# Utilizations, vulnerability and conservation practices of *Saba senegalensis* (A. DC.) Pichon (Apocynaceae), a high value local species in Burkina Faso

# Utilisations, vulnérabilité et practiques de conservation de *Saba senegalensis* (A. DC.) Pichon (Apocynaceae), une espèce locale à haute valeur socio-économique au Burkina Faso

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## Research

## Abstract

*Background*: *Saba senegalensis* is a woody liana that provides medicinal products, food, income and ecological benefit (soil and water conservation) to the populations in sub-Saharan Africa. In Burkina Faso, the species is mismanaged by the local population, but few studies have been conducted on its uses. This study seeks to understand the local knowledge of *S. senegalensis* uses and its vulnerability.

*Methods*: Semi-structured ethnobotanical surveys were conducted in the provinces characterized by slightly (Houet), moderately (Mouhoun) and severely (Yatenga) dry climate in Burkina Faso. A total of 180 randomly selected individuals responded to the questionnaire. Socio-demographic characteristics of the informants, the plant parts used, and the categories of uses were recorded. Analyses included an index of uses and vulnerability, importance values of plant parts used, and frequency calculations.

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*Results:* Local knowledge of *S. senegalensis* uses varied according to the locality and informant age. Seven use categories were identified: traditional medicine, food, construction, fodder, handicrafts, domestic energy, and magic. All vegetative organs of *S. senegalensis* are used. The species' vulnerability index (IV=2.75) is higher than 2.50, making it vulnerable. The leaves and tendrils plant are the most common plant parts used in traditional medicines. Generally, crude drugs are used in the form of decoction, followed by infusion forms. The diversity of medicinal uses of *S. senegalensis* highlights the need for future ethno-pharmacological studies of the species. Exploitation of the fruits of the species contributes substantially to food and nutritional security and to improving the living conditions of local populations.

*Conclusion:* Our findings provide essential information for decision-making for effective domestication initiatives for *S. senegalensis*. The findings also provide a baseline for future research into the development of value chains for the species. They also draw attention to the need for conservation measures for the plant.

*Keywords:* Local knowledge; wild fruit tree; goose liana; forest products; use category; metric index; vulnerability index.

## Resumé

*Contexte* : La liane goïne (*Saba senegalensis*) est une liane ligneuse qui fournit des médicaments, de la nourriture, des revenus et des avantages écologiques (conservation des sols et de l'eau) aux populations d'Afrique subsaharienne. Au Burkina Faso, l'espèce est mal exploitée par les populations locales alors que peu d'études se sont intéressées sur ses usages. L'objectif de la présente étude est d'appréhender les connaissances locales sur *S. senegalensis* et les pratiques qui sont source de sa vulnérabilité.

*Méthodes*: La collecte des données s'est faite au moyen d'interviews semi-structurées conduites dans les provinces caractérisées par un climat légèrement (Houet), modérément (Mouhoun) et sévèrement (Yatenga) sec au Burkina Faso. Au total, 180 personnes choisies de manière aléatoire ont répondu au questionnaire. Les caractéristiques sociodémographiques des informateurs, les organes utilisés de la plante et les domaines d'utilisation ont été recensés. Le traitement des données a consisté en des calculs de fréquences et des indices de valeurs d'usage, d'importance et de vulnérabilité (IV) des organes de l'espèce.

*Résultats* : Les résultats ont montré que les connaissances locales relatives aux usages de *S. senegalensis* varient suivant les localités et l'âge des répondants. L'espèce est sollicitée dans sept domaines d'usage que sont : la médecine traditionnelle, l'alimentation, la construction, le fourrage, l'artisanat, l'énergie domestique et socio-culturel. Tous les organes de la plante sont utilisés. L'indice de vulnérabilité (IV = 2,75) est supérieur à 2,50 classant ainsi l'espèce comme très vulnérable. Les feuilles et les vrilles sont les organes les plus couramment utilisées dans la médecine traditionnelle. Généralement, les médicaments à l'état brut sont utilisés sous forme de décoction, suivie de formes d'infusion. La diversité des usages médicinaux de l'espèce constitue un atout pour la valorisation de ses propriétés médicinales à travers des études ethno-pharmacologiques. En plus des usages médicinaux, l'exploitation des fruits de l'espèce contribue substantiellement à l'amélioration de la sécurité alimentaire et nutritionnelle et des revenus des populations locales.

*Conclusion*: Nos résultats fournissent des information de base pours des recherches futures en vue du développement de chaînes de valeur de l'espèce à travers la mise en place d'une véritable filière. Aussi, ils attirent l'attention sur la nécessité de prise de mesures pour la conservation de la plante.

*Mots clés:* Connaissances locales, fruitier sauvage, liane goïne, Produits forestiers, domaine d'usage, indice métrique, indice de vulnérabilité.

## Background

Rural people depend on plant resources and use their accumulated knowledge over time to benefit from them and manage them sustainably (Berkes *et al.* 2000, Cotton *et al.* 1997). In sub-Saharan Africa, rural people exploit local plant parts for food, medicine, fodder, energy and to support other aspects of their well-being (Masters *et al.* 2004, Pehou *et al.* 2020). The exploitation of local plants, although creating significant income to support the economy of these rural populations and improve their living conditions, is still traditional (artisanal) and local. Previous work has shown that rural populations are the primary knowledge holders of local plants (Aziz 2021).

The exploitation of non-timber forest products by local populations is done through the use of traditional know-how passed down from generation to generation (Aziz 2021, Silva de Oliveira *et al.* 2021). This traditional or local knowledge constitutes the knowledge accumulated by a community about its surrounding environment and which influences the daily lives of community members (Cotton 1997, Nadembega *et al.* 2011, Saussey *et al.* 2008). Increasingly, such traditional knowledge is proving vital to complement scientific knowledge, especially in the sustainable management of forest ecosystems, but also in the domestication of wild tree species with high production potential (Olsson *et al.* 2004, Tengö *et al.* 2013, Watson *et al.* 2003). Some ethnobotanists have indicated the extent of this traditional knowledge in the knowledge base of medicinal plants and the ailments they cure as well as other cultural values attached to these products (Adjanohoun *et al.* 1988).

Patterns in the distribution of local plant knowledge may vary according to cultural (Kouyaté *et al.* 2020, Ouédraogo *et al.* 2019) and socio-economic variables (Aziz *et al.* 2021, Kouyaté *et al.* 2020, Lawin *et al.* 2019). For example, men and women have distinct ethnobotanical knowledge that is related to the different roles they play in the household (Grenier 1998, Howard *et al.* 2003, Pehou *et al.* 2020). Thus, to understand the distribution patterns of knowledge within communities, quantitative methods have been used (Atakpama *et al.* 2015, Souto & Ticktin 2012), including logistic regression models (Kouyaté et al. 2020, Reyes-García *et al.* 2007, Salako *et al* 2018). This is especially important in the sense that the effects of one variable may depend on the levels of another variable and conducting analyses that do not allow for this could mask the 'true' knowledge of local plant species, and lead to biased conclusions (Souto & Ticktin 2012).

Meeting a community's immediate needs for livelihood resources such as energy, agriculture and livestock, pharmacopoeia, and handicrafts usually leads to excessive pressures on local forest resources. This overexploitation leads to a slow recovery of forest resources, thereby compromising the provision of goods and services for present and future generations. This is notably the case for *Saba senegalensis* (A. DC.) Pichon, which is a wild woody liana species of the Apocynaceae family native to sub-Saharan Africa. The species is commonly found in riverine areas and open woodlands at elevations from near sea level to around 800 m (Orwa *et al.* 2009). It is a bushfire resistant species (Arbonnier 2009) in environments with low to moderate rainfall (Martin *et al.* 1987). It occurs in areas where annual precipitations range from 600-1500 mm (Le Houerou 1986). The species begins to bear fruit around 3-4 years after planting (Arbonnier 2009). Previous studies have revealed certain uses of *S. senegalensis* in various countries. Thus, the species is known as a medicinal and food plant (Arbonnier 2009, Kouyaté *et al.* 2020, Sarr *et al.* 2018) with multiple uses and a strong potential to contribute to soil and water conservation. It produces ovoid berries whose sweet-acid pulp is rich in vitamins A, B, K and C, dietary fiber, and minerals such as iron, potassium, magnesium and calcium (Diabagaté *et al.* 2019, Lamien *et al.* 2010, Nafan *et al.* 2013, Tiendrébéogo *et al.* 2020). The trade of fruits contributes to income generation and the improvement of livelihoods of rural populations in the Sudanian savannahs throughout West Africa (Lamien *et al.* 2010; Sarr *et al.* 2018). In Burkina Faso, *S. senegalensis* is one of the woody species that is largely exploited (Hien *et al.* 2021; Kabré *et al.* 2020, Ouédraogo *et al.* 2017) but has received limited research attention.

A strategy of domestication and conservation of *S. senegalensis* must therefore be implemented to ensure the sustainability of this forest resource and the preservation of local biodiversity. Conservation strategies for *S. senegalensis* cannot be sustainable if they do not consider the social, cultural and economic values that local communities place on this species. In this sense, an ethnobotanical study of *S. senegalensis* is appropriate to better understand the uses and socio-cultural perceptions of the species by local people in Burkina Faso and other parts of sub-Saharan Africa.

Most ethnobotanical studies on *S. senegalensis* in Burkina Faso have focused on its medicinal properties and uses (Zerbo *et al.* 2007), and its levels of overexploitation and vulnerability in the north of the country (Hien *et al.* 2020, Ouédraogo *et al.* 2017). Studies are still needed on other uses of the species and its vulnerability in other regions of the country with respect to climate gradient. Thus, the overall objective of the present study was to identify local uses of *S. senegalensis* among different socio-cultural groups in slightly (Houet), moderately (Mouhoun) and severely (Yatenga) dry climate in Burkina Faso. More specifically the study aimed at: (i) to identify the organs/parts of the species used and their types of uses by local people; (ii) to assess the vulnerability of the species in the context of daily use; and (iii) to identify the management practices adopted by the local populations for the conservation of the species.

## Materials and Methods

### *Study site description*

The investigations were carried out at three sites - namely Diaradougou (11° 26' N; 4° 43' W), Tchériba (12° 26' N; 3° 06' W) and Somiaga (13° 30' N; 2° 24' W), located across a climatic gradient in Burkina Faso. Diaradougou is located in the Sudanian climatic zone while that of Tchériba and Somiaga are located in the Sudano-Sahelian zone (Figure 1).

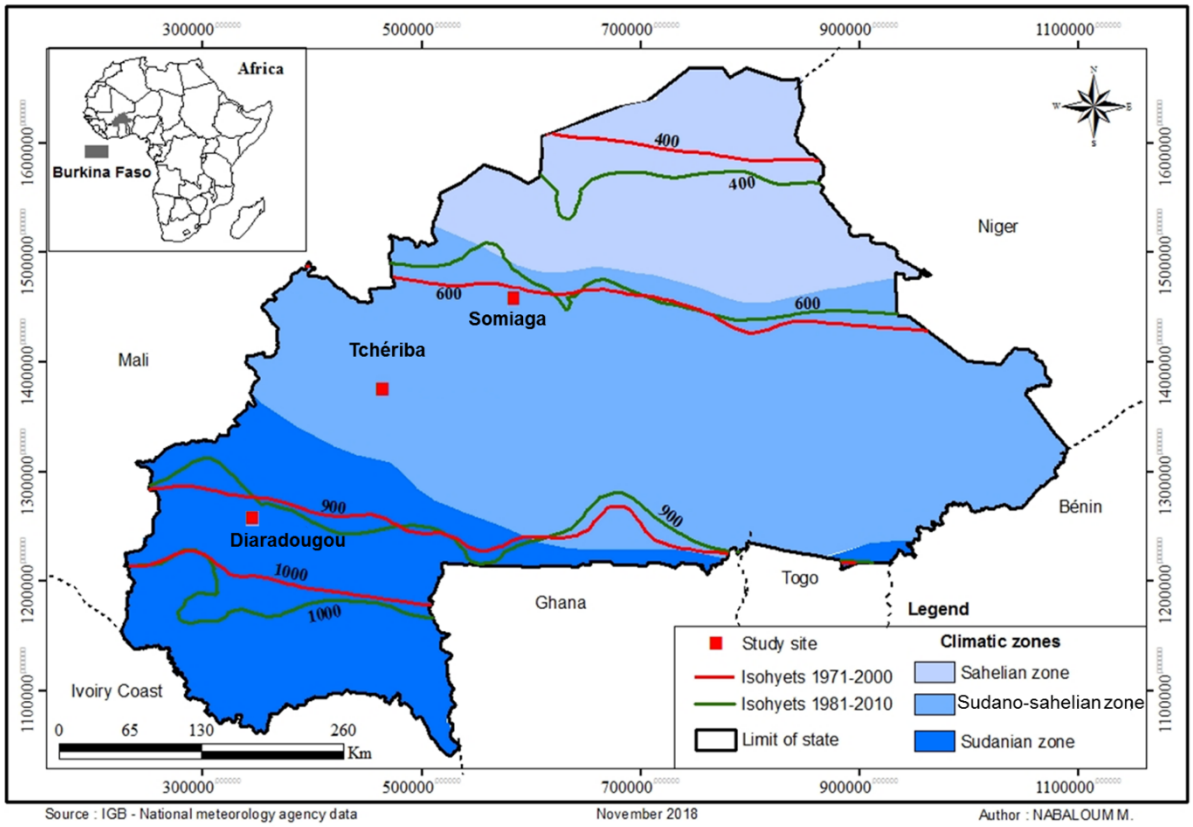


Figure 1. Location of the three study sites in Burkina Faso all highlighted in red color.

The Sudanian zone occupies the southern part of the country, where the rainy season lasts from 5 to 6 months with the level of rainfall attaining or even exceeding 1100 mm annually. It is marked by an average temperature of 27.9°C. The vegetation is dominated by a mosaic of savannahs and woodlands. In the Sudano-Sahelian zone, the annual rainfall varies between 600 and 900 mm over 4- to 5-month period while the annual temperature ranges from 20 to 30 °C. It is the most extensive climatic zone as it extends over all the central part of the country (Thombiano & Kampmann, 2010). *Saba senegalensis* is found in both areas and its plants parts are used by local populations for improve their living conditions (Ouédraogo et al., 2017; Traoré et al., 2019). It has a climbing or bushy habit (Figure 2). The populations of the study areas are mainly composed of dominant ethnic groups such as the Mossi in Somiaga, the Bobo in Diaradougou, and the Gourounsi and Dafing in Tchériba. Agriculture, livestock breeding, and trade are the main activities of these populations, which is similar to other rural communities throughout Burkina Faso.

### *Sampling design and data collection*

Before surveys, a pilot study (pretest) was conducted in June 2019 to determine the number of respondents. In total, a random sample of 50 people, which is a statistically acceptable number ($N > 30$) were selected for the pilot study. In order for the sample size to be representative, the number of respondents was calculated using the following formula (Dagnelie 1998):

In this equation, $N$ is the total number of people surveyed; $U$ is the value of the random normal variable for a probability value of α; $U_{1-\alpha/2} = 1.96$ if $\alpha = 0.05$; $p$ is the proportion of respondents who used or knew the species; and $d$ ($d = 5\%$) is the margin error. In our case, all 50 respondents in each locality knew or used *S. senegalensis*. This means that regardless of the number of people surveyed, the sample size will be representative. This led us to survey 60 people per locality.

A)

B)

Figure 2. Bushy habit (A) and climbing habit (B) of *Saba senegalensis*

Subsequently, individual semi-structured interviews (Cotton 1997) were conducted during the season of availability of *S. senegalensis* between June and August 2019 to identify local uses of the species' organs. The questionnaire sent to the informants was in their local language. In addition, a guide with a good understanding of the local languages and the species name (vernacular and scientific name) assisted us in collecting data in each locality. During the survey, a sample of the species' fruit was shown to the informants for identification of the species. The questionnaire administered to the informants collected data on (i) their socio-demographic characteristics (ethnic group, age, gender), (ii) the local names of the species, (iii) the organs used, (iv) the use categories of each organ, (v) the traditional product(s) made from each organ, (iv) the management practices for the species, and (vi) the degree of availability of the species in time and space.

***Data analysis***

Data processing was carried out with the statistical software package R and consisted of a quantitative analysis using the *ethnobotanyR Package* version 3.6.3 (Whitney *et al.* 2018). The quantitative analysis was used to calculate use and cultural value indices as defined by Tardío and Pardo-deSantayana (2008) and Albuquerque et al. (2006) for multi-species studies. The indices of use values calculated are the basic metrics commonly used in ethnobotany, which are:

- Frequency of citation (*FC*), which is the number of informants who cited the use of organ *i* of the species:

$$FCs = \sum_{i=i1}^{iN} URi \quad (1)$$

- Number of uses (*NU*), which is the number of use categories for each organ of the species:

$$NUs = \sum_{u=u1}^{Unc} URu \quad (2)$$

- Use report (*UR*) per species organ, which is the number of uses reported by all informants and for all use categories of organ *i*.

$$URs = \sum_{u=u1}^{Unc} \sum_{i=i1}^{iN} URui \quad (3)$$

Then, indices from the basic metrics were also calculated:
- Relative frequency of citation (*RFC*):

$$RFCs = \frac{FCs}{N} \quad (4)$$

- Cultural importance index (IC) was calculated by dividing UR by the number of informants

- Use value (UV) per species organ:

$$UV_s = \sum UR_i/N \quad (5)$$

Also, the *ethnobotanyR package* was used to construct a chord diagram linking ethnobotanical uses to the species' organs. This diagram allows a better visualization of the frequency of citation of each organ for the different use categories. *S. senegalensis* use value for each socio-demographic variable (locality, gender and age category) were analyzed using the Generalized Linear Model (GLM) with Poisson error distribution (Zuur *et al.* 2009). Finally, the vulnerability index (IV) of the species was calculated based on the following formula: IV = N/4, with N = N1 + N2 + N3 + N4.

Where N1 is the frequency of citation of the species, N2 is the number of use categories in which the species is found, N3 is the organ used and N4 the harvesting mode (picking, cutting and stump removal) (Badjaré *et al.* 2018, Betti 2001, Traoré *et al.* 2011). The parameters used in the formula are major indicators of the pressures and threats exerted on the species in the study area.

If the IV is < 2, the species is lowly vulnerable; if the IV is 2 ≤ - < 2.5, the plant is moderately vulnerable, and if the IV is ≥2.5, the plant is highly vulnerable.

## Results

### *Demographic information and traditional knowledge about the uses of S. senegalensis*

A total of 180 informants were interviewed and classified into two main age categories: adults (20-50 years) and seniors (>50 years). The informants consisted of 90 men and 90 women with an age range of 20-95 years. They belonged to the following ethnic groups: Bobo, Dafing, Gourounsi and Mossi (Table 1). For their livelihoods, the informants relied mainly on agro-silvopastoral activities or a combination of these activities and other small income generating activities such as trade.

Table 1. Socio-demographic characteristics of the study informants

| Ethnic group | Gender | Adult | Senior | Percentage of total informants (%) | Local name |
|---|---|---|---|---|---|
| Bobo | F | 14 | 12 | 23.33 | **Vô** |
| | M | 4 | 12 | | |
| Dafing | F | 12 | 3 | 11.67 | **Zaban** |
| | M | 1 | 5 | | |
| Gourounsi | F | 9 | 8 | 20 | **Loou** |
| | M | 7 | 12 | | |
| Mossi | F | 24 | 7 | 33.33 | **Wêdga** |
| | M | 10 | 19 | | |
| Minor ethnic group | F | 2 | 0 | 11.67 | |
| | M | 9 | 10 | | |
| Proportion of total informants | | 51.11 | 48.89 | 100 | |

F=female, M=male

In total, 66 uses of the different organs/parts of *S. senegalensis* were cited by the informants (Supplementary material 1). Also, seven use categories were identified by the informants, among which traditional medicine (UR = 345 and CI = 1.92), food (UR = 183 and CI = 1.02) and construction (UR = 95 and CI = 0.53) were the most important according to people's daily needs. The magic domain was the least important use category for the informants (UR = 3 and CI = 0.02) (Table 2).

Table 2. Description of seven use categories and sum of use reports (UR) and cultural importance index (CI) for nine plant organs of *Saba senegalensis* in three localities in Burkina Faso

| Use category | Description | UR | CI |
|---|---|---|---|
| Medicine | Medicinal uses for acute illnesses and general health | 345 | 1.92 |
| Food | Human alimentation in eating and drinking | 183 | 1.02 |
| Construction | Use for service, house building, hangar | 95 | 0.53 |
| Handicraft | Handicrafts, hunting instruments, dyes, toys | 34 | 0.19 |
| Energy | Firewood for cooking mealt | 31 | 0.17 |
| Fodder | Animal alimentation | 7 | 0.04 |
| Magic | Ritual and magical uses | 3 | 0.02 |

In the three villages, nine organs/plant parts were used for different purposes by the local populations (Figure 3), with the most used ones being tendrils and fruits (Table 3). The number of uses was fairly evenly distributed for all organs, while fruits had many uses in one category. The number of uses cited per organ was as follows: bark (3

uses), flower (3 uses), fruit (3 uses), leaf (4 uses), root (5 uses), seed (3 uses), stem (6 uses), tendril (5 uses) and young twigs (4 uses) (Table 3).

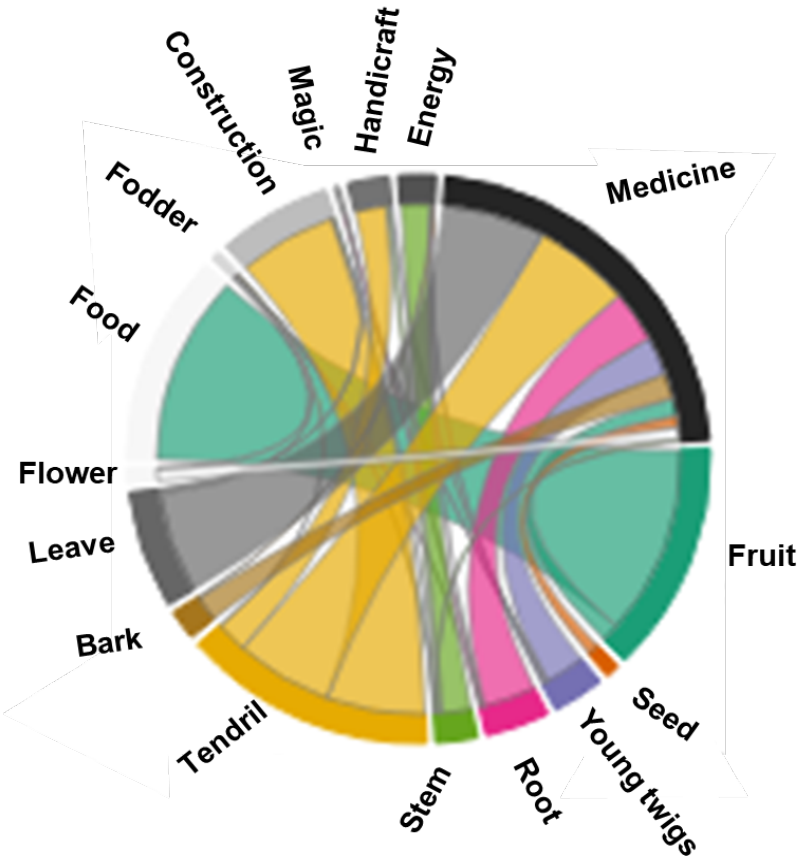


Figure 3. Uses of plant parts of *Saba senegalensis* by the studied local populations in Burkina Faso. Each plant part (bass top half of diagram) is linked to its different uses (upper top half of diagram). For example, the fruits are used in food and traditional medicines.

The informants reported that *S. senegalensis* is used in the treatment of 30 diseases and symptoms (Table 4). In the human pharmacopoeia, the leaves and tendrils of the species are the plant parts that are highly used in the treatment of several diseases. The leaves are used to treat dysentery, diarrhea, umbilical hernia, malaria, and intestinal worms. People in the three localities also combine the leaves of the species with those of other plants to combat sinusitis, hip pain, and dysmenorrhea. The tendrils are also used to treat stomach aches and umbilical hernia. In addition, informants combine the organs of *Cassia sieberiana* with the tendrils of *S. senegalensis* to combat fever and malaria. In veterinary use, the leaves help to treat diarrhea and constipation and to expel retained placenta after birth. In addition, the juice of the fruit pulp helps to treat bloating in cattle. The unripe fruit is used to treat split feet and the epicarp treats ringworm, while the juice of the ripe fruit is used to treat fever and constipation.

In terms of diet, the fruit, which was generally available from May to August, was used by the populations of Diaradougou, Tchériba and Somiaga to balance their diet or compensate for the food deficit during food shortage periods. The pulpy seeds were consumed directly or processed into juice in the three localities. The fruit was also processed into syrup and wine. The juice from the pulpy seeds or the whole fruit was used to prepare porridge, millet, or maize leg (locally called 'tô') and a drink made from millet flour ('zom-kom' in Mooré). The epicarp of the fruit was used for the production of potash and as a food additive.

In terms of construction, tendrils were most used organ by the populations of the three localities to build huts, shelters, granaries, sheds and to make roofs. Tendrils were used to make baskets, cages, traps, beehive covers and tools for transporting bundles of wood. As a source of energy, it was the dead stem and dry twigs of the species that are used by some women to cook meals. As far as magic practices are concerned, the most used organs were the roots, flowers, and tendrils. The roots were used to purify masks, the flowers were a source of happiness, and the tendrils were used to ward off evil spells (Supplementary material 1).

Table 3. Basic metrics on the use of *Saba senegalensis* plant organs by the studied local populations in Burkina Faso

| | Frequency of citation | | | | | | | Use report | Relative frequency of citation | Number of use categories | Use value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plant parts** | Alimentation | Fodder | Construction | Magic | Handicraft | Energy | Medicine | **UR** | **RFC** | **NU** | **UV** |
| Bark | 0 | 0 | 0 | 0 | 0 | 1 | 24 | 25 | 0.14 | 3 | 0.14 |
| Flower | 0 | 1 | 0 | 0 | 0 | 0 | 11 | 12 | 0.07 | 3 | 0.07 |
| Fruit | 180 | 0 | 0 | 0 | 0 | 0 | 17 | 197 | 1.09 | 3 | 1.09 |
| Leaves | 0 | 3 | 0 | 1 | 0 | 0 | 102 | 106 | 0.59 | 4 | 0.59 |
| Root | 0 | 1 | 0 | 2 | 0 | 1 | 49 | 53 | 0.29 | 5 | 0.30 |
| Seeds | 3 | 0 | 0 | 0 | 0 | 0 | 11 | 14 | 0.08 | 3 | 0.16 |
| Stem | 0 | 1 | 1 | 0 | 3 | 27 | 2 | 34 | 0.19 | 6 | 0.19 |
| Tendril | 0 | 1 | 92 | 0 | 29 | 0 | 92 | 214 | 1.19 | 5 | 2.17 |
| Young twigs | 0 | 0 | 2 | 0 | 2 | 2 | 37 | 43 | 0.24 | 4 | 0.24 |

Table 4. Frequency of citation on the specific uses of *Saba senegalensis* plant organs by the studied local populations in Burkina Faso

| Use category | Specific uses | Frequency of citation (%) |
|---|---|---|
| Medicine (Diseases and symptoms) | Malaria | 100 |
| | Fever | 94.44 |
| | Constipation | 88.89 |
| | General fatigue | 88.89 |
| | Vitamin deficiency | 61.11 |
| | Anorexia | 55.56 |
| | Dysmenorrhea | 50 |
| | Umbilical hernia | 50 |
| | Hemorrhoids | 13.89 |
| | Infertility | 11.11 |
| | Ulcers | 11.11 |
| | Bewitchment | 7.22 |
| | Bloating | 5.56 |
| | Cough | 5.56 |
| | Diarrhea | 5.56 |
| | Dysentery | 5.56 |
| | Prostate | 3.33 |
| | Tuberculosis | 3.33 |
| | Blindness | 2.22 |
| | Hypertension | 2.22 |
| | Sinusitis | 2.22 |
| | Tooth decay | 1.67 |
| | Cardiovascular diseases | 1.11 |
| | Conjunctivitis | 1.11 |
| | Intestinal greens | 1.11 |
| | Ringworm | 1.11 |
| | Asthma | 0.56 |
| | Boils | 0.56 |
| | Hip pain | 0.56 |
| | Split feet | 0.56 |
| Alimentation | Fruit pulp | 94.44 |
| | Juice | 94.45 |
| | Millet flour drink | 50 |
| | Porridge | 50 |
| | Millet or maize paste | 50 |
| | Potash | 38.89 |
| | Syrup | 5.56 |
| | Wine | 1.67 |

***Metric indices of S. senegalensis use***

In general, the overall use value (UV) of *S. senegalensis* varied significantly between localities ($p < 0.05$) and informant age categories ($p = 0.0002$) (Table 5). Informants in Tchériba knew more about the species than those in Diaradougou and Somiaga. Also, the senior informants knew more the uses of the organs of the species than adults. However, there was no significant difference in knowledge of species uses between men and women ($p = 0.20$) (Figure 4). By use category, the General Linear Model results indicated that the UV of *S. senegalensis* for construction ($p < 0.0001$), service ($p < 0.0001$), energy ($p < 0.0001$), and traditional medicine ($p = 0.038$) varied significantly between the three localities. Also, there was a significant difference in the perceived use value between men and women in the three locations.

Table 5. Effect of socio-demographic variables on *Saba senegalensis* use value

| Use category | Locality (L) | Gender (G) | Age category (A) | L x G | L x A | G x A |
|---|---|---|---|---|---|---|
| **Food** | 0.9461ns | 0.924ns | 0.797ns | 0.935ns | 0.998ns | 0.971ns |
| **Fodder** | 0.065ns | 0.005** | 0.537ns | 0.032* | 0.182ns | 0.885ns |
| **Construction** | 0.0001*** | 0.723ns | 0.316ns | 0.734ns | 0.455ns | 0.586ns |
| **Magic** | 0.3674ns | 0.064ns | 0.462ns | 0.476ns | 0.146ns | 0.749ns |
| **Handicraft** | 0.0001*** | 0.963ns | 0.22ns | 0.739ns | 0.317ns | 0.135ns |
| **Energy** | 0.0001*** | 0.208ns | 0.964ns | 0.146ns | 0.803ns | 0.144ns |
| **Medicine** | 0.038* | 0.011* | < 0.0001*** | 0.08ns | 0.803ns | 0.345ns |

*** = $p < 0.0001$ ; ** = $p < 0.001$ ; *= $p < 0.05$ ; ns = $p > 0.05$

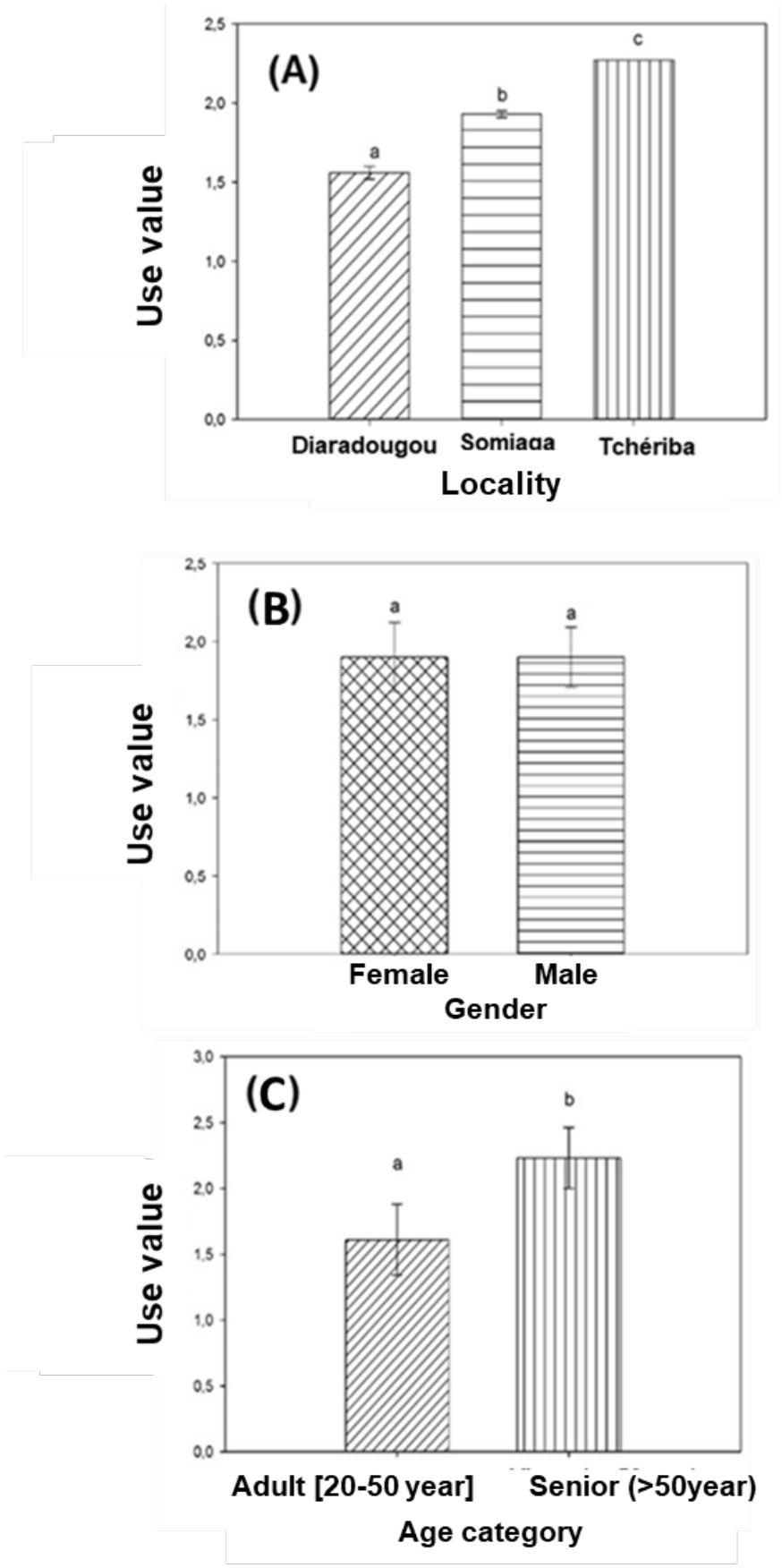


Figure 4. Use value of *Saba senegalensis* by locality (A), gender (B) and age category (C)

Table 6. Parameters used to calculate the index of vulnerability (IV) for *Saba senegalensis*

| Parameters | 1(Low scale) | 2(Average scale) | 3(Strong scale) |
|---|---|---|---|
| Frequency of use (FU) | FU < 20% | 20% = FU < 60% | FU = 60% |
| Number of use categories (NU) | NU < 2 | 2 ≤ NU ≤ 4 | NU ≥ 5 |
| Plant parts used | Root, stem, seed, flowers, bark | Young twigs | Fruit, tendrils, leaves |
| Harvesting methods | Barking, cutting and stumping | Cutting | Barking, cutting |

Source: adapted from Betti (2001)

***Harvesting methods of plant organs and vulnerability of S. senegalensis***

Harvesting methods of *S. senegalensis* organswere principally: debarking, cutting, and stumping. Fruits, leaves and flowers were usually picked by hand or using a long stick. Wood, young twigs and bark are collected using a machete or hatchet. Roots are obtained from stump removal. Leaves, leafy twigs, trunk bark and roots are collected throughout the year, while the collection of fruits and tendrils of the species is periodic (June to August). The IV shows that *S. senegalensis* is highly vulnerable (IV=2.75, >2.5) (Table 6).

*Conservation status (availability, threats and management) of S. senegalensis*

The populations surveyed have local knowledge on the availability and conservation of *S. senegalensis*, as well as the threats on the species. People from Diaradougou (90%) and Tchériba (94%) considered that there is good availability of the species in their forest and agro-pastoral landscape. In addition, in these two localities, 90% of the informants thought that the species is under little threat and that any threats are due in part to the overexploitation of its fruits and to recurrent bushfires. Informants from the Somiaga, in the sudano-sahelian zone, reported a low availability of the species in the agro-pastoral landscape. Also, 100% of the population surveyed in Somiaga considered the species to be threatened. The perceived threats included overexploitation of the fruit, bushfires, harvesting of immature fruit, uncontrolled clearing and natural mortality due to drought. The threats listed by the informants did not vary significantly by gender, locality, and age category (p-value < 0.05). Nowadays, because of the high economic value of marketing *S. senegalensis* fruits, informants are increasingly conserving the species and have rejected the myth that *S. senegalensis* is a tree that harbors snakes and evil spirits. They also carry out assisted natural regeneration by keeping the natural offshoots of the species from the seeds in their fields. However, none of the informants had planted the species.

## Discussion

***Knowledge of the uses of S. senegalensis***

*Saba senegalensis* has multiple uses for the local populations across the sudanian and sudano-sahelian zones of Burkina Faso. All the plant organs are used to satisfy the daily needs of these populations. This diversity of uses of the species' organs is an indication of its importance for ethnobotany and biodiversity (Thiombiano *et al.* 2012). The use of all organs in traditional medicines (UR = 345 and CI = 1.92) and the use of the fruit for food (UR = 183 and CI = 1.02, Table 3) were the most practiced by the informants. This result reflects the high medicinal and dietary importance and overall cultural importance of the species for the populations of the three localities. Construction (UR = 95 and CI = 0.53) was the third most common use of the species by the populations, with the woody tendrils being the most exploited to make huts, granaries, sheds and roofs. This use is justified by the fact that the tendril, which is the thread-like fastener used by the species to cling to trees, due to its flexible morphology is easy to handle for attaching the rafters used for the constructions. The same reason explains its use in handicrafts, to make baskets, cages, traps, beehive lids, and tools for transporting bundles of wood. However, the populations make little use of the wood of the species in cooking, as they consider that the wood catches fire too quickly and does not last in fireplaces and is therefore considered rather poor-quality firewood for cooking meals.

Our results also showed that the informants used *S. senegalensis* in the treatment of 30 diseases and symptoms. This number is higher than the 20 diseases and symptoms reported in the literature (Arbonnier 2009, Koné & Atindehou 2008, Magassouba *et al.* 2007, Zerbo *et al.* 2007). This could be explained by the diversity of socio-cultural groups considered in the present survey. Many of the diseases identified in this study (e.g. blindness, colic, cough, tuberculosis, fontanel, migraines, and anorexia) have been mentioned in previous studies as being treatable with *S. senegalensis* (Arbonnier 2009, Nacoulma-Ouédraogo 1996, Traoré *et al.* 2009, Zerbo *et al.* 2007).

Several organs of *S. senegalensis* are used in the traditional medicines, especially the leaves and tendrils. The leaves of the species have been frequently indicated in other ethnobotanical studies for the treatment of chronic headaches, wounds, food poisoning, vomiting, adenitis and blindness (Arbonnier 2009, Koné & Atindehou 2008,

Traoré *et al.* 2009). This frequent use of leaves for medicines could be explained by the ease and speed of harvesting (Bitsindou 1986), but also by the fact that this organ is the major place of synthesis of the plant's secondary metabolites responsible for the plant's biological properties (Mangambu *et al.* 2014). Studies conducted on its pharmacological properties have shown that the aqueous extract of *S. senegalensis* leaves has an anthelmintic property and may justify its use in traditional medicine for the treatment of gastrointestinal parasites (Belemlilga *et al.* 2016).

Phytochemical screening by Yougbaré-Ziebrou (2016) revealed that the leafy stems of *S. senegalensis* have anti-inflammatory properties and justify the use of the plant in traditional medicine against inflammatory diseases. Fortunately, the intensive harvesting of leaves is not harmful to the plant (Poffenberger *et al.* 1992). According to these authors, the removal of 50% of the leaves of a plant does not affect it as much as debarking. Debarking usually leaves scars on the trunk and stems, through which the plant is later attacked by fungi, birds and caterpillars (Ouattara 2006). Furthermore, uprooting, lopping, debarking and felling are dangerous exploitation methods for the plant. The people interviewed were aware of the harmful effects on the plant, fight against the removal of the roots for therapeutic purposes and very rarely use the roots of the species for their care. Moreover, decoction is the most commonly used method of preparation, as it allows for the best possible collection of active ingredients and attenuates or cancels out the toxic effect of certain medicinal recipes (Salhi *et al.* 2010). However, ingestion of *S. senegalensis* seeds can cause abdominal pain and intestinal obstruction (Diallo *et al.* 2018).

In general, the fruit is the most commonly consumed plant organ among NTFP species (Djihounouck *et al.* 2018). Our results show that the fruits of *S. senegalensis* are consumed in different forms. In rural areas, its fruits are used to improve the taste of porridge and cereal leg (Anon 2004, Paget 2004). Mixed with water and sugar, the fruit pulp makes a delicious juice (Arbonnier 2009, Diabagaté *et al.* 2019). In addition to the food uses of the fruit identified in this study, it can also be processed into puree, nectar, jam, preserves and jellies of 'maad' (in Wolof language) or 'goïne liana' (Boamponsem *et al.* 2013, Sarr *et al.* 2018). The fruit of *S. senegalensis* is highly nutritious ( Diabagaté *et al.* 2019, Lamien *et al.* 2010, Nafan *et al.* 2013, Tiendrébéogo *et al.* 2020). It has high polyphenolic and antioxidant properties (Lamien-Meda *et al.* 2008) and contains carotenoids, anthracene glycosides (Kini *et al* 2008, Lamien *et al.* 2010), tannins, flavonoids, saponins, coumarins, anthocyanosides, triterpenes and sterols (Kini *et al.* 2008, Yougbaré-Ziebrou *et al.* 2016). The presence of these active compounds in the fruit could play an important role in the prevention and treatment of certain vitamin deficiencies and metabolic diseases (Kini *et al.* 2008). Elsewhere, the leaves of *S. senegalensis* are used to stimulate appetite in young Fulani people (Arbonnier 2009). The diversity of uses of *S. senegalensis* organs could be due to local environmental conditions that govern the distribution and availability of the species (Sop *et al.* 2012) and the needs of local populations (Assogba *et al.* 2017, Houètchégnon *et al.* 2015).

***Metric indices of S. senegalensis use***

The use of ethnobotanical indices is a fundamental tool to assess the level of knowledge of local communities on local fruit species that constitute a natural heritage on which their well-being depends. The use of these indices in the present study has thus made it possible to evaluate the ethnobotanical uses of *S. senegalensis* according to the different localities, gender and age categories of informants. The variation in the use of the organs between localities is a result of the different cultures and endogenous knowledge of the plant genetic resources that each community has inherited. Informants from the locality of Tchériba in the sudano-sahelian zone, mainly represented by the Gourounsi and Dafing ethnic groups, had more knowledge about the uses of *S. senegalensis* for construction, handicrafts, energy as firewood, and traditional medicine than those of Somiaga, another locality from sudano-sahelian zone, and Diaradougou, represented by the majority Mossi and Bobo ethnic groups, respectively. Such differences in local plant uses between ethnic groups has been mentioned previously by other authors (Assogba *et al.* 2017, Issa *et al.* 2018, Lawin *et al.* 2019) for other local species with multiple uses in West Africa. Ethnicity is therefore a factor in differences in plant uses and knowledge between communities (Adjéha *et al.* 2015). According to Houètchégnon *et al.* (2015), endogenous knowledge is culturally-based and therefore varies from one ethnic group to another. In our study, the senior informants knew of more uses of the organs of *S. senegalensis* for traditional medicines than adults did. This could be explained by the fact that knowledge increases with age (Phillips & Gentry 1993). It also highlights the risk of long-term erosion of endogenous knowledge about *S. senegalensis* (Voeks & Leony 2004). This is because the transmission of local plant use knowledge from generation to generation is now facing a gradual disappearance, partly due to the rural exodus (Geng *et al.* 2016) and the current scarcity of medicinal plants leading adults to limit the use of herbal health care. But it is also possible that adults will later reach the same level of knowledge as the elderly, if the chain of transmission of traditional knowledge does not erode (Ouédraogo *et al.* 2019). A cross-sectional analysis of knowledge and use

over time could therefore provide further insight into the risks of losing traditional knowledge about *S. senegalensis*. Many authors have shown that social characteristics such as age can influence knowledge of local plant resources and their use within a community (Muller *et al.* 2015 , Sharma *et al.* 2019).

Our results also showed that there was no significant difference in knowledge of *S. senegalensis* uses between the male and female informants. Women are increasingly taking on tasks traditionally assigned to men. This explains the homogenisation of plant knowledge between men and women. Nevertheless, the use of *S. senegalensis* in traditional medicine and as fodder was relatively more marked among men than among women. This is explained by the fact that the harvesting of plant parts for the treatment of diseases is more the responsibility of men than women. According to Pfeiller & Butz (2005), knowledge acquisition and differentiation is guided by access to resources and the social roles played by different genders. Similar results have been cited for other species (Camou-Guerrero *et al.* 2008, Lawin *et al.* 2019). Guimbo *et al.* (2011) also reported that gender and age have important effects on local knowledge of useful plants.

***Vulnerability of S. senegalensis***

The vulnerability of a plant species depends on the category of use, the type of organs collected, the frequency of use, the mode of collection, and the stage of development at which the plant is used (Agbo *et al.* 2017, Ayéna *et al.* 2016, Traoré *et al.* 2021), but also the morphological type of the species (Dassou *et al.* 2014). This vulnerability increases depending on whether the plant organ removed regenerates easily or not. In this study, the IV of *S. senegalensis* was found to be 2.75. This high IV found in all three study areas was mainly due to its high frequency of use (N1=43.11%), the large number of use categories (N2=7), the particular organs used (N3=9), and the mode of collection (N4=gathering, cutting and stump removal).

All organs of *S. senegalensis* are used to satisfy the daily needs of the population. Tendrils and fruits are the most used organs of the species. Fortunately, their exploitation does not necessarily lead to the death of adult trees (Peters 1997), whereas the exploitation of bark, stem and roots almost always kills the trees (Betti 2001). On the other hand, intensive harvesting of immature fruits can lead to a gradual decline in the individuals that produce fruits through a lack of adequate regeneration. In addition to the anarchic exploitation of the species' organs, there are also factors of environmental degradation such as bushfires, overgrazing and uncontrolled clearing. These disturbances inevitably lead to a low recruitment capacity of juveniles. Kabré *et al.* (2020) found that *S. senegalensis* has a high regeneration potential in the Sudanian, Sudano-Sahelian and Sahelian climatic zones of Burkina Faso, however, it remains vulnerable because of the apparent difficulties in the recruitment of seedlings to juvenile and adult aged trees despite a certain resilience. Thus, the combined effects of climatic pejoration and anthropic pressures are making it increasingly difficult to conserve *S. senegalensis* in its natural habitat in Burkina Faso and elsewhere throughout sub-Saharan Africa with similar environmental conditions. This situation reveals the urgency of adopting a sustainable management plan for the species, such as its integration into reforestation and local plant domestication programs.

## Conclusion

This ethnobotanical study of *S. senegalensis* in three provinces, across two climatic zones in Burkina Faso has revealed that it is a highly-valued multipurpose species well known to local people and much exploited. All the organs of the species are used in seven main use categories by the local populations to satisfy their daily needs. The organs are mainly used for therapeutic and food purposes. The study determined that *S. senegalensis* has an IV of 2.75, meaning it is a highly vulnerable woody species in slightly (Houet), moderately (Mouhoun) and severely (Yatenga) dry climate. It is therefore critical to develop sustainable management strategies for *S. senegalensis* to ensure its long-term conservation of the species in these areas. Thus, there is an urgent need to sensitize local populations on best harvesting practices of plant organs. It is also imperative to encourage and intensify the planting of this species in agroforestry systems, surrounding natural forest areas, and in urban areas to help reduce the pressure on ageing natural trees. We suggest that this study be extended to other localities where *S. senegalensis* occurs in Burkina Faso, and within other socio-cultural groups, to identify other possible uses of the species and a greater understanding of its ethnobotanical potential. Propagation studies should also be undertaken to promote the cultivation of *S. senegalensis*.

## Declarations

**Ethics approbation and participation consent**: Individual consent to participate in the study was obtained prior to the administration of the questionnaire.

**Data and material availability**: In this study, data treated are available for eventual request by the journal.

**Interest conflict**: authors declare that there is no conflict of interest.
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**Authors' contributions:** SD, AO and PS conceived the work with advice from AO. SD collected and processed the data. SD and PS performed the statistical analyses. SD drafted the manuscript with contribution of LS, BK, PS and AO. All authors read and approved the final manuscript.

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