 to 900 mm. The southern part of Zoundwéogo has a Sudanese climate with average annual rainfall exceeding 900 mm (Sambare 2013). The vegetation in Sanmatenga belongs to the sub-Sahelian phytogeographic sector of Burkina Faso, where Sahelian and Sudanese species coexist. The provinces of Bazèga and Zoundwéogo belong to the northern Sudanese phytogeographic sector of Burkina Faso. There, vegetation cover comprises wooded, shrubby, and herbaceous savannas (Fontès & Guinko 1995).

In Benin, the study was conducted with herbalists in the markets of Dantokpa, Calavi-Tokpa, Akassato and Pahou. The study area covers a dynamic urban and peri-urban belt in the south of the country, encompassing the municipalities of Cotonou and Abomey-Calavi. It is a strategic hub for trade, logistics and population. Cotonou, Benin's economic capital, is home to the

Dantokpa market, one of West Africa's largest open-air markets. Abomey-Calavi is a rapidly growing municipality, home to the Calavi-Tokpa, Akassato and Pahou markets, linked to migratory flows and urban expansion (Fig. 1).

The climate is subequatorial with average annual rainfall ranging from 900 to 1,500 mm, characterised by two rainy seasons and two dry seasons. This climate is typical of the coastal areas of the Gulf of Guinea. The average annual values for temperature, relative humidity, and sunshine duration are 26.5°C, 75 %, and 2,290 hours, respectively (Oyede *et al.* 2022; Oyédé 2023). The predominant plant formations are dense shrub thickets, with oil palm as the dominant species and a few *Ceiba pentandra* trees. These formations represent a stage of degradation of the original mesophilic forest, formerly characterised by species such as *Cola cordifolia*, *Triplochyton scleroxylon*, *Chlorophora exelsa* and *Ceiba pentandra*, of which only a few fragments remain today. The coastal lagoon areas are mainly occupied by Cyperaceae grasslands. There are also discontinuous mangrove formations dominated by *Rhizophora racemosa* and *Avicennia africana*, as well as a few clumps of *Phoenix reclinata*, particularly between Cotonou and the Togo border (Igue *et al*. 2013).

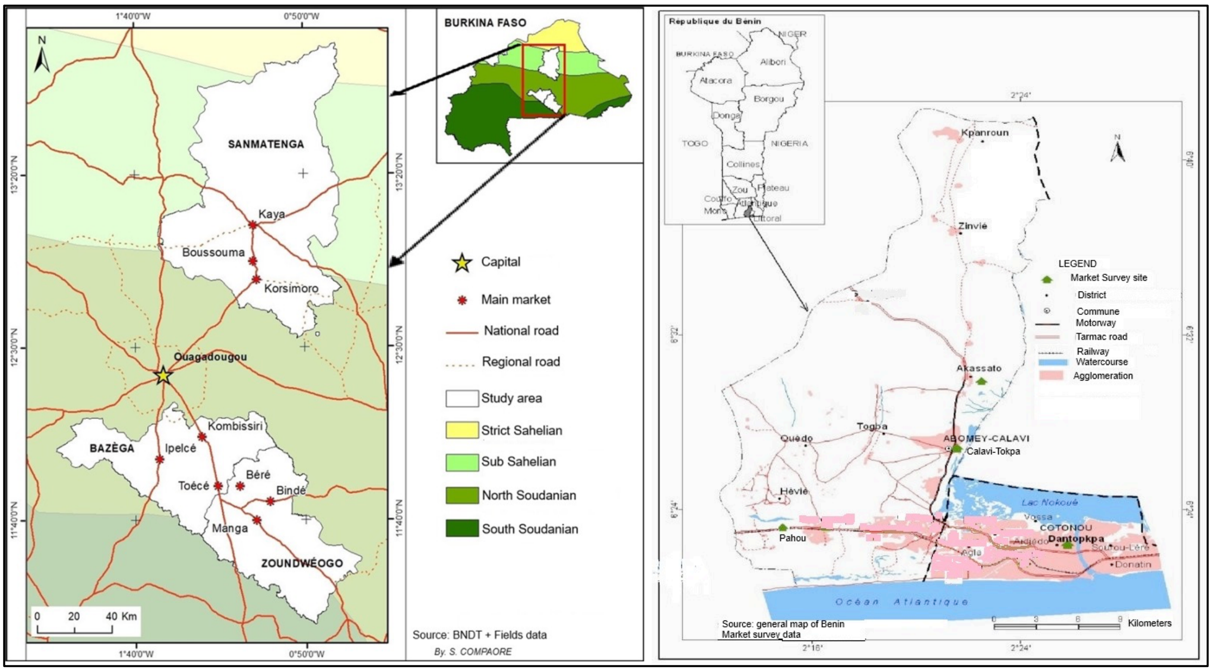

Figure 1. Location of the study area in Burkina Faso and in Benin

Data Collection

Market surveys

For data collection, market surveys were conducted among 27 herbalists in each of the two countries. They were carried out between October and November 2023 in Burkina Faso and between October and November 2024 in Benin. The surveys were conducted using semi-structured interviews with herbalists who agreed to participate. The main information sought related to the local names of plants sold that are of interest for diabetes, methods of preparation and administration of recipes, prices of recipes, methods of use and prohibitions. At the end of the interview, the recipes listed were paid for and transported to the laboratory. Indeed, the collected samples were weighed using an SF-400 precision scale with a capacity of 10,000 g. After two (02) weeks of drying in a ventilated room away from sunlight, the samples were weighed again. The plants included in the herbalists' recipes were identified on site at the stalls, based on personal experience from previous studies and on the local names given by the herbalists. Samples of plants that could not be identified on site were collected with the help of the herbalists. These samples were then stored for identification at the National Herbarium of Joseph Ki-Zerbo University (UO) and the National Herbarium of Benin (HNB). Latin binomials and botanical families were updated in accordance with APG III (2009).

Plant material and extraction methods

Five (05) plant species were initially selected in each of the two countries, based on their frequency of citation. In Burkina Faso, the selected species were *Ficus platyphylla* Delile (Trunk bark), *Lannea acida* A. Rich. (Trunk bark), *Daniellia oliveri* (Rolfe) Hutch. & Dalziel (Trunk bark), *Cassia italica* (Mill.) Lam. ex F.W. Andrews (Leaves) and *Boscia angustifolia* A. Rich. (Trunk bark). As these species had been previously studied (Compaore *et al.* 2020), the present study focused on plants selected in Benin. These were *Conyza aegyptiaca* (L.) Ait. (Whole plant), *Catharanthus roseus* (L.) G. Don (Leafy stems), *Heliotropium indicum* L. (Whole plant), *Clausena anisata* (Wild.) Hook. f. (Leafy stems) and *Momordica charantia* L. (Whole plant), identified respectively under the numbers: YH 1193 / HNB; YH 1194 / HNB; YH 1195 / HNB; YH 1196 / HNB, and YH 1197 / HNB. Plant parts were collected in November 2023 and dried at room temperature. Dried material was ground and stored in freezer bags. Decoction and maceration were employed as extraction methods, following herbalists' instructions. Each extraction was performed in triplicate.

Phytochemical screening

Phytochemical screening of the extracts was conducted using HPTLC plates (20 cm × 10 cm) coated with silica gel $60\ F_{254}$ (Merck, Darmstadt, Germany). Each extract (5 µL, c = 20 µg/µL) was applied as an 8 mm band with a semi-automatic sample dispenser (CAMAG, Linomat 5, Switzerland), positioned 8 mm from the bottom edge of the plate (Koala *et al*. 2021). The distance between application spots was 3.4 mm, with 20 mm between the first spot and the left edge, and 20 mm between the last spot and the right edge. A constant application flow rate of 100 nL/s was maintained. Linear ascending development was performed with 10 mL of mobile phase in a CAMAG double-trough glass chamber lined with filter paper and pre-saturated with mobile-phase vapor for 20 minutes. The development distance was approximately 70 mm. Plates were dried after development using a hairdryer. The mobile phases used in the double-trough chamber were as follows: Hexane/ethyl acetate (20:4, v/v) was used for triterpenes; $CHCl_3$/MeOH (90:10, v/v) for alkaloids and cardenolides; and AcOEt/HCOOH/H_2O (80:10:10, v/v/v) for saponosides, flavonoids, tannins, and coumarins.

Spectrophotometric determination of total phenolic compounds

Total phenolic compound (TPC) content was determined using the Folin-Ciocalteu method (Kaboré *et al*. 2023). One millilitre of Folin-Ciocalteu reagent (FCR) was added to 1 mL of extract or standard solution. The mixture was maintained at room temperature for 8 minutes, followed by the addition of 2 mL of 7.5 % Na_2CO_3 solution. Absorbance was measured at 760 nm after incubation for 30 minutes at 37 °C. TPC was calculated by plotting absorbance values against a calibration curve established with gallic acid as the standard. Results are expressed as milligrams of gallic acid equivalents (GAE) per gram of dry matter.

Spectrophotometric determination of total flavonoid content (TFC)

Total flavonoid content (TFC) was assessed using the aluminium trichloride method (Ordoñez *et al*. 2006; Srivastava *et al*. 2012)), with quercetin as the reference standard. A standard curve was generated using quercetin solutions at concentrations ranging from 0.001 to 0.5 mg / mL. 3 mL of sample solution were mixed with 3 mL of 2 % methanolic aluminium chloride ($AlCl_3$). After 1 hour of incubation at room temperature, absorbance of the supernatant was measured at 415 nm using a single-cell spectrophotometer. Experiments were performed in triplicate. TFC was determined by plotting absorbance values against the quercetin calibration curve. Results are expressed as milligrams of quercetin equivalents (EQ) per gram of dry matter.

Data Analyses

The raw data from the market surveys were entered into Excel, which was used not only to calculate proportions and ethnobotanical parameters but also to generate graphs for interpretation purposes. Thus, to determine the species most frequently cited by herbalists, the frequency of citation of each species (FC) was calculated as follows:

$$FC = \Sigma c / \Sigma C \times 100$$

Where Σc is the total number of citations per species and ΣC is the total number of citations for all species.
To better understand the structure of ethnomedical practices, the distribution of knowledge and the possible dominance of certain species in the management of diabetes in Burkina Faso and Benin, we determined the diversity indices:

-Shannon-Wiener (H'): measures the richness and uniformity of citations

$$H' = -\Sigma\ (n_i / N) \times \ln\ (n_i / N)$$

ni = number of citations of species i ; N = total number of citations; n_i / N = proportion of citations of species i

-Simpson (1-D): measures the probability that two citations refer to different species.

$$D = 1 - \Sigma (n_i / N)^2$$

-Pielou index (J'): indicates whether citations are distributed evenly across species

$$J' = H' / \ln(S)$$

S = total number of species (species richness)

-Jaccard similarity index (Ij) between species used in Benin and Burkina Faso for the management of diabetes

$$IJ = c / (a + b - c)$$

a = total number of species in Benin; b = total number of species in Burkina Faso; c = number of species common to both countries

A non-parametric statistical test (Mann-Whitney U) was used to compare the distributions of citations between the two countries.

-To assess the consensus level of plant, use among herbalists in each country, the Informant Consensual Factor (ICF) was determined by the following formula:

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

N_{ur} was the number of citations used in diabetes, and N_t was the number of species cited for the management of diabetes. The ICF varies between 0 and 1. An IFC close to 1 indicates a strong consensus among herbalists regarding the sale of plants used for diabetes management (Latoundji *et al.* 2019).

-The market availability index (MAI) for each species was determined using the formula adopted by Collie *et al*. (2022).

$$MAI_i = \frac{\mathbf{Mi}}{\mathbf{Mnt}}$$

M_i : number of markets where species i is sold; M_{nt} : total number of markets

Spearman's correlation (ρ) was used to examine the relationship between MAI and IUCN (International Union for Conservation of Nature) status (coded 1-5: 1 = LC; 2 = NT; 3 = VU; 4 = DD; 5 = NE). The NE and DD categories have been retained in order to obtain a comprehensive overview of the state of knowledge on commercially traded species, in accordance with the methodological recommendations of the IUCN (2019), indicating that DD taxa should be considered with caution as potentially threatened.

The Kruskal-Wallis test was used to see whether MAI varies according to IUCN status. Statistical significance (p) was tested at the 5 % level.

Results

Specific richness of plants used for diabetes management in Benin

The market survey identified forty (40) plant species used by herbalists for the management of diabetes (Fig. 2). These species belonged to 22 families and 36 genera, with a predominance of Phyllanthaceae (13.92%). Among these species, *Conyza aegyptiaca* and *Phyllanthus amarus* were the most frequently cited (FC = 8.86%). In addition to these species, four others were cited at a frequency of approximately 5%. These are *Heliotropium indicum*, *Momordica charantia*, *Morinda lucida,* and *Pricalima nitida*. The majority of species (60 %) had low citation frequencies (FC ≤ 2 %). These results may reflect the low availability of plants on the markets of Bénin, but also the limited dissemination of traditional knowledge on diabetes management in Benin.

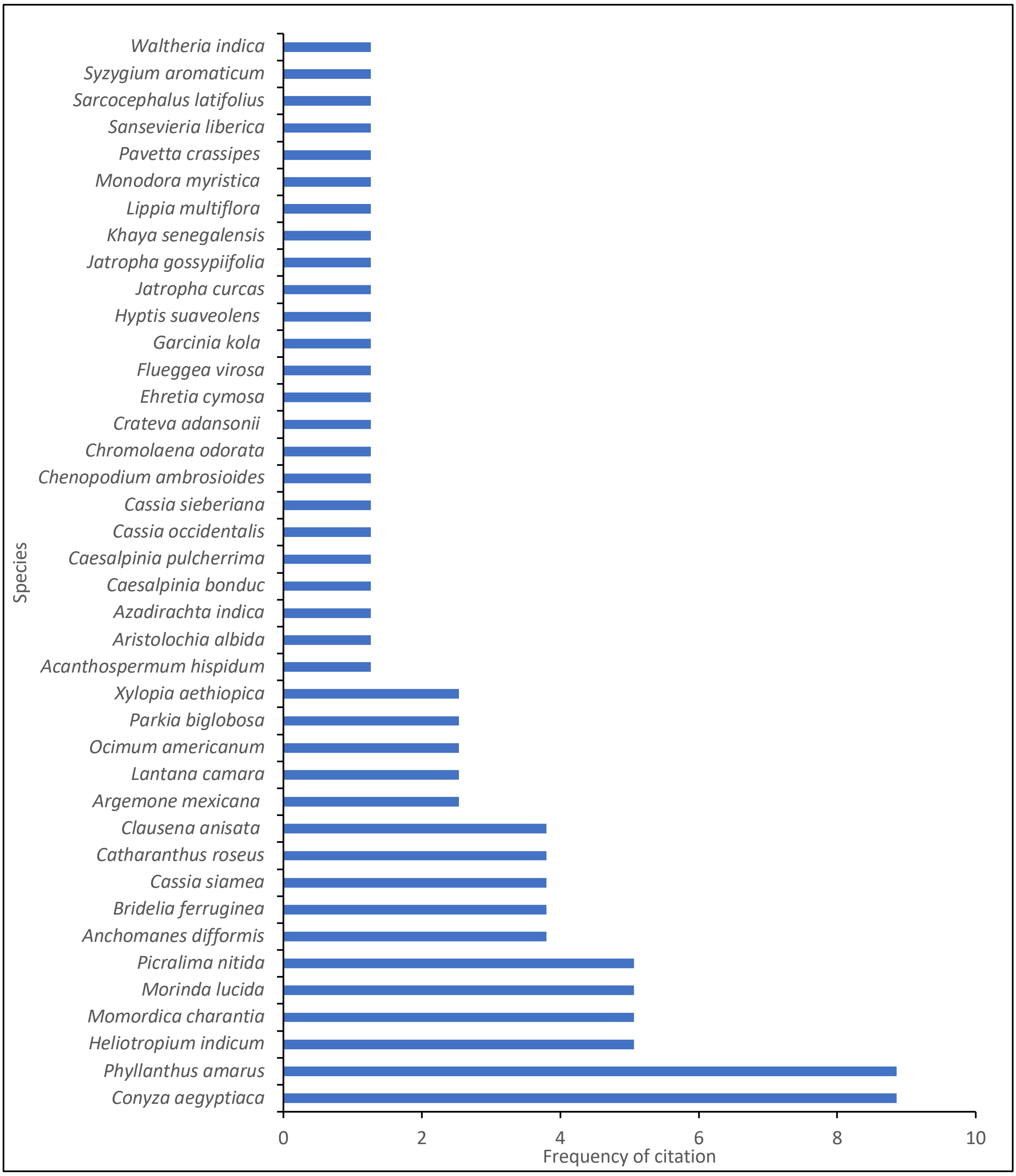

Figure 2. Plants cited in diabetes management from Benin markets

Specific richness of plants used for diabetes management in Burkina Faso

Forty (40) species were identified for diabetes management on the stalls of herbalists surveyed in the markets of the provinces of Sanmatenga, Bazèga, and Zoundwéogo (Fig. 3). They belong to 22 families and 38 genera, with a predominance of Fabaceae (25.41 %). Among these species, *Pteleopsis suberosa* is frequently cited (FC = 12.15 %) by herbalists. This species is followed by *Entada africana*, *Annona senegalensis,* and *Boswellia dalzielii*, which are cited more than 5 % of the time. The majority (57.5 %) of the identified species had a citation frequency of 2 % or less. Among them, twelve (12) species are very rarely cited (FC ≤ 1 %). These are: *Tinospora bakis*, *Tamarindus indica*, *Sclerocarya birrea*, *Saba senegalensis*, *Lannea microcarpa*, *Ficus platyphylla*, *Combretum glutinosum*, *Cienfuegosia digitata*, *Calotropis procera*, *Boscia angustifolia*, *Alternanthera pungens,* and *Acacia senegal*. This low frequency of citation for most species suggests a significant dispersion of ethnobotanical knowledge among herbalists in the management of diabetes.

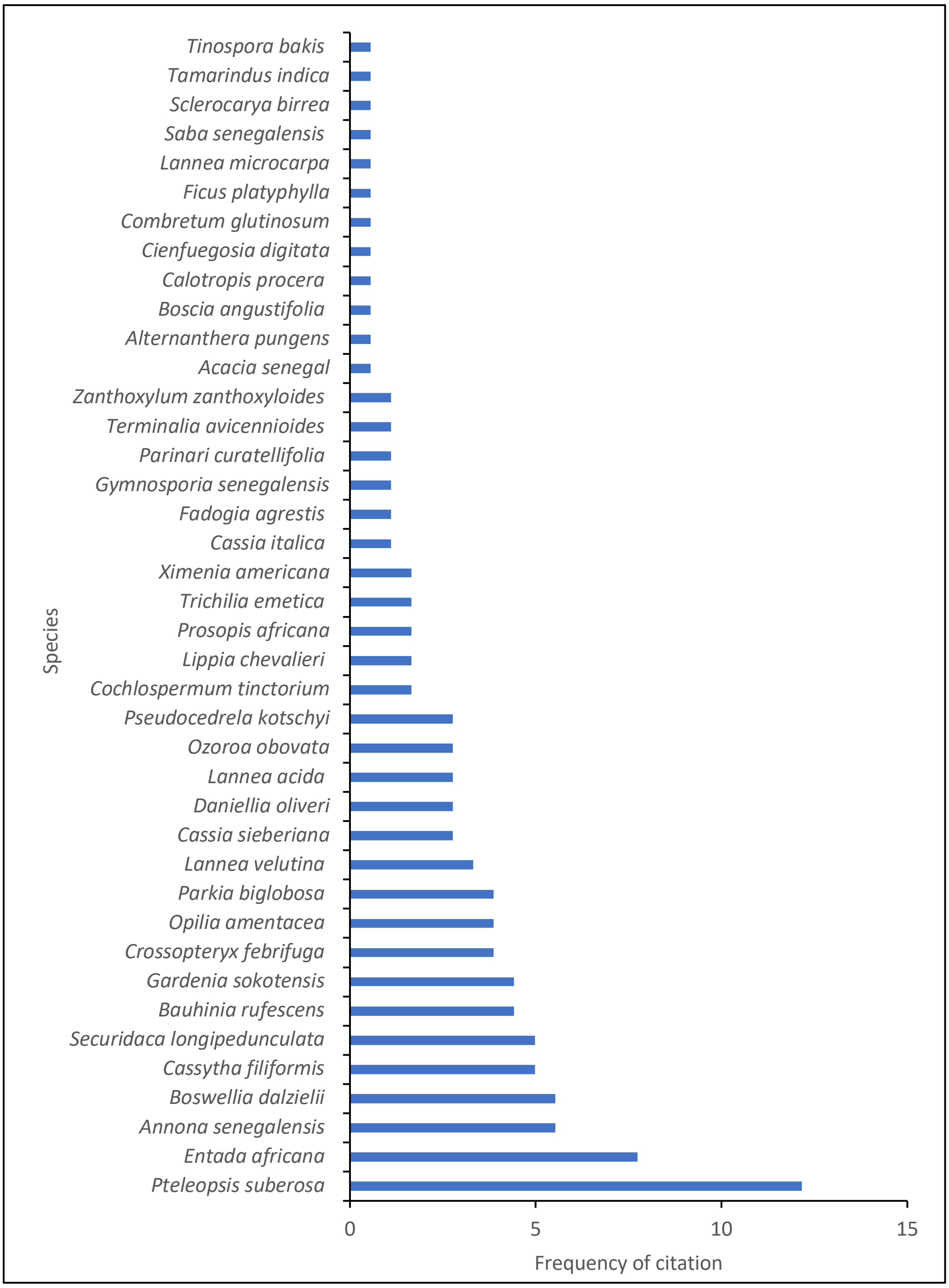

Figure 3. Plants cited in diabetes management from Burkina Faso markets

Diversity of species and consensus level for diabetes management in Benin and in Burkina Faso

The Shannon index values show that both countries have high ethnobotanical diversity in diabetes management, indicating that herbalists' citations are well distributed among several species. Benin has slightly greater diversity (H' = 2.417), with herbalists' citations distributed a little more evenly. The Simpson index of over 70 in both cases (0.738 and 0.740) reflects fairly good diversity in both countries and confirms a low dominance of single species. Similarly, the Piélou equitability index (J') of over 60 % (0.633 and 0.651) in both countries indicates that citations are relatively well distributed among the different species, but not perfectly homogeneous. This means that several species are used in the management of diabetes, without any one species dominating completely in either country.

From a statistical point of view, the p-values indicate that there is no significant difference between Benin and Burkina Faso in terms of the diversity and distribution of species used in diabetes management. The Shannon and Piélou index, which are slightly higher in Benin, reflect a tendency towards a more homogeneous distribution of citations, although this variation remains statistically insignificant.

Analysis of the consensus factors of the informants reveals a tendency towards the convergent use of a limited number of plants in Burkina Faso (ICF = 0.78), while in Benin, use appears to be more diversified, with some marked preferences (ICF = 0.5). Despite this high diversity of species used in both countries, the similarity index, estimated at 2.56 %, reveals a low level of floristic convergence between the two countries, with only two species in common (*Cassia sieberiana* DC. and *Parkia biglobosa* (Jacq.) R. Br. ex G. Don). This contrast highlights that, despite comparable diversity profiles, local pharmacopoeias are based on largely distinct floristic assemblages, reflecting both the ethnobotanical richness and cultural specificity of traditional practices (Table 1).

Table 1. Specific diversity according to survey areas

Parameters	Burkina Faso	Bénin	*p-value*
Shannon index	2.352	2.417	0.312
Simpson index	0.738	0.740	0.401
Pielou index	0.633	0.651	0.289
Mann-Whitney	-	-	0.227
Informant Consensual factor (ICF)	0.78	0.5	
Jaccard index (Ij)	0.0256		

Use of plants for diabetes management in Benin and Burkina Faso

In Burkina Faso, diabetes management is based mainly on woody species (80 %), unlike in Benin, where herbalists mainly use herbaceous plants (55 %). Furthermore, in Burkina Faso, the parts of plants most commonly sold for diabetes treatment are bark (38.5 %) and roots (26.2 %), putting already endangered woody species at risk. As for herbalists in Benin, they mainly offer leaves (38.3 %) to patients for diabetes management, which is less destructive and reduces ecological pressure on woody resources (Table 2).

Table 2. Biological type and use of plant parts

	Country	**Burkina Faso**	**Bénin**
Species richness	Number of species	40	40
Biological type	Woody species (%)	80	55
	Herbaceous (%)	20	45
Dominant plant parts	Bark (%)	38.5	18.3
	Leaves (%)	20	38.3
	Root (%)	26.2	13.3
Ecological impact		Highly destructive	Moderate

Relationship between market availability and conservation status of species of interest for diabetes

In Benin, the inventory of plants used for diabetes management shows that *Phyllanthus amarus* (MAI = 1) is the most widely available species on the market. It is followed by *Picralima nitida* (MAI = 0.75) and *Morinda lucida* (MAI = 0.75). According to the IUCN criteria, all these species have an 'LC' status, meaning that they are not currently vulnerable. Other species, such as *Garcinia kola* (MAI = 0.25), *Khaya senegalensis* (MAI = 0.25), and *Parkia biglobosa* (MAI = 0.25), are very scarce on the markets and are near threatened (NT) or vulnerable (VU). Most species (52.5 %) that are scarce on the markets are of least concern (LC). Furthermore, the plants most readily available on the markets are not necessarily the most threatened (Table 3).

In Burkina Faso, market availability indices are generally lower and more consistent across IUCN categories. Indeed, 35 % of species inventoried in Burkina Faso are very rarely available (MAI = 0.11) on the markets. The majority (71.43 %) of these species are of least concern, and only *Sclerocarya birrea* is near threatened according to the IUCN. The highly available species, namely *Pteleopsis suberosa* (MAI = 1) and *Boswellia dalzielii* (MAI = 0.78), are classified as of least concern and near threatened, respectively. Other moderately available species, such as *Entada africana* (MAI = 0.67), *Annona senegalensis* (MAI = 0.67), *Cassytha filiformis* (MAI = 0.56), *Gardenia sokotensis* (MAI = 0.56), and *Opilia amentacea* (MAI = 0.56) are mostly of least concern (Table 3).

The results of the correlation tests (p = 0.35; p = 0.85) and Kruskal-Wallis tests (p = 0.77; p = 0.56) indicate that there is no statistically significant relationship between the market availability of species and their conservation status according to the IUCN Red List. This suggests that the plants most readily available on the markets in both Benin and Burkina Faso are not necessarily those most threatened according to IUCN criteria (Table 4).

Table 3. Market availability indices and conservation status of species

Species	Family	MAI_Burkina	MAI_Bénin	IUCN
Senegalia senegal (L.) Britton	Fabaceae	0.11		LC
Acanthospermum hispidum DC.	Asteraceae		0.25	LC
Alternanthera pungens Kunth	Amaranthaceae	0.11		NE
Anchomanes difformis (Blume) Engl.	Araceae		0.5	NE
Annona senegalensis Pers.	Annonaceae	0.67		LC
Argemone mexicana L.	Papaveraceae		0.5	LC
Aristolochia albida Duch.	Aristolochiaceae		0.25	NE
Azadirachta indica A. Juss.	Meliaceae		0.25	LC
Bauhinia rufescens Lam.	Fabaceae	0.56		LC
Boscia angustifolia A. Rich.	Capparaceae	0.11		LC
Boswellia dalzielii Hutch.	Burseraceae	0.78		NT
Bridelia ferruginea Benth.	Phyllanthaceae		0.25	LC
Guilandina bonduc L.	Fabaceae		0.25	LC
Caesalpinia pulcherrima (L.) Sw.	Fabaceae		0.25	LC
Calotropis procera (Aiton) Dryand.	Apocynaceae	0.11		LC
Senna italica Mill.	Fabaceae	0.11		LC
Senna occidentalis (L.) Link	Fabaceae		0.25	LC
Senna siamea (Lam.) H.S.Irwin & Barneby	Fabaceae		0.5	LC
Cassia sieberiana DC.	Fabaceae	0.44	0.25	LC
Cassytha filiformis L.	Lauraceae	0.56		LC
Catharanthus roseus (L.) G.Don	Apocynaceae		0.5	LC
Dysphania ambrosioides (L.) Mosyakin & Clemants	Chenopodiaceae		0.25	LC
Chromolaena odorata (L.) R.M.King & H.Rob.	Asteraceae		0.25	LC
Cienfuegosia digitata Cav.	Malvaceae	0.11		DD
Clausena anisata (Willd.) Hook.f.	Rutaceae		0.5	LC
Cochlospermum tinctorium Perrier ex A.Rich.	Bixaceae	0.22		LC
Combretum glutinosum Perr. ex DC.	Combretaceae	0.11		LC
Conyza aegyptiaca (L.) Aiton	Asteraceae		0.5	LC
Crateva adansonii DC.	Capparaceae		0.25	LC
Crossopteryx febrifuga (Afzel. ex G.Don) Benth.	Rubiaceae	0.33		LC
Daniellia oliveri (Rolfe) Hutch. & Dalziel	Fabaceae	0.44		LC
Ehretia cymosa Willd. ex Roem. & Schult.	Heliotropiaceae		0.25	LC
Entada africana Guill. & Perr.	Fabaceae	0.67		LC
Vangueria agrestis (Schweinf. ex Hiern) Lantz	Rubiaceae	0.22		DD
Ficus platyphylla Delile	Moraceae	0.11		LC
Flueggea virosa (Roxb. ex Willd.) Royle	Phyllantaceae		0.25	LC
Garcinia kola Heckel	Clusiaceae		0.25	NT
Gardenia sokotensis Hutch.	Rubiaceae	0.56		DD
Gymnosporia senegalensis (Lam.) Loes.	Celastraceae	0.22		LC
Heliotropium indicum L.	Heliotropiaceae		0.25	LC
Mesosphaerum suaveolens (L.) Kuntze	Lamiaceae		0.25	LC
Jatropha curcas L.	Euphorbiaceae		0.25	LC
Jatropha gossypiifolia L.	Euphorbiaceae		0.25	LC
Khaya senegalensis (Desr.) A.Juss.	Meliaceae		0.25	VU

Species	Family	MAI_Burkina	MAI_Bénin	IUCN
Lannea acida A.Rich.	Anacardiaceae	0.44		LC
Lannea microcarpa Engl. & K.Krause	Anacardiaceae	0.11		LC
Lannea velutina A. Rich.	Anacardiaceae	0.22		LC
Lantana camara L.	Verbenaceae		0.25	LC
Lippia chevalierii Moldenke	Verbenaceae	0.22		DD
Lippia multiflora Moldenke	Verbenaceae		0.25	LC
Momordica charantia L.	Cucurbitaceae		0.5	LC
Monodora myristica (Gaertn.) Dunal	Annonaceae		0.25	LC
Morinda lucida Benth.	Rubiaceae		0.75	LC
Ocimum americanum L.	Lamiaceae		0.5	LC
Opilia amentacea Roxb.	Opiliaceae	0.56		LC
Ozoroa obovata (Oliv.) R.Fern. & A.Fern.	Anacardiaceae	0.33		DD
Parinari curatellifolia Planch. ex Benth.	Chrysobalanaceae	0.11		LC
Parkia biglobosa (Jacq.) R.Br. ex G.Don	Fabaceae	0.44	0.25	NT
Pavetta crassipes K.Schum.	Rubiaceae		0.25	DD
Phyllanthus amarus Schumach. & Thonn.	Phyllanthaceae		1	LC
Picralima nitida (Stapf) T.Durand & H.Durand	Apocynaceae		0.75	LC
Anonychium africanum (Guill. & Perr.) C.E.Hughes & G.P.Lewis	Fabaceae	0.22		VU
Pseudocedrela kotschyi (Schweinf.) Harms	Meliaceae	0.33		NT
Pteleopsis suberosa Engl. & Diels	Combretaceae	1		LC
Saba senegalensis (A.DC.) Pichon	Apocynaceae	0.11		LC
Dracaena liberica (hort. ex Gérôme & Labroy) Byng & Christenh.	Asparagaceae		0.25	NE
Sarcocephalus latifolius (Sm.) E.A.Bruce	Rubiaceae		0.25	LC
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	0.11		NT
Securidaca longipedunculata Fresen.	Polygalaceae	0.67		NT
Syzygium aromaticum (L.) Merr. & L.M.Perry	Myrtaceae		0.25	LC
Tamarindus indica L.	Fabaceae	0.11		LC
Terminalia avicennioides Guill. & Perr.	Combretaceae	0.22		LC
Tinospora bakis (A.Rich.) Miers	Menispermaceae	0.11		DD
Trichilia emetica Vahl	Meliaceae	0.33		LC
Waltheria indica L.	Malvaceae		0.25	LC
Ximenia americana L.	Olacaceae	0.33		LC
Xylopia aethiopica (Dunal) A.Rich.	Annonaceae		0.5	LC
Zanthoxylum zanthoxyloides (Lam.) Zepernick & Timler	Rutaceae	0.22		NT

MAI : Market Availability Index ; LC : Least Concern; NT : Near Threatened; VU : Vulnerable; DD : Data Deficient; NE : Not Evaluated

Table 4. Correlation test between MAI and IUCN

Country	Spearman's correlation (ρ)	p-value	Kruskal-Wallis	p-value
Bénin	-0.153	0.35	1.82	0.77
Burkina Faso	-0.031	0.85	3.00	0.56

Phytochemical screening and dosage of compounds of interest for diabetes

Phytochemical screening by HPTLC of extracts from the five Beninese plant species revealed several compounds of interest. At UV/366 nm, triterpenes, flavonoids, and coumarins were detected, while visible light revealed saponosides, tannins, alkaloids, and cardenolides (Fig. 4). *Clausena anisata* (CA) exhibited a rich profile with multiple intense, colored, and fluorescent bands, suggesting the presence of flavonoids, coumarins, and aromatic alkaloids. *Momordica charantia* (MC) displayed multiple green and orange fluorescence bands, indicating the probable presence of triterpenes, flavonoids, and saponins. *Catharanthus roseus* (CR) showed a simple but intense profile, with blue coloration likely indicating indole alkaloids. *Conyza aegyptiaca* (COA) presented a moderate but specific profile, characterized by the probable presence of alkaloids. *Heliotropium indicum* (HI) exhibits few bands with low fluorescence, suggesting the presence of simple flavonoids and tannins.

Assay results indicated that Clausena anisata had the highest flavonoid content (211.78 mg EQ/g DE), while *Conyza aegyptiaca* exhibited the lowest (77.59 ± 0.06 mg EQ/g DE). In terms of phenolic compounds, *Catharanthus roseus* demonstrated the highest content (83.60 mg EAG/g DE), followed by *Conyza aegyptiaca* (69.64 ± 0.16 mg EAG/g DE) and *Clausena anisata* (64.26 ± 0.16 mg EAG/g DE). *Heliotropium indicum* had the lowest total phenolic content (31.20 ± 0.01 mg EAG/g DE). The highest extraction yield was observed for *Catharanthus roseus* (23.19 %), significantly exceeding the yields of the other species (approximately 7-9 %), suggesting its potential for industrial application (Table 5).

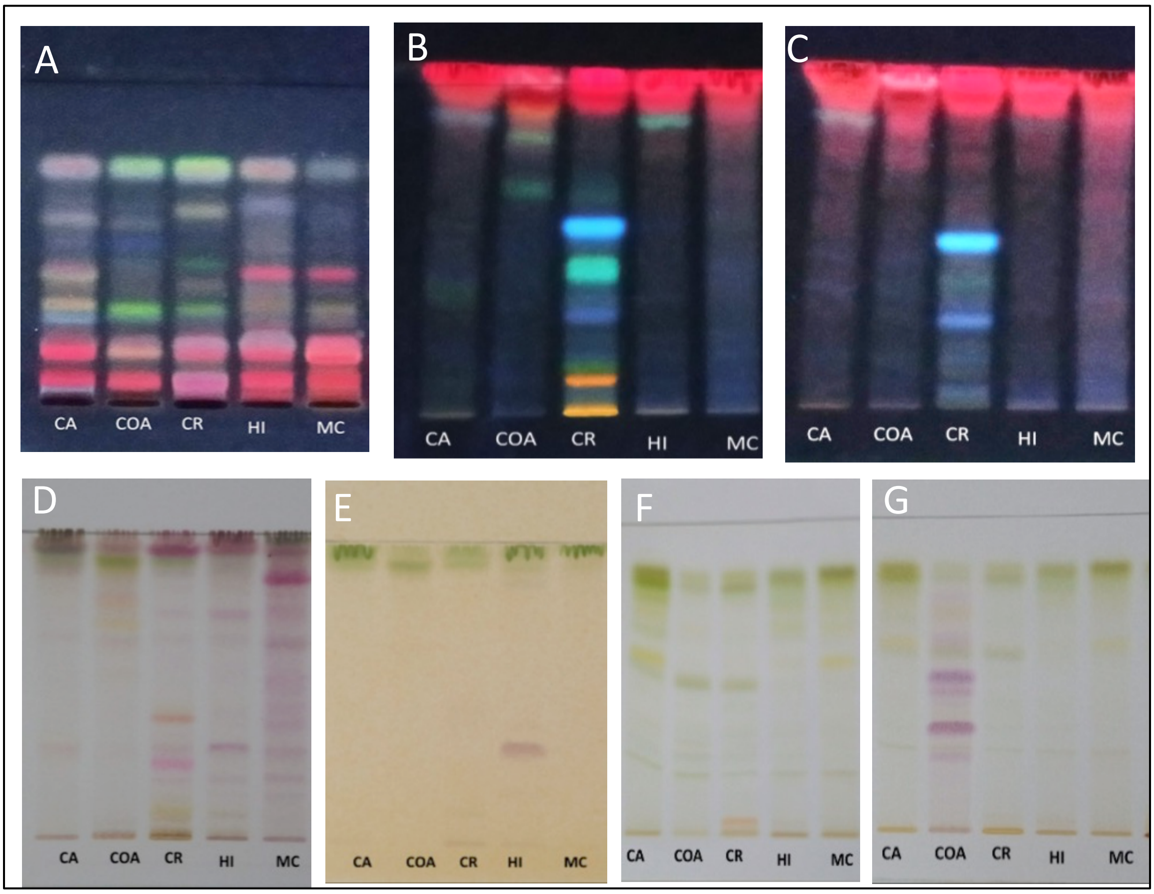

Figure 4. Detection at UV/366 nm of triterpenes (A), flavonoids (B), and coumarins (C), and at visible light of saponosides (D), tannins (E), alkaloids (F), and cardenolides (G) by HPTLC **. CA** : *Clausena anisata* ; **COA** : *Conyza aegyptiaca* ; **CR** : *Catharanthus roseus* ; **HI** : *Heliotropium indicum* ; **MC** : *Momordica Charantia*

Table 5: Results of total phenolic compound (CPT) and total flavonoid (TFT) measurements of extracts and extraction yields

Plant extract	Family	Voucher N°	CPT (mg EAG/g DE)	TFT (mg EQ/g DE)	Yield (%)
Clausena anisata (Willd.) Hook.f.	Rutaceae	YH 1196 / HNB	64.26 ± 0.16	211.78 ± 0.13	7.76
Conyza aegyptiaca (L.) Aiton	Asteraceae	YH 1193 / HNB	69.64 ± 0.16	77.59 ± 0.06	9.14
Catharanthus roseus (L.) G.Don	Apocynaceae	YH 1194 / HNB	83.60 ± 0.11	86.45 ± 0.02	23.19
Heliotropium indicum L.	Heliotropiaceae	YH 1195 / HNB	31.20 ± 0.01	92.74 ± 0.01	7.45
Momordica Charantia L.	Cucurbitaceae	YH 1197 / HNB	42.94 ± 0.06	133.66 ± 0.03	9.06

EAG: gallic acid equivalent, **EQ**: quercetin equivalent, **DE:** dry extract

Discussion

Diversity and distribution of knowledge in diabetes management in Burkina Faso and Benin

The results obtained show a high level of ethnobotanical diversity in the plants used in traditional diabetes management in both Benin and Burkina Faso. Indeed, the citation frequency values and Shannon, Simpson, and Piélou indices reflect a high level of species richness and a good distribution of herbalists' knowledge on the use of plants for diabetes management. Previous studies conducted in Nigeria and Morocco on plants with antidiabetic properties have reported similar results, demonstrating local ethnobotanical knowledge (Mechchate *et al*. 2020; Ajao *et al.* 2023).

The convergence of knowledge among herbalists of each country on a limited number of plants for the management of diabetes suggests the existence of shared ethnobotanical knowledge, likely fostered by cultural, linguistic, and ecological continuities (Diop *et al*. 2022; Ngbolua *et al.* 2023). Such consensus reinforces the ethnopharmacological credibility of plants and can guide research towards priority candidates for phytochemical and pharmacological research (Macedo *et al.* 2018; Uddin *et al.* 2023). Furthermore, in herbalist practice, usage seems to be based on a diversity of species with similar functions, rather than on a limited number of emblematic plants that concentrate all uses. This phenomenon, frequently observed in traditional West African medicine, reflects an adaptation strategy based on functional redundancy, enabling practitioners to cope with seasonal fluctuations and climatic constraints (Zizka *et al*. 2015; Compaore *et al.* 2020).

Specific similarity of plants used for diabetes management in Burkina Faso and Benin

Despite the wide diversity of plants used by herbalists in both countries to manage diabetes, the similarity index remains very low, with only two species in common: *Cassia sieberiana* DC. and *Parkia biglobosa* (Jacq.) R.Br. ex G. Don. This situation highlights a significant floristic divergence in the management of diabetes between the two countries, taking into account not only local flora but also cultural specificity.

Indeed, each country has a range of medicinal species that reflect local biodiversity and the depth of traditional knowledge. Therapeutic knowledge is based on local traditions passed down from generation to generation in a specific ecological context. This is all the more justified given that herbalists in Benin mainly use herbaceous plants and leaves for the management of diabetes, unlike those in Burkina Faso, who rely mainly on woody plants and barks. Furthermore, the frequent use of herbaceous plants and introduced species such as *Momordica charantia* and *Catharanthus roseus* in Benin reflects a diversification of medicinal resources, often linked to the proximity of urban markets and a much more Guinean flora (Sobakin *et al.* 2022). These contrasts have been observed in several studies reporting that the diversity of species used to treat diseases varies from region to region, even for the same therapeutic indication (Tibiri *et al*. 2020; Nargawe *et al.* 2023). Some authors justify this variation as an adaptation strategy that allows populations to focus on available local resources and diversify therapeutic solutions in the face of ecological and seasonal constraints (Mattalia *et al*. 2021; Tareau *et al.* 2022).

The use of *Cassia sieberiana* and *Parkia biglobosa* by herbalists in both Burkina Faso and Benin is particularly significant and reflects the fact that these two species are widely recognised in West Africa for their medicinal uses. Indeed, both species are known for their antihyperglycemic properties (Ihedioha *et al*. 2014; Hassan *et al.* 2020). In addition, a study on the traditional use of plants reported that these two species are among the top 20 most useful medicinal species in Burkina Faso (Zizka *et al.* 2015). In Benin, they are widely used for their medicinal properties and play a crucial role in local ecosystems (Bio *et al.* 2014; Kombienou *et al.* 2022).

Influence of conservation status on the market availability of species used for diabetes management

The relationship between the market availability of medicinal plants and their conservation status is a major challenge for the sustainability of traditional medical practices, especially in sub-Saharan Africa. The results show that among the species most frequently sold by herbalists for the management of diabetes in Burkina Faso and Benin, several have a conservation status of concern (NT and VU), while others remain poorly documented (DD, NE). This situation presents a potential risk of overexploitation for species whose harvested organs are difficult to renew and which are simultaneously in high commercial demand. Indeed, several studies have shown that commercial exploitation is one of the main factors in the decline of medicinal plants, contrary to domestic use (Chauhan *et al.* 2013; Zhao *et al.* 2023). This is consistent with the findings for species such as *S. longipedunculata*, *B. dalzielii*, *K. senegalensis,* and *Pseudocedrela kotschyi*, whose high economic value leads to intensive exploitation that is likely to reduce populations (Sabo *et al.* 2021; Mofokeng *et al*. 2022).

The study also shows that species classified as Least Concern (LC) remain in the majority in the markets, but this classification does not guarantee the absence of threats. Indeed, species that are widely sold, such as *M. lucida*, *L. acida*, *C. aegyptiaca*, *A. senegalensis,* and *P. nitida*, but are not currently threatened, may become vulnerable if demand increases or habitats continue to deteriorate. Ticktin (2004) emphasises that, especially woody species, can accumulate latent risk and their status is only updated late when the cumulative pressure exceeds the threshold of ecological resilience.

On the other hand, species classified as Data Deficient (DD) or Not Evaluated (NE) raise another concern in that they are sold, harvested, and used on a large scale, but without any reliable information on their population dynamics. This can mask situations of vulnerability. A recent IUCN report of the Species Survival Commission emphasises the need to integrate local medicinal plants into IUCN assessment programmes, particularly in Africa, where dependence on herbal medicine is high (IUCN 2023).

Finally, the lack of correlation between market availability and conservation status observed in our results confirms the conclusion of a study that market availability is not always a good indicator of ecological abundance (Zinnen *et al.* 2024). A species may remain abundant in markets even if its natural populations are declining, particularly due to opportunistic collection, interregional movement, or export practices (Almeida *et al.* 2023; Hughes *et al.* 2023).

Antidiabetic potential of the plants most frequently sold by herbalists in Benin

The plants most frequently sold by herbalists in Benin for the management of diabetes have particularly interesting antidiabetic potential, confirmed by both local ethnobotanical knowledge and recent scientific literature. Among the best-selling plants, several, notably *Clausena anisata*, *Momordica charantia*, *Heliotropium indicum*, *Catharanthus roseus,* and *Conyza aegyptiaca*, are rich in chemical compounds known for their antidiabetic properties. Indeed, the flavonoids, alkaloids, terpenoids, and saponins identified in these plants are well known for their ability to regulate blood sugar levels. Recent studies show that *M. charantia*, which is widely sold, contains bioactive compounds, including charantin, polypeptide-p, and cucurbitacins, which have hypoglycaemic effects comparable to those of certain oral antidiabetic drugs (Mahwish *et al*. 2021; Rahman *et al*. 2021; Yadav *et al.* 2025). Similarly, *Clausena anisata* is rich in coumarins, flavonoids, and alkaloids, which several studies have shown to have antidiabetic activity, particularly by inhibiting intestinal glucose absorption and reducing oxidative stress (Agyepong *et al.* 2015; Tarnam *et al.* 2016; Athipornchai *et al*. 2021). *Heliotropium indicum* and *Conyza aegyptiaca* are also recognised for their hypoglycaemic and antioxidant activity, mainly attributed to the phenols, tannins, and alkaloids they contain (Mohammad *et al.* 2014; Akakpo *et al*. 2017; Adebayo *et al.* 2025).

Finally, *Catharanthus roseus*, well known for its anti-cancer alkaloids (vinblastine, vincristine), also has anti-diabetic properties demonstrated by several recent studies, notably thanks to indole and flavonoid compounds capable of improving cellular glucose uptake and reducing blood sugar levels (Espejel-Nava *et al*. 2018; Goboza *et al.* 2020).

The high frequency with which these plants are cited by herbalists in Benin is therefore consistent with current chemical and pharmacological data justifying their use by the population.

Conclusion

This study shows that traditional diabetes management in Benin and Burkina Faso is based on rich but largely distinct medicinal flora, reflecting specific ecological contexts. Despite this low floristic similarity, the two countries have comparable levels of ethnobotanical diversity, indicating a similar functional organisation of therapeutic knowledge. The high market availability of certain species, such as *Phyllanthus amarus*, *Morinda lucida*, *Pteleopsis suberosa*, *Picralima nitida,* and *Securidaca longipedunculata,* does not seem to be directly influenced by their conservation status. However, the heavy dependence on organs such as bark and roots, particularly in Burkina Faso, raises major concerns about conservation and resource sustainability. Conversely, the dominant use of leaves in Benin appears to be a practice that is potentially more compatible with sustainable exploitation. The phytochemical results obtained for the most frequently cited species reinforce the pharmacological credibility of traditional knowledge and open up prospects for the development of antidiabetic herbal medicines. This study highlights the need to integrate ethnobotanical, ecological, and chemical data into strategies for the promotion and conservation of medicinal plants, to reconcile public health, biodiversity preservation, and the sustainability of traditional healthcare systems in West Africa.

Declarations

List of abbreviations: FC - frequency of citation; HPTLC - High-Performance Thin-Layer Chromatography; ICF - Informant Consensual Factor; IUCN - International Union for Conservation of Nature; MAI - market availability index; MEF - Ministère de l'Economie et des Finances; WHO - World Health Organisation.

Ethics approval and consent to participate: Verbal informed consent was obtained from all participants before their involvement in the survey.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that there is no conflict of interest.

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Author contributions: CS, LSI, and KB: conceptualization, methodology, and Investigation; CS, KB: analysed data; BL, OS, TA, and ACA: Writing original Draft and manuscript validation.

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