Local perceptions and endogenous knowledge of Hoary Basil (*Ocimum americanum* L.) in Burkina Faso

Kaboré Hervé, Kiébré Mariam and Nanema Kiswendsida Romaric

Correspondence

Kaboré Hervé*, Kiébré Mariam, Nanema Kiswendsida Romaric

Bioscience Laboratory, Faculty of Earth and Life Sciences, University Joseph Ki-Zerbo, P. O. Box 7021 Ouagadougou, Burkina Faso.

*Corresponding Author: hervekabore28@gmail.com

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Research

Abstract

Background: Ocimum americanum is an aromatic species from the family of *Lamiaceae*. It has significant socioeconomic potential and is used by the local population in Burkina Faso. Although the species makes a significant contribution to household well-being, the organizations in charge of natural resource management are unaware of and undervalue its socioeconomic value. This study was initiated to assess local communities' perception of the uses and management techniques of *Ocimum americanum* to establish sustainable strategies for its better valorization.

Methods: An ethnobotanical survey was conducted in 21 villages covering three phytogeographical sectors of Burkina Faso. All, 160 farmers were interviewed. Relative frequency of citation (RFC) and use value (UV) were used to express the results.

Results: The results showed that socio-cultural factors significantly affect the use value of the species at a threshold of 5%. The primary uses of wild basil are traditional medicine, food, conservation of seeds and foodstuffs, fodder, insect repellant, and tradimystics. The species is still found in the wild, although the majority of informants (54.9%) reported a decline in its population, making it threatened with extinction. However, for beneficial purposes, 24.5% of respondents keep the species in paraculture.

Conclusion: This study demonstrates how important this species is to local communities. The endogenous knowledge collected among the local population could serve as a baseline for the valuation of the species.

Keywords: Ocimum americanum, ethnobotanical survey, endogenous knowledge, Burkina Faso.

Background

Ocimum americanum is an annual herb of the Lamiaceae family. Commonly called hoary basil, lemon basil, royal herb or queen of herbs, it is a fragrant species from sub-Saharan Africa (Luanda *et al*. 2023, Yayi-Ladekan *et al*. 2011). It is renowned for being resilient and for having an excellent capacity to adapt to a variety of ecological zones (Chevalier and Perrot 1905, Lakusic *et al.* 2006). According to Rivière *et al.* (2017), it has simple, opposite decussate and erect leaves. It has also a quadrangular stem that can grow up to 50 cm. Basil is commonly used by the local populations in the treatment of illnesses, including gastroenteritis, hepatitis, malaria, syphilis, gonorrhea, and respiratory infections (Adjanohoun *et al*. 1989, Anton & Lobstein 2005, Janssen 1989, Kaou 2008, Monjoin 1981, Morton 1981, Pousset 1989, Zahran *et al.* 2020). Moreover, its

leaves are often used as a spice and leafy vegetable and as flavorings in sweet beverages (Anton & Lobstein 2005, Kaou 2008, Luanda *et al.* 2023, Monjoin 1981, Morton 1981, Pousset 1989, Yayi-Ladekan *et al*. 2011). It is a plant that contains essential oils and insect-repellent, larvicidal, anti-diabetic, anti-microbial, and anti-bacterial (Zengin et al. 2019, Ali et al. 2022, Chan et al. 2021, Win and Thar 2019, Ilboudo et al. 2010).

Because of the benefits and the diverse applications of *Ocimum americanum,* it may be a feasible alternative for improving the health as well as economic conditions of the local population in a climate change context. Unfortunately, little research on this species mainly focused on the biochemical and biological features of essential oils (Bayala 2014, Ilboudo 2009). No investigation of indigenous knowledge or the perceptions of local communities on the species has been done in Burkina Faso. The implementation of suitable techniques or systems for the development of natural resources, however, depends on understanding the level of relevance and use of a species by populations. The objective of this study is to assess local communities' perception of the uses and management techniques of *Ocimum americanum* to guide the development of strategies that will assure the plant's rational and long-term management in Burkina Faso.

Materials and Methods

Choice and description of study area

The study was carried out in Burkina Faso. It is a country located in the center of West Africa and lies between latitudes 09°02' south and 15°05' North and longitudes 02°02' East and 05°03' West. Burkina Faso is subdivided into four phytogeographic sectors based on climate, plant formations, and flora (Fontes & Guinko, 1995). A stratified sampling method was used to select the study locations (Figure 1). The parameters for stratification were determined by the local climate, floral diversity, and population diversity. Thus, two stratification levels were maintained. The first level was concerned with the major ethnic groups, and the second level was the phytogeographic sectors. Three phytogeographic sectors have been chosen, considering the security situation in Burkina Faso. These are sub-Sahelian, north and south-Sudanian sectors.

The average annual rainfall in the sub-Sahelian phytogeographic sector ranges from 500 to 700 mm. The rainy season lasts for three to five months. Tiger bushes and thickets are the main types of vegetation. Rainfall varies from 700 to 900 mm in the North Sudanian phytogeographic sector. The rainy season lasts for five to six months. Savannahs predominate in the northern Sudanese sector's vegetation. The average annual rainfall in the southern Sudanese phytogeographic sector ranges from 900 to 1100 mm. The rainy season lasts between six and seven months. Wooded and tree savannahs make up most of the landscape's vegetation. The majority of forest formations are associated with the presence of waterways (Ouedraogo 2006). Six major ethnic groups out of eleven were considered. These groups are *Bissa*, *Bobo*, *Gourmantché*, *Gourounsi*, *Mossi*, and *Sénoufo*. The International Association of French-speaking Demographers (AIDELF) (2008) claims that an ethnic group is identified by a common geographic location, set of traditions, and culture. Therefore, a province was chosen at random in each region that belonged to a different ethnic group, except the Mossi ethnic group. We chose four provinces there since it was the largest. Thus, nine provinces were selected in the three phytogeographic sectors including the six ethnic groups.

Sampling and data collection

The study was carried out from September 2020 to April 2021. The research tools employed were ethnobotanical surveys. Thus, semi-structured interviews with consenting informants were carried out throughout this period. A questionnaire was established to capture data on the characteristics of the studied population (age, sex, level of education, ethnic group and occupation) and ethnobotanical data. The ethnobotanical data included the respondents' knowledge of the species, local names given to the species, uses (diversity of uses, plant parts used, and modes of use), and local assessments of *O. americanum* population dynamics.

Data analysis

The informants were divided into three age groups as defined by Assogbadjo *et al.* (2008), namely young people (age ≤ 30 years old), adults (30 years old < age < 60 years old) and old people (age ≥ 60 years old). Also, they were divided into groups based on academic level and gender (male and female). Three modalities were considered in terms of academic level: the illiterate, the literate (primary, post-primary level, and training in the local language), and the educated (secondary and university level). Citation frequencies (FC) for all respondents were determined to appreciate the diversity of knowledge and assess the importance of each use for the sampled population. These frequencies, which were also used to generate bar graphs, were determined using the formula below:

$$FC = \frac{n}{N} * 100$$

n: number of citations for a category
N: Total number of citations in all categories.

A generalized linear model (GLM) was used to assess the probable influence of socio-cultural factors on use values. The use value formula used is that of Phillips *et al.* (1994) modified by Rossato *et al*. (1999):

$$UV = \sum_{i=1}^{i=n} U_i \Big/ n$$

Ui:number of uses cited by informant I
n:number of respondents questioned in total.
The generalized linear model was established using Rstudio software (R Core Team 2022).

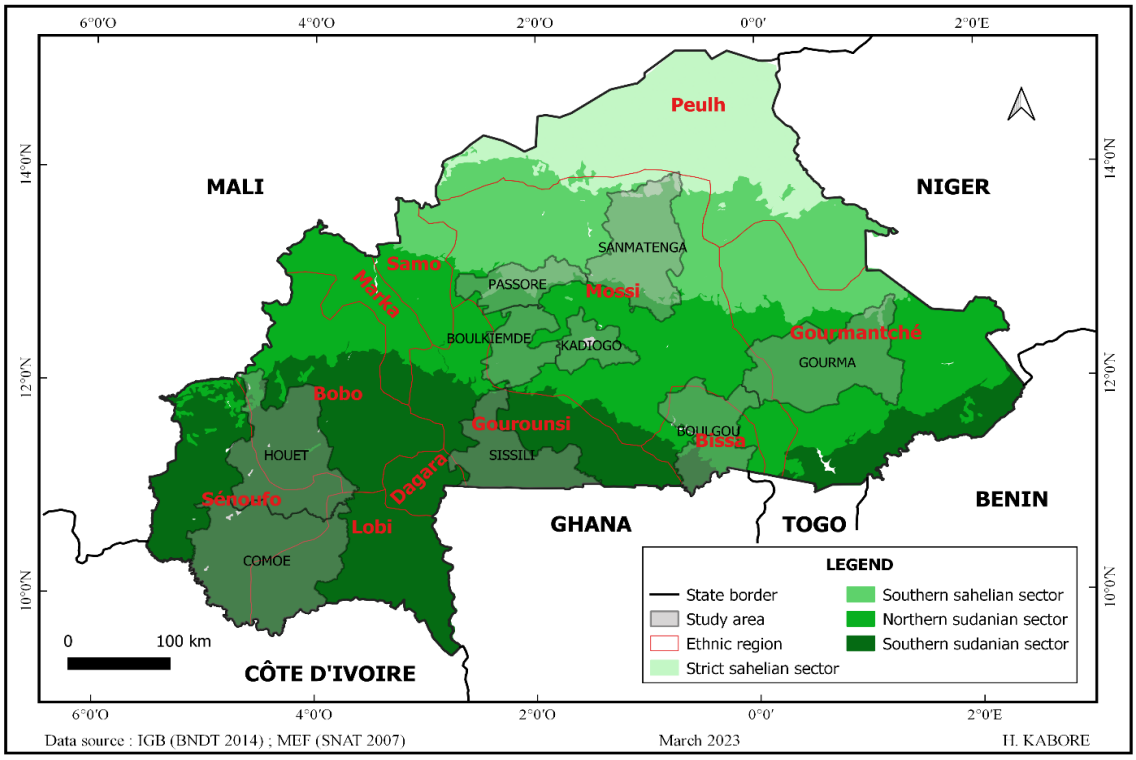

Figure 1. Map of Burkina Faso showing phytogeographic sectors, major ethnic groups and studies provinces.

Results

Profile of respondents

A total of 160 individuals from ten different ethnic groups were interviewed (Table 1). The *Mossis* (63.2%), *Gourounsis* (10%), *Gourmatchemas* (5%), *Senoufos* (5%), *Bobo* (3.75%) and *Bissa* (3.75%) were the dominant ethnic groups. "Other ethnic groups" refers to the collection of ethnic groups whose proportion of the surveyed population was less than 3%. This category included the following ethnic groups: *Peulhs*, *Goins*, *Karaboros*, *Turkas* and *Kos*.

The respondent's age varied from 18 to 90 and the majority were male (62.5%) and illiterate (56.9%). All respondents' primary occupation is agriculture, but some also were engaged in other supplementary activities. Consequently, 12.42% of respondents were also traditional healers, 8.33% were breeders, and 10.2% were involved in other activities such as trading, catering, mechanics, etc.

Table 1. Percentage of people surveyed by ethnic group, sex, age group and academic level

Socio-cultural factors	Modalities	Proportion (%)
Ethnic groups	*Mossi*	63.12
	Bobo	3.75
	Gourmatche	5.63
	Bissa	3.75
	Senoufo	5.00
	Gourounsi	10.00
	Other ethnic groups	8.75
Sex	Male	62.51
	Female	37.49
Age	Age ≤30	8.13
	30<age ≤60	68.12
	Age >60	23.75
Academic level	Illiterate	56.90
	Literate	36.20
	Educated	6.90

The survey revealed that the only ethnic group in the sub-Sahelian sector's population was the *mossi*. In the north Sudanian sector, the ethnic group *mossi* was the most representative (69.81%) but other ethnic groups such as *gourmatchemas* (16.98%) and *bissa* (11.32%) were also recorded.

Many ethnic groups were identified in the South Sudanian sector. These are the *gourounsis* (29.63%), *mossis* (20.37%), *senoufos* (14.81%), *bobos* (11.11%), and *turkas* (9.26%). In the southern and northern Sudanese sectors, the other ethnic groups represented respectively 14.81% and 1.89% of the respondents.

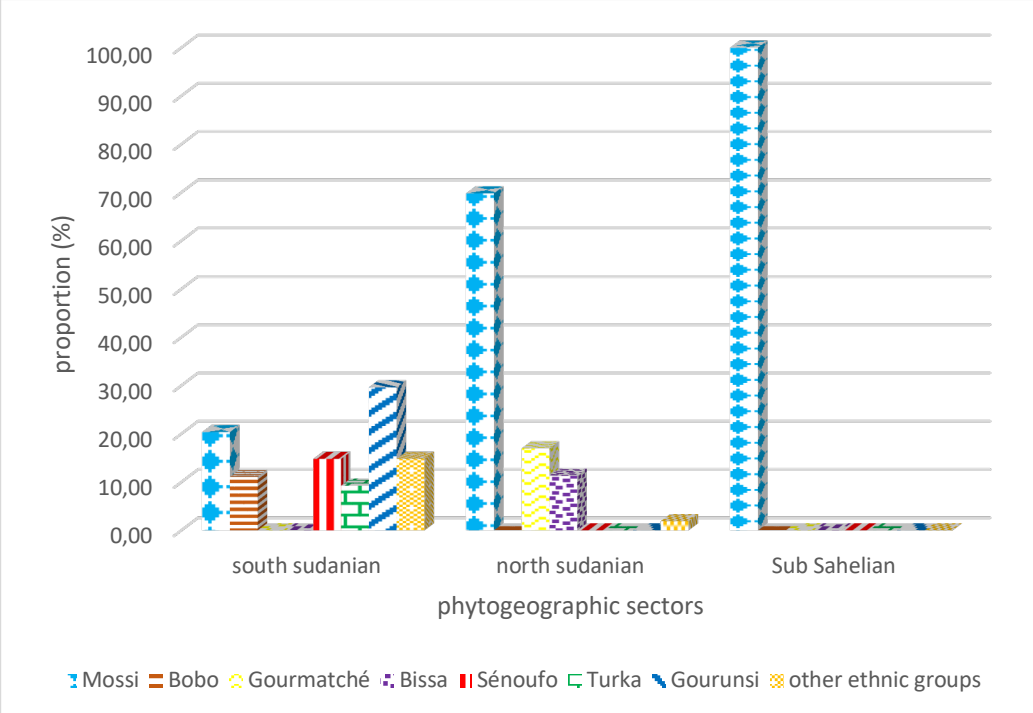

Figure 2. Distribution of the respondents by ethnic groups by phytogeographical sectors

Knowledge, identification and perceptions of the variability of *O. americanum*

Hoary basil is well-known and could be identified by nearly the whole farmers (99.37%). Moreover, 21.25% of respondents indicated that the species has various morphotypes. Indeed, plant size, leaf color and branching ability were used by respondents to describe variability within the species. According to these characteristics, two morphotypes were identified by the farmers. The first morphotype, also known as "male basil" is characterized by its small plant size, thin, green leaves,

and sparsely branching stems. According to the respondents, this morphotype can be used to feed animals in their fresh stage before flowering. The second morphotype, also known as the "female basil" has a large foliage with light-green leaves that have a strong aroma and densely branched stems.

Local perceptions of population dynamics of *O. americanum*

For the five years preceding the year of the study, the majority of respondents (54.4%) noticed a decline (regression) in the populations of *O. americanum* in nature (Figure 3). But still, 31.9% of respondents claimed that *O. americanum* populations increased in the study region when only 8.8% noticed that *O. americanum* populations were stable. Therefore, some respondents (4.4%) recognized that there is variation in the species' populations according to the rainy season length. Abundant rainfall is favorable to the development of large populations of *O. americanun*.

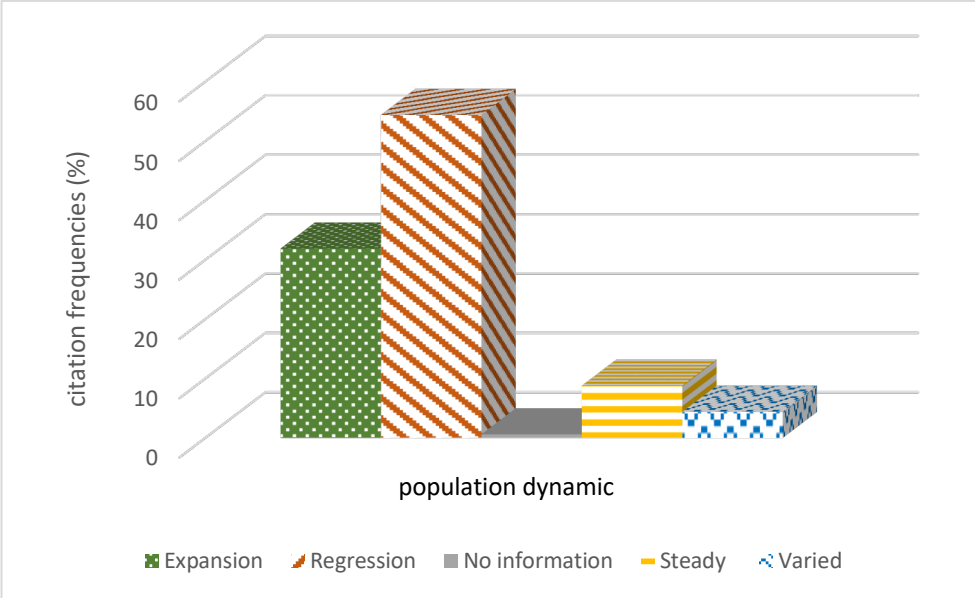

Figure 3. *O. americanum* population dynamics

Mode of management of *O. americanum* by the local population

O. americanum is a non-cultivated species and is considered a weed in fields, according to the majority of respondents (Figure 4). So, 75.6% of respondents removed it automatically from their fields. Nevertheless, some farmers (23.8%) practice the species' paraculture for beneficial reasons.

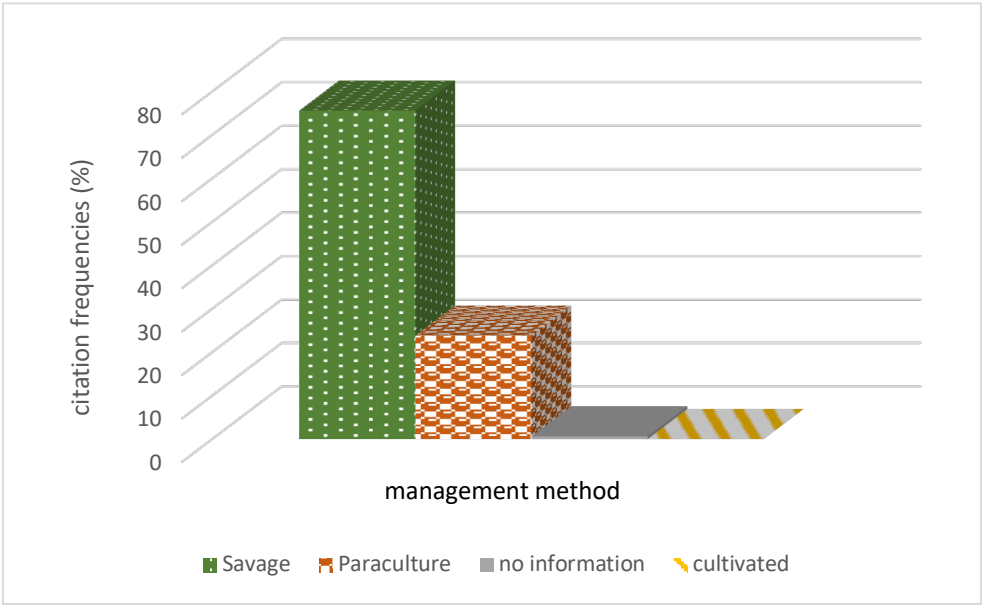

Figure 4. The local population's method of *O. americanum* management

Socio-cultural factors influencing the diversity of use of *O. americanum*

The model developed to assess the impact of socio-cultural factors on the use values of *O. americanum* is globally significant at a threshold of 5%. The coefficient of determination (R^2) shows that the socio-cultural factors explained 86% of the variation of use (Table 2). The results show that the use value is significantly influenced by age, ethnic group and academic level at a threshold of 5% (p-value 5%). Indeed, the results show that respondents with higher academic levels are better aware of the variety of uses for *O. americanum*. The higher use value was observed for the ethnic groups of Bissa (28%) and Bobo (31%). However, the use value for the young respondents (those under 30 years old) is -9%.

Table 2. Correlation between Use Value and socio-cultural factors of *O. americanum*

Variables	Modalities	Coeff	Pr	Sig
Age	Young	-0.09	0.0000	***
	Old	-0.01	0.41	ns
Ethnic groups	*Bissa*	0.28	0.0000	***
	Bobo	0.31	0.0000	***
	Gourmatche	0.02	0.33	ns
	Gourunsi	-0.14	0.0000	***
	Mossi	-0.19	0.0000	***
	Senoufo	-0.001	0.96	ns
Sex	Male	0.001	0.91	ns
Educational level	Illiterate	-0.02	0.08	ns
	Educated	0.08	0.0000	***
F test		0.0000		
R^2		0.86		

*** p<.01, ** p<.05, * p<.1

Legend:Coeff:coefficient; Sig:significance; R^2:coefficient of determination ; ns :not significant; Pr: probabilty; F test:Fisher's test

Uses of *O. americanum*

The local people use *O. americanum* as a biopesticide, spice and food flavoring, insect repellant, and medicinal plant in the treatment of various diseases (Figure 5). In herbal medicine, 49.47% of those surveyed stated that the species is used in traditional medicine to treat a range of diseases (Table 3). Indeed, the species' leaves would be used in several ways to treat a variety of diseases like diabetes, hypertension colds, etc. In addition, the entire plant would be used to make a filtrate or decoction to cure diseases like malaria. The seeds are used in the treatment of diarrheal illnesses or to remove impurities from the eyes.

Table 3. Organs used, diseases treated and forms of use of *O. americanum*

Used organs	diseases cured by basil organs	forms of use
Leaves	earache, sterility, common cold, fever, painful rule, breast pain, diabetes, high blood pressure	filtrate, smoke, decoction, natural, infusion
Entire plant	malaria, high blood pressure, common cold, headache, tonsillitis	decoction, infusion, Filtrate, smoke,
Seeds	cleans eyes, diarrhoea, the common cold	natural, decoction

O. americanum is also used in mystical ways, most frequently in the treatment of juvenile diseases. Indeed, 12.63% of respondents said that women would use it to drive evil spirits away from kids, especially babies, or to fend off evil spirits from concessions. According to 11.23% of the people interviewed, *O. americanum* is used as feed for animals like rabbits when fresh grass is scarce in the natural habitat. The results showed that 9.47% of those polled mentioned the species as an insect repellent because of the way it smells, which would repel insects like mosquitoes, cockroaches, spiders, etc. The usage of the species in human food is also mentioned by 9.47% of respondents. The leaves are used as a spice, leafy vegetable, and

for tea flavoring. Some respondents mentioned that *O. americanum* leaves are used for deodorizing shea butter, fresh meat, and fresh fish. Regarding its application as a biopesticide, 5.96% of respondents mentioned the species in the preservation and protection of seeds and foodstuffs against attacks by insects and fungi. This protection is mostly applied to cereals (corn) and legumes (cowpeas, Bambara nut).

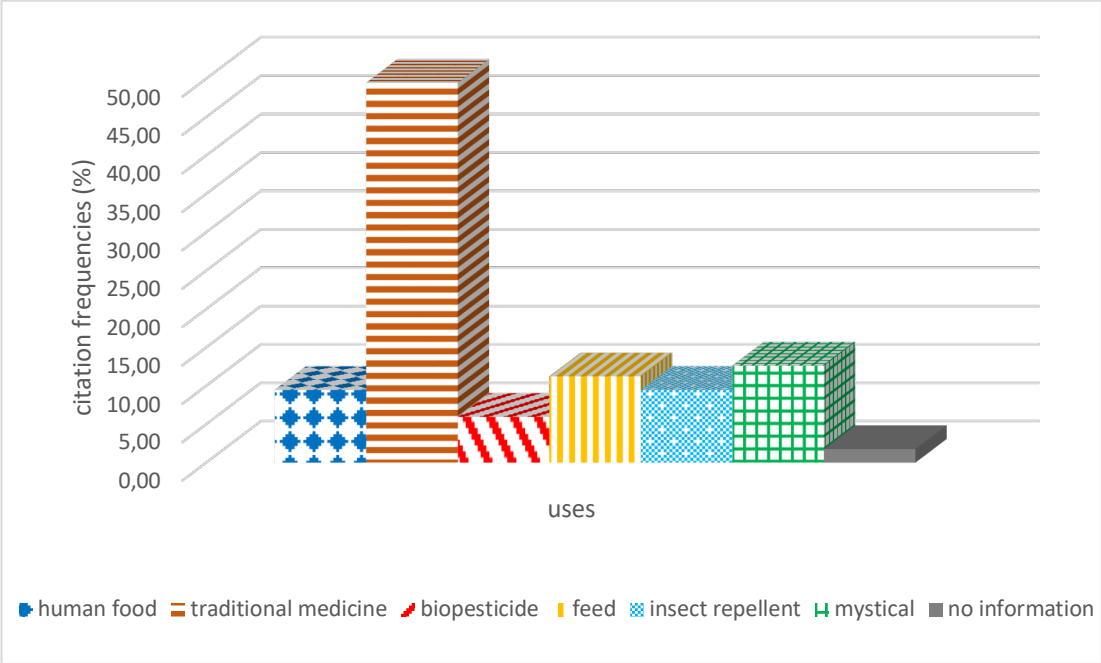

Figure 5. Uses of *O. americanum*

O. americanum's uses varied according to the phytogeographic sectors (Figure 6). Six utilizations have been identified in the North Sudanese and South Sudanese sectors. However, four uses have been reported in the sub-Sahelian sector. Indeed, *O. americanum*'s uses in human food and seed preservation were not mentioned in this sector. In all the phytogeographic sectors studied, the majority of farmers mentioned the use of *O. americanum* in traditional medicine. The use of the species as human food is more cited by the farmers from the southern Sudanian sector (23.47%), while the use of *O. americanum* in seed conservation is more cited by respondents from the northern Soudanian sector (12.93 %).

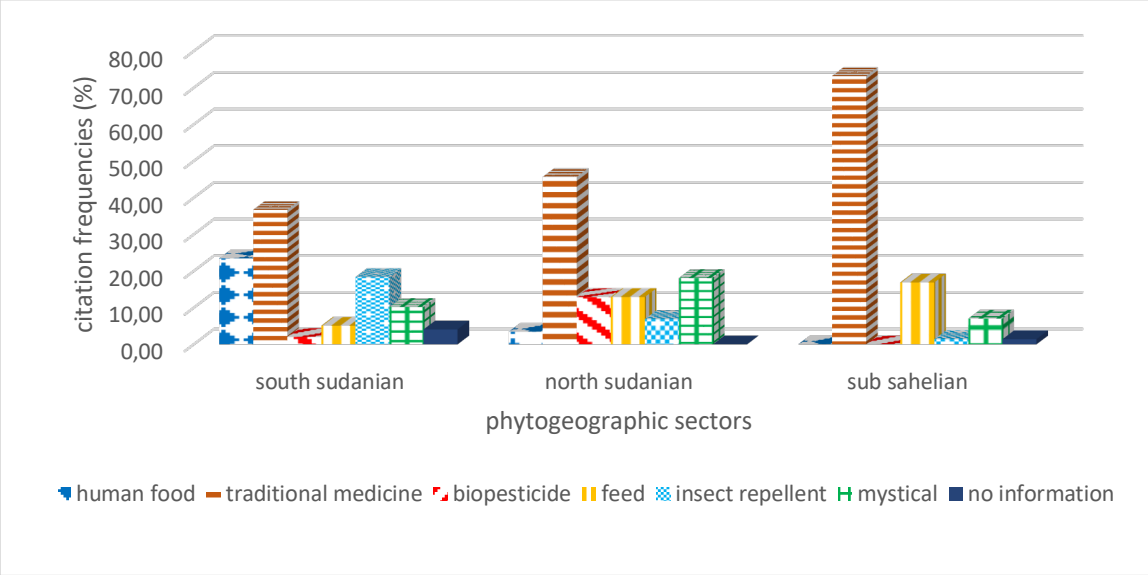

Figure 6. Uses of *O. americanum* according to phytogeographic sectors

Discussion

In the current study, adults (aged 30 or more) represented the majority of the population interviewed. This can be explained by the fact that older people have a better understanding of minor and wild species management than young people. As a matter of fact, according to Kudokpon *et al*. (2016), it is the elderly who tend to the ancestors' knowledge of plants. Nacambo *et al*. (2021) also mentioned that extending the survey to the elderly would provide increasing access to traditional endogenous knowledge and practices on species. Nevertheless, the inclusion of young people in the study should lead to the evaluation of their degree of plant knowledge. The men made up most of the respondents. The respondents' inclusion of traditional healers might account for this. Indeed, traditional healers constitute a more restricted class of knowledge on the plants used traditionally and are often associated with other sciences such as geomancy reserved for men and intended for the elderly.

Previous research works mentioned similar observations (Agbankpe *et al.* 2014, Danssou *et al.* 2014, Klotoe *et al.* 2013). The results also showed that many ethnic groups were considered in this investigation according to Adjatin (2006), endogenous knowledge varies from one ethnic group to another. The presence of different ethnic groups contributes to evaluating the variability of farmers' knowledge of wild species. Also, the studies of Gaoue *et al.* (2017) suggested that a given plant species or family is selected and used depending on the socio-demographic characteristics of local communities. Thus, it is crucial for ethnobotanical research to consider socio-demographic factors.

O. americanum is well known by the local population. This might be explained by the species' wide distribution in Burkina Faso and its capacity for adaptation to different ecological and agroclimatic zones and the various uses by local communities. Its socioeconomic importance might also be used to account for the local population's high degree of knowledge. Indeed, the survey's findings showed that hoary basil was served in traditional medicine. According to Bussmann *et al*. (2006) and Koudokpon *et al.* (2015), the species of the family of *Lamiaceae* are commonly used as medicinal herbs by herbalists and traditional healers. The results of this investigation also indicated that *O. americanum* is used in human food. Its use as food has also been noted by Yayi *et al*. (2011). The knowledge of a species' usage, however, differs depending on the phytogeographic sectors. The existence of many ethnic groups in these sectors could explain this finding. The use value varied according to sociocultural factors such as ethnic groups, age, and academic levels. It is then crucial to include these socio-cultural parameters while working on endogenous knowledge.

The level of knowledge of the species could be linked to its bio-pesticidal potential. The repellent effect of *O. americanum* might enable local communities to prevent paludism and other insect-borne diseases. Previous research works revealed that *O. americanum* is widely used as a repellent against many insects such as *Aedes aegypti*, *Anopheles dirus*, and *Culex quinquefasciatus* (Ali *et al*. 2022, Cavalcanti *et al.* 2004, Chan *et al*. 2021, Chokechaijaroenporn *et al.* 1994, Tawatsin *et al.* 2001, Win and Thar 2019, Zengin *et al.* 2019). Biochemical investigations support this endogenous knowledge. Ilboudo (2009) also mentioned the insecticidal properties of *O. americanum*. This species can be a low-cost alternative for insect control. Many other proprieties were also revealed by other research on this species. These are larvicidal, antifungal, and antibacterial effects (Dellar *et al.* 1996, Lisboa *et al.* 2006, Lukwa 1994, Owuor & Kisangou 2005). These proprieties might explain why *O. americanum* is used as a biopesticide to preserve seeds and foods.

The majority of respondents mentioned a regress in *the O. americanum* population. This might be explained by factors such as population expansion, climate change, and bad farming practices that deteriorate natural ecosystems. According to Gaisberger *et al.* (2017) and Traoré *et al.* (2019), the deterioration of natural ecosystems contributes to species regression in the environment. Kabré (2021) claims that this decrease in local species populations endangers biodiversity and hurts the food, nutritional, and financial security of the communities who strongly rely on them.

In Burkina Faso, hoary basil is still an uncultivated herb, unlike in nations like Nigeria, Cameroon, and Benin (Onayade *et al.* 1990, Yayi-Ladekan *et al.* 2011). The findings offered trustworthy data and tools for building up sustainable strategies for the development, promotion, and domestication of hoary basil.

Conclusion

In the lengthy process of domesticating the species, the highlighting of hoary basil local perceptions in Burkina Faso and its ethnobotanical assessment serve as a basis. In Burkina Faso, vulnerable groups may benefit from the development and promotion of natural resources like hoary basil. Studies of the genetic diversity and the content of its essential oils could be

conducted to fulfil these results and then contribute to establishing a sustainable strategy for the preservation and valorisation of hoary basil genetic resources.

Declarations

Ethics statement: Each participant gave their oral agreement before the survey
Consent for publication: All authors gave their verbal consent.
Availability of data and materials: The manuscript contains all the data.
Competing interests: We declare that there is no conflict of interest.
Funding: The authors did not receive any funding for this study.
Authors' contributions: KH and NKR designed the study; KH conducted the fieldwork, KH and NKR conducted the main statistical analysis; KH wrote the manuscript, KM and NKR revised the data analysis and the manuscript; all authors read, corrected, and approved the manuscript.

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Literature Cited

Adjanohoun EJ. Adjakidjè V, Ahyi MR.A, AkéAssi L, Akoègninou A, d'Almeida J, Apovo F, Boukef K, Chadare M, Cusset G, Draman K, Eyme J, Gassita JN, Gbaguidi N, Goudote E, Guinko S, Houngnon PLI, Keita A, Kiniffo HV, Kone-Bamba D, Musampa Nseyya A, Saadou M, Sodogandji T, De Souza S, Tchabi A, Zinsou Dossa C, Zohoun T. 1989. Contribution aux études ethnobotaniques et floristiques en République Populaire du Bénin. Agence de Coopération Culturelle et Technique, Paris, France, pp :274-282.

Adjatin A. 2006. Contributions à l'étude de la diversité des légumes feuilles traditionnels consommés dans le département de l'Atacora (Benin). Université de Lomé (Togo), Diplôme d'Études Approfondies, 55 p.

Agbankpé AJ, Dougnon TV, Bankolé HS, Yèhouénou B, Yédomonhan H, Lègonou M. 2014. Etude ethnobotanique des légumes feuilles thérapeutiques utilisés dans le traitement des diarrhées au sud-Bénin (Afrique de l'Ouest). International Journal of Biological and Chemical Sciences 8:1784-1795.

AIDELF. 2008. Démographie et culture. Acte du colloque de Quebec, pp :1162-1171

Ali H, Nguta J, Musila F, Ole-Mapenay I, Matara D, Mailu J. 2022. Evaluation of Antimicrobial Activity, Cytotoxicity, and Phytochemical Composition of Ocimum americanum L. (Lamiaceae). Evidence-Based Complementary and Alternative Medicine,1-11. doi:10.1155/2022/6484578.

Anton R., Lobstein A. 2005. Plantes Aromatiques. Épices, Aromates, Condiments et Huiles Essentielles. Tec & Doc:Paris, 522p.

Assogbadjo AE, Glèlè Kakaï R, Chadaré FJ, Thomson L, Kyndt T, Sinsin B, Van Damme P. 2008. Folk classification, perception and preferences of baobab products in West Africa:Consequences for species conservation and improvement. Economic Botany 62:74-84.

Bayala B. 2014. Etude des propriétés anti-oxydantes, anti-inflammatoires, anti-prolifératives et anti migratoires des huiles essentielles de quelques plantes médicinales du Burkina Faso sur des lignées cellulaires du cancer de la prostate et de glioblastomes. These de doctorat, Université blaise pascal, 224p.

Busmann RW, Gilbreath GG, Solio J, Lutura M, Lutuluo R, Kunguru K, Wood N and Mathenge SG. 2006. Plant use of the Maasai of Sekenani Valley. Maasai Mara, Kenya. Journal of Ethnobiology and Ethnomedicine 2:22.

Cavalcanti ESB, Morais SM, De Lima MAA, Santana EWP. 2004. Larvicidal activity of essential oils from Brazilian plants against Aedes aegypti L. Memorias do Instituto Oswaldo Cruz 99:541- 545.

Chan SM, Khoo KS, Sekaran SD and Sit NW. 2021. Mode-dependent antiviral activity of medicinal plant extracts against the mosquito-borne chikungunya virus. Plants 10(8):1658.1644.

Chevalier A. et Perrot E., 1905. Les *Coleus* à tubercules alimentaire. *In* :les végétaux utiles de l'Afrique Tropicale francaise. Etudes scientifiques et agronomiques, Vol I, Fasc. I, Paris, pp:100-152.

Chokechaijaroenporn O, Bunyapraphatsara N, Kongchuensin S. 1994. Mosquito repellent activities of *Ocimum* volatile oils. Phytomedicine:International Journal of Phytotherapy and Phytopharmacology.

Danssou HG, Ogni CA, Yédomonhan H, Adomou AC, Tossou M, Dougnon JT, Akoègninou A. 2014. Diversité, usages vétérinaires et vulnérabilité des plantes médicinales au Nord-Bénin. International Journal of Biological and Chemical Sciences 8(1):189-210.

Dellar JE, Cole MD and Waterman PG. 1996. Antifungal polyoxygenated fatty acids from *Aeollanthus parvifolius*. Journal of Chemical Ecology 22:897- 906. doi:10.1007/BF02029943

Fontès J et Guinko S. 1995. Carte de la végétation et de l'occupation des sols du Burkina Faso. Notice explicative, Ministère de la coopération française, projet Campus, Toulouse, p.68.

Gaisberger H, Kindt R, Loo J, Schmidt M, Bognounou F, Da SS, Diallo OB, Ganaba S, Gnoumou A, Lompo D, Lykke AM, Mbayngone E, Nacoulma BMI, Ouedraogo M, Ouedraogo O, Parkouda C, Porembski S, Savadogo P, Thiombiano A, Zerbo G, Vinceti B. 2017. Spatially explicit multi-threat assessment of food tree species in Burkina Faso:A fine-scale approach. Plos One 12(9):e0184457. doi:10.1371/journal. pone.0184457

Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC and McMillen H. 2017. Theories and major hypotheses in ethnobotany. Economic Botany 71:269-287

Ilboudo Z. 2009. Contribution à l'étude de l'activité Biologique des huiles essentielles contre *Callosobruchus maculatus* Fab. (Coleoptera :Bruchidae), en vue de leur utilisation optimale en protection des stocks de niébé au Burkina Faso. Thèse de doctorat, université de Ouagadougou, Burkina Faso, 126p.

Janssen A.M, Scheffer JJC, Ntezurubanza L, Baerhem-Svendsen A. 1989. Antimicrobial activities of some *Ocimum* species grown in Rwanda. Journal of Ethnopharmacology,26:57-63.

Kabré B. 2021. Connaissances sur les plantes ligneuses alimentaires locales et disponibilité des des ressources *de Saba senegalensis* (A. DC.) Pichon et de *Ziziphus mauritiana* Lam. au Burkina Faso. Doctorat unique, université Joseph Ki-Zerbo, 156P.

Kaou AM, Mahiou-Leddet V, Hutter S, Aïnouddine S, Hassani S, YahayaI, Azas N, Ollivier E. 2008. Antimalarial activity of crude extracts from nine African medicinal plants. Journal of Ethnopharmacology 116(4):74- 83.

Klotoé JR, Dougnon TV, Koudouvo K, Atègbo JM, Loko F, Akoègninou A, Aklikokou K, Dramane K, Gbeassor M. 2013. Ethnopharmacological survey on antihemorrhagic medicinal plants in South of Benin. European Journal of Medicinal Plants, 3(1):40-51.

Koudokpon H, Dougnon TV, Bankolé HS, Fah L, Hounmanou YMG, Baba-Moussa L, Loko F. 2015. Enquête ethnobotanique sur les plantes utilisées dans le traitement des infections au Sud-Bénin. Cahiers UAE 10-1:55-71

Lakusic B, Lakusic D, Jancic R and Stevanovic B. 2006. Morpho-anatomical differentiation of the Balkan populations of the species *Teucrium falvum* L. (*Lamiaceae*). Flora 201:108-119.

Lisboa ACCD, Mello ICM, Nunes RS, Dos Santos MA, Antoniolli AR, Marçal RM, Cavalcanti SC. 2006. Antinociceptive effect of Hyptis pectinata leaves extracts. Fitoterapia 77:439-442.

Luanda A, Ripanda A, Sahini MG, Makangara JJ. 2023. Ethnomedicinal uses, phytochemistry and pharmacological study of Ocimum Americanum L.:A review. Phytomedicine plus, 16p. doi:10.1016/j.phyplu.2023.100433

Lukwa N. 1994. Do traditional mosquito repellent plants work as mosquito larvicides? African Journal of Medicine 40:306-309.

Monjoin M. 1981. Possibilité d'utiliser la médecine traditionnelle pour améliorer les soins de santé primaire aux Comores. Thèse de doctorat (PhD), Université de Bordeaux-II, p.340.

Morton. 1981. Atlas of Medicinal Plants of Middle America I. Springfield:Illinois, USA; 745-750.

Nacambo H, Nanema KR, Kiébré M, Traoré RE, Sawadogo N, Ouédraogo MH, Tiama D, Bougma LA, Sombié PAED, Sawadogo B, Bationa/Kando P, Sawadogo M. 2021. Nomenclacture locale et usage de *Senna obtisifolia* (L.) au Burkina Faso. Journal of Applied Biosciences 160:16436-16453, ISSN 1997-5902.

Onayade OA, Looman A, Scheffer JJC, Svendsen AB. 1990. Composition of the herb essential oil of *Hyptis spicigera* Lam. Flavor and Fragrance Journal 5(2):101-105.

Ouédraogo A. 2006. Diversité et dynamique de la végétation ligneuse de la partie orientale du Burkina Faso. Thèse de doctorat unique, Université de Ouagadougoun, 195 p.

Owuor BO and Kisangau DP. 2005. Kenyan medicinal plants used as antivenin: a comparison of plant usage. Journal of Ethnobiology and Ethnomedicine,2:7.

Phillips O, Gentry AH, Reynel C, Wilkin P, Gálvez-Durand BC. 1994. Quantitative ethnobotany and Amazonian conservation. Conservation Biology 8(1):225-248.

Pousset JL. 1989. African medicinal plants: Practical utilization. Univ. Poitier, ACCT, Paris, France, 156p. ill ISBN 2-7298-8918-3

R Core Team. 2022. R:A language and environment for statistical computing. R Foundation, for statistical computing, Vienna, Austria, URL https://www.R-project.org/.

Rivière L, Pasquier B, et Godin M. 2017. La diversité du genre *Ocimum* dans les collections du CNPMAI. Conservatoire National des Plantes à Parfum, Médicinales, Aromatiques et Industrielles, 286p.

Rossato SC, Leitao FH, and Begossi A. 1999. Ethnobotany of caicares of the Atlantique forest coast (Brazil). Economic Botany, 53:387-395.

Tawatsin A, Wratten SD, Scott RR, Thavara U, Techadamrongsin Y. 2001. Repellency of volatile oils from plants against three mosquito vectors. Journal of Vector Ecology 26:76- 82.

Traoré GH, Sanou L, Koala J. 2019. Diversité d'utilisations et de connaissances des espèces locales preférées dans le corridor forestier de la Boucle du Mouhoun, Burkina Faso. Science et technique, Sciences naturelles et appliquées 38(1) 101-117

Win KS and Thar AC. 2019. Comparative Studies on Phytochemical Screening and Blood Glucose Lowering Activity of Leaves of Gynura procumbens (Lour.) Merr and *Ocimum americanum* L., in 2nd 64 Myanmar Korea Conference Research Journal. pp. 64- 68.

Yayi-Ladekan E, Kpoviessi DSS, Gbaguidi F, Kpadonou-Kpoviessi BGH, Gbenou J, Jolivalt C, Moudachirou M, Accrombessi GC et Quetin-Leclercq J. 2011. Variation diurne de la composition chimique et influence sur les propriétés antimicrobiennes de l'huile essentielle de *Ocimum canum* Sims cultivé au Bénin. International Journal of Biological and Chemical Sciences 5(4) :1462-1475, 14p.

Zahran EM, Abdelmohsen UR, Khalil HE, Desoukey SY, Fouad MA, Kamel MS. 2020. Diversity, phytochemical and medicinal potential of the genus *Ocimum* L. (Lamiaceae). Phytochemistry Reviews. doi:10.1007/s11101-020-09690-9.

Zengin G, Ferrante C, Gnapi DE, Sinan KI, Orlando G, Recinella L, Diuzheva A, Jeko J, Cziaky Z, Chiavaroli A, Leone S, Brunetti L, Picot-Allain C, Mahomoodally MF, Angelini P, Covino S, Venanzoni R, Tirillini B, Menghini L. 2019. Comprehensive approaches on the chemical constituents and pharmacological properties of flowers and leaves of American basil (*Ocimum americanum* L). Food Research International. doi:10.1016/j.foodres.2019.108610