

RESEARCH PAPER

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Medicinal plants sold in Daloa markets: Traditional knowledge and Public health issues

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ABSTRACT

The aim of this ethnobotanical study is to invent and analyze the medicinal plants sold in the public markets of the city of Daloa, highlighting local traditional knowledge and current public health issues. Data were collected through surveys of vendors and users in six main markets. The combined use of questionnaires, semi-structured interviews and direct observation enabled us to collect precise information on the plant species used. A total of 47 medicinal species were identified. The majority of these come from the surrounding rural areas, as well as from central and northern Côte d'Ivoire. Four plant parts are sold: bark (38%), leaves (30%), roots (22%) and stems (10%). The results of the ANOVA test show a highly significant difference between the parts used ($F = 23.7$; $p < 0.0001$). Four main preparation methods were observed: decoction (58.2%), followed by maceration (26.3%), grinding (14.6%) and infusion (5.6%). The results revealed a significant difference between preparation methods ($F(3.17) \approx 76.2$; $p < 0.0001$). The preparation method is used at a significantly different frequency from the others in our sample. Decoction largely dominates, followed by maceration, then infusion, and finally grinding is very marginal. In all, 12 main pathologies were identified as being treated by the plants sold. Malaria is the most frequently cited pathology, testifying to its importance in traditional medicine in the region.

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INTRODUCTION

Medicinal plants play an important role in traditional African health systems. Indeed, between 80% and 85% of the population of sub-Saharan Africa use traditional medicine (TM) as their first resort for healthcare (UNESCO, 2010; Okaté, 2018). The factors contributing to this high use of TM are mainly socio-cultural, better access to plant resources (Ouoba *et al.*, 2023), and traditional remedies that are better accepted culturally and sometimes considered more effective than modern medical treatments. In Côte d'Ivoire, public markets contribute enormously to the promotion, dissemination and development of the medicinal plant trade. In the markets of Daloa (a crossroads town in the centre-west of the country), this trade is particularly active (Zadou *et al.*, 2017), attracting traders and buyers from a variety of origins, notably from the centre and north of the country and from neighbouring countries such as Mali and Burkina Faso (Guele and Koffi, 2021).

However, this sector remains poorly documented (Abo *et al.*, 2020). Some study was made to identify medicinal plants used to treat the most frequent diseases in the Daloa region (Ekissi *et al.*, 2021). Others study was made to learn about the different uses of *Alchornea cordifolia* in the locality of Daloa (Koulibaly *et al.*, 2016). Finally, some study was made to identify the collection and marketing circuit of these plants and on the other hand to draw up the socio-demographic profile of the actors while highlighting its economic impact (Guele and Koffi, 2021). Despite the almost widespread use of medicinal plants sold on markets in Daloa, there is a lack of precise scientific data on the species sold, their uses and the risks associated with their use without supervision. This unfortunate situation is hampering the recognition and regulation of traditional medicine.

The general objective of this research is to study the medicinal plants sold in the markets of Daloa with a view to contributing to their development and to a better understanding of the associated traditional practices. This general objective is broken down into

three specific objectives. Firstly, to identify the main medicinal plant species sold in Daloa markets. Secondly, to describe the therapeutic uses, preparation methods and administration methods of the plants identified. Finally, to analyse the socio-cultural characteristics of the players involved in this trade.

Study area

Geographical location

This study of medicinal plants was conducted in the town of Daloa. This locality is located in the Centre-West of Côte d'Ivoire, in the Haut-Sassandra region (Zadou *et al.*, 2017). The town of Daloa lies approximately 383 km north-west of Abidjan and is positioned between latitudes 6°52'N and longitudes 6°27'W (Koné *et al.*, 2018, Guele and Koffi, 2021). The city is surrounded by several towns (Figures 1). These towns are: Issia in the south, Vavoua in the north, Zoukougbeu in the west and Bouaflé in the east (Coulibaly *et al.*, 2019). Its strategic location on the roads linking the north to the south and the east to the west of the country makes it a major commercial transit point.

Ethnobotanical surveys were carried out in order to take better advantage of the benefits of the plants sold in the markets of this crossroads town. These surveys targeted the city's main urban markets where the sale of medicinal plants is particularly active. These markets are Lobia, Orly, Kennedy 1, Kennedy 2, Garage, Abattoir and Tazibouo. These markets host vendors from various rural and urban localities in the centre and north of the country, making the town of Daloa essential for the dissemination and exchange of ethnobotanical knowledge (Zirihi *et al.*, 2010; Kouassi *et al.*, 2016).

Target population

The study concerned two main categories of stakeholders. Firstly, the sellers of medicinal plants, who are a major player in the possession and transmission of traditional knowledge. Secondly, users or consumers, who are the beneficiaries of plant-based remedies.

MATERIAL AND METHODS

Plant material

The plant material used in this study consists of various parts of medicinal plants collected from traditional traders in the Daloa markets. This material mainly comprises stem and root barks, fresh

or dried leaves, whole cut stems and roots, depending on availability. These plant parts represent the active elements traditionally used in the preparation of remedies, and their selection depends on the specific therapeutic uses transmitted by local ethnobotanical knowledge.

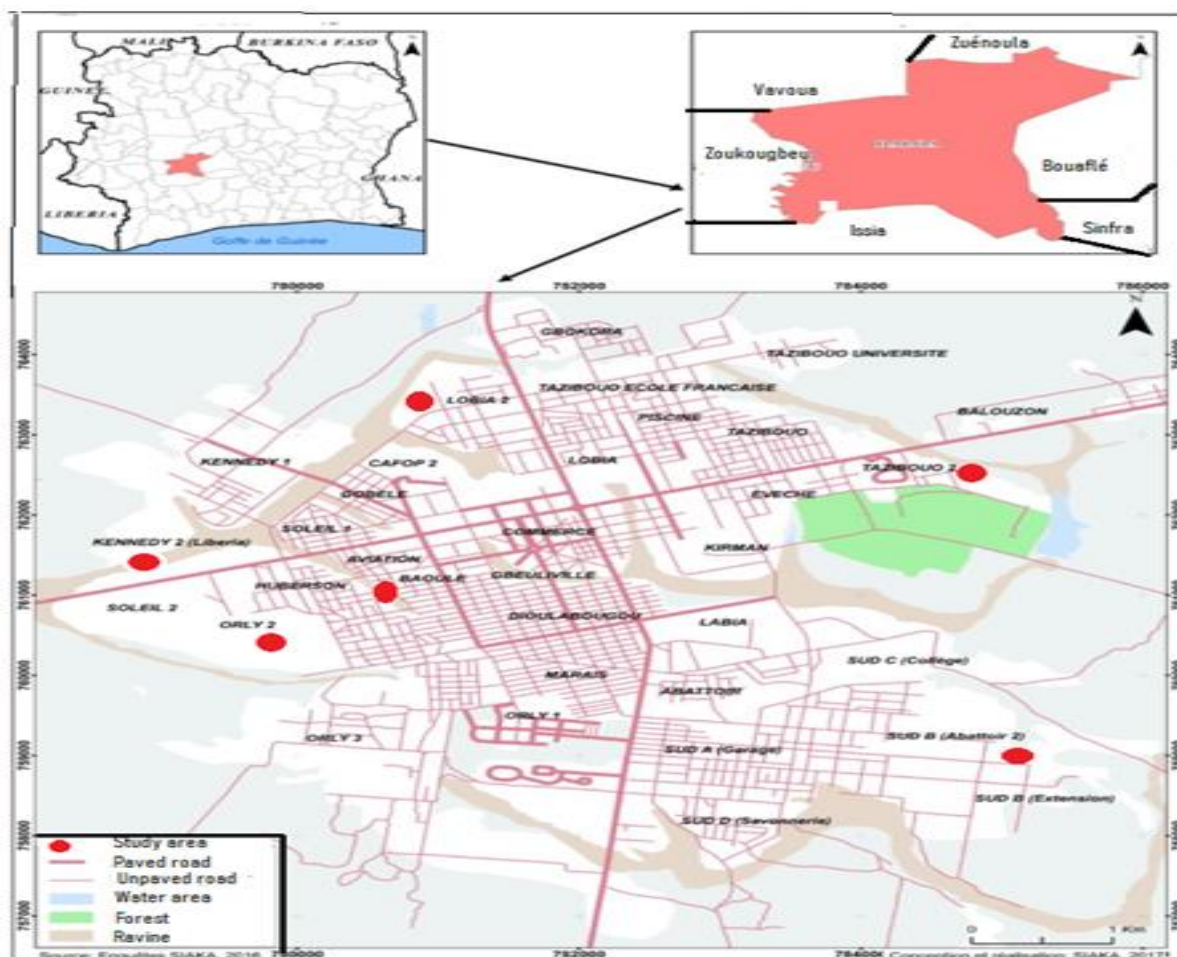


Fig. 1. Geographical location of the town of Daloa.

Technical equipment

This ethnobotanical study is based on several types of equipment. It consists of data collection and processing equipment.

The data collection equipment includes: a field notebook for taking notes during direct observations and interviews, a GPS used to geo-locate the collection sites or the markets surveyed, a digital camera used to visually document the plant species and the contexts of sale, plastic bags for transporting plant samples and botanical presses and newsprint for packaging and drying specimens and for making a

herbarium.

The data processing material consisted of botanical identification documents for the plant parts sold and documents classifying therapeutic uses into pathological categories. In addition to these documents, we used a tool (XLSTAT software) to analyse the data.

Methods

Data collection methods

Data were collected using a combination of questionnaires, semi-structured interview guides and

direct market observations. The questionnaires were used to collect standardised information on the species sold, their uses and origin, as well as the socio-demographic characteristics of the respondents. This method allows rapid collection of quantitative data and facilitates statistical comparisons between respondents (Cámara-Leret *et al.*, 2015). In this study, semi-structured interviews enabled certain topics to be explored in greater depth, in particular, plant-related knowledge and modes of transmission. This type of interview offers flexibility, allowing the interviewer to adapt the questions according to the relevance of the responses, while maintaining a common structure (Malan and Neuba, 2021). Direct observation was used to validate certain statements made by respondents, document sales practices and visually identify plants. This approach makes it possible to contextualise verbal data, better understand the sales environment, and increase the reliability of the results (Houéhanou *et al.*, 2015).

Data processing methods

The data collected was analysed using a combination of qualitative and quantitative methods. The qualitative approach made it possible to interpret what the traders had to say, their practices and the traditional knowledge associated with the use of medicinal plants. The information was grouped into categories: species used, plant parts, methods of preparation and administration, and diseases treated. The quantitative approach involved processing the numerical data from the questionnaires using software such as Excel. Statistical analyses were carried out, including a one-factor ANOVA test (ANOVA 1) to compare the proportions of different plant parts and preparation methods. The Chi² test was used to assess differences in proportions between routes of administration. These analyses were used to identify the dominant trends and verify the significance of the differences observed.

Identification

Botanical identification of the plant parts sold was carried out in collaboration with experts and using reference floras such as Flore de la Côte d'Ivoire (Aké

Assi, 2001) and Plant Resources of Tropical Africa (PROTA, 2012). Some of the specimens collected were compared with those in herbaria available at the Centre National de Floristique (CNF) in Abidjan. A magnifying glass was used to observe morphological details. A botanical classification was established according to families, genera and species, using current scientific nomenclature (APG IV, 2016). Each plant was associated with its therapeutic uses, its parts used, and its method of preparation and administration. Therapeutic uses were grouped into pathological categories (digestive, respiratory, infectious, etc.) according to ethnopharmacological classifications (Heinrich *et al.*, 2018).

Statistical processing

The data collected was entered into Microsoft Excel 2016. They were then analysed using XLSTAT software. The statistical processing was based mainly on two types of test:

- The one-factor analysis of variance (ANOVA 1) was used to compare the means of the proportions between the different modalities (e.g. preparation methods, parts used, etc.). This test was used to determine whether there was a statistically significant difference between the groups studied ($p < 0.05$). In the event of a significant difference, a Tukey HSD post-hoc test was applied to identify the groups responsible for the variation.
- The Chi² (χ^2) test was used to analyse the frequency of use of the different routes of administration of the remedies, as well as other qualitative variables. This test was used to verify independence between the modalities and to detect any statistically significant associations between the variables ($p < 0.05$).

RESULTS

Diversity of medicinal plants sold

A total of 47 medicinal plant species have been identified in Daloa's public markets. These plants are used to treat a number of common ailments, including malaria, respiratory infections, digestive disorders and skin ailments. The majority of these

plants come from the surrounding rural areas and from localities in the centre and north of the country.

Plant parts sold

Four main plant parts are sold. These are bark, leaves (including leafy twigs), roots and stems (Figure 2). Bark is the most frequently sold part, accounting for around 38% of the total, followed by leaves (30%), roots (22%) and stems (10%). Analysis of variance (one-way ANOVA) was performed on the proportions of use of the different parts of medicinal plants (barks, leaves, roots and stems) recorded in the Daloa markets. The results of the ANOVA test indicate a highly significant difference between the different

parts used ($F = 23.7$; $p < 0.0001$). This means that not all parts are used with the same frequency.

As the ANOVA revealed a highly significant difference between the average proportions of plant parts used, a Tukey HSD post-hoc test was carried out to identify the groups between which these differences were significant. The results are shown in Table 1. Bark was found to be used significantly more than leaves ($p = 0.001$), roots ($p = 0.001$) and stems ($p = 0.001$). It also appears that stems are used significantly less than leaves ($p = 0.033$). On the other hand, there was no significant difference between leaves and roots, nor between roots and stems ($p > 0.05$).

Table 1. Results of the Tukey HSD post-hoc test between different part.

Comparison	Difference in averages	p-value	Significant difference
Barks - Leaves	35.33	0.001	Yes
Barks - Roots	33.33	0.001	Yes
Barks - Stems	48.67	0.001	Yes
Leaves - Roots	2.00	0.900	No
Leaves - Stems	13.33	0.033	Yes
Roots - Stems	11.33	0.072	No

These results confirm the dominance of barks in the traditional medicinal practices observed on the Daloa markets, to the detriment of stems, which are used very little.

Methods of preparing remedies

Four main methods of preparation were observed. These were decoction, grinding, maceration and infusion. Decoction had the highest average proportion (58.2%), followed by maceration (26.3%), grinding (14.6%) and infusion (5.6%). Maceration and grinding are used for preserved preparations or preparations combined with other plants (Figure 3).

A one-factor analysis of variance (ANOVA 1) was performed to determine whether there was a significant difference between the proportions of use of the different remedy preparation modes. The results revealed a highly significant difference between modes $F(3,17) \approx 76.2$; $p < 0.0001$, indicating that the choice of preparation mode varies

markedly according to informants' practices. Given that there was a significant difference, a Tukey HSD post-hoc test confirmed that all differences between groups were statistically significant ($p < 0.05$).

The Tukey HSD post-hoc test showed that the results recorded in Table 2. It shows that:

- the difference between decoction and maceration was significant ($p < 0.01$),
- decoction differs significantly from grinding ($p < 0.001$) and infusion ($p < 0.001$),
- maceration is used significantly more than grinding ($p < 0.05$) and infusion ($p < 0.01$),
- Finally, the difference between grinding and infusion is also significant ($p < 0.05$). These results indicate that each preparation method is clearly different from the others in terms of frequency of use. We can say that each method of preparation is used significantly differently from the others in our sample. Decoction largely dominates, followed by maceration, then infusion, and finally.

Table 2. Summary of the Tukey HSD post-hoc test between modes of preparation.

Comparison	Difference in averages	p-value	Significant difference
Decoction - Infusion	41,83	< 0,001	Yes
Decoction - Maceration	32,67	< 0,001	Yes
Decoction - Grind	54,00	< 0,001	Yes
Infusion - Maceration	-9,17	0,027	Yes
Infusion - Grind	12,17	0,001	Yes
Maceration - Grind	21,33	< 0,001	Yes

Methods of administering remedies

Remedies are mainly administered orally (65%), followed by the cutaneous (22%) and anal (13%) routes. Chi² pairwise analyses were carried out to compare the frequency of use of the different routes of administration. The comparison between the oral and cutaneous routes showed a highly significant difference (ddl = 1, $p < 0.001$). Similarly, the oral route was significantly more frequently used than the anal route (ddl = 1, $p < 0.001$). Finally, the difference between the cutaneous and anal routes was also significant (ddl = 1, $p = 0.015$). These results confirm the predominance of the oral route in the administration of remedies.

The oral route is preferred for the treatment of internal ailments such as malaria, abdominal pain and respiratory infections.

Types of recipes sold

An analysis of the preparations offered by traders reveals that multispecific recipes are the most common. In fact, 67% of sellers use several plants in the same preparation, compared with 33% who offer single-species recipes.

Diseases treated

A total of 12 main diseases were identified as being treated by the plants sold. Among these, the most frequently cited were: malaria (the most commonly treated condition), abdominal pain, respiratory infections, fever, skin diseases, urinary infections, headaches, coughs, gynaecological disorders, digestive disorders, joint pain and fatigue-related disorders. Malaria remains the most frequently cited condition, accounting for more than 30% of reports.

DISCUSSION

A total of 47 species of medicinal plants have been identified in Daloa's public markets. This high number of medicinal plants illustrates the richness and diversity of plants used in traditional medicine in this region. This result is similar to several recent studies conducted in West Africa, which highlight the importance of medicinal plants in traditional health systems (Traoré *et al.*, 2022; Kouamé *et al.*, 2023). The diversity of medicinal plants reported does not mean that the plants sold are ineffective. However, according to Kouakou (2019), this great diversity reflects both local biodiversity and the wealth of ethnobotanical knowledge transmitted within communities. The strong presence of these species on markets also indicates a significant economic role, particularly for women, who are often the main traders (Bamba *et al.*, 2020). These results are in line with those of Tano *et al.* (2024), who have shown that the marketing of medicinal plants contributes to the empowerment of local social groups.

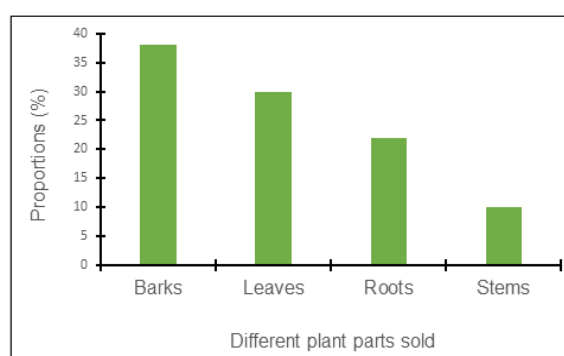


Fig. 2. Proportions of different plant parts sold at the Daloa market

An analysis of the parts of medicinal plants sold in Daloa reveals that bark accounts for 38% of sales,

making it the most widely sold part. This part (bark) is followed by leaves (30%). This predominance of bark is consistent with observations made in several recent African studies, including Diallo *et al.* (2023). According to these authors, bark is often preferred in traditional recipes for its concentrated active ingredients and ease of collection. However, the intensive exploitation of bark raises major ecological concerns. Abusive bark harvesting can compromise plant survival, leading to a gradual decline in plant populations (M'Bengue *et al.*, 2021; Traoré *et al.*, 2023). These results highlight the importance of adopting sustainable practices and encouraging domestic cultivation of medicinal species to limit the pressure on wild resources (N'Guessan *et al.*, 2022). The one-way analysis of variance (ANOVA 1) revealed significant differences in the frequency of use of the different plant parts ($p < 0.05$). This result suggests that users do not use all plant parts in the same way. Bark, for example, is the most widely used, probably because of its concentration of secondary active ingredients such as alkaloids and tannins (Ouattara *et al.*, 2021). These data indicate a delicate balance between therapeutic use, marketing and conservation, calling for integrated strategies for managing medicinal plants in local markets.

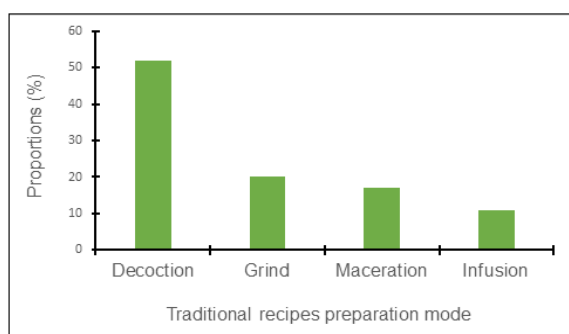


Fig. 3. Proportion of plant preparation methods sold in Daloa markets.

Four main methods of preparing medicinal plants were identified, with a clear predominance of decoction, used in 52% of cases. This high use of decoction as a method of preparing recipes has several advantages. Firstly, the bark is the most commonly used part and decoction appears to be the best method for extracting the active ingredients.

Secondly, many parts come from different horizons and have sometimes been preserved for a long time. This storage can lead to contamination. As a result, a long cooking time is needed to eliminate as many micro-organisms as possible that could cause other pathologies through ingestion. Decoction is therefore the best way to extract the active ingredients needed to treat the various pathologies.

This observation was made by Adjovi *et al.* (2021). According to these authors, decoction is more widely used for its effectiveness in extracting water-soluble active ingredients, particularly in woody parts such as bark and roots. Furthermore, Mahmoudi *et al.* (2013) demonstrated that extraction by decoction yields better results than maceration. The high proportion of decoction use is similar to the results of recent studies in ethnopharmacology, which report that decoction is often preferred in the preparation of traditional remedies in West Africa (Doumougue *et al.*, 2023; Wangny *et al.*, 2019). Finally, decoction remains the most popular method due to its ability to quickly extract active substances, especially from bark and roots (Heinrich *et al.*, 2018).

This predominance of decoction thus reflects traditional knowledge adapted to the physical and chemical properties of the plants used, but also suggests the need to promote other techniques to diversify and optimize therapeutic preparations. Thus, other methods of preparation, such as maceration or infusion, although less commonly used, offer an alternative for extracting heat-sensitive compounds (Diallo *et al.*, 2022). One-way analysis of variance (ANOVA 1) revealed significant differences between the methods of preparation of the recipes (high F, $p < 0.05$), with decoction being the dominant method. This preference can be explained by its effectiveness in extracting water-soluble active ingredients and its widespread adoption in African pharmacopoeias (Koudou *et al.*, 2020).

The results show that herbal remedies are mainly administered orally (65%), followed by cutaneous (22%) and anal (13%) routes. This trend is widely documented in African ethnomedical literature,

where oral administration remains the most common due to its effectiveness in treating systemic conditions, particularly infectious diseases such as malaria (Kouamé *et al.*, 2022; Traoré *et al.*, 2023). The cutaneous route, which includes local application to the skin, is preferred for the treatment of dermatological conditions or wounds, and its use is well recognized in traditional practices (Adjovi *et al.*, 2021). As for the anal route, although less common, it is used for certain digestive or hemorrhoidal conditions, allowing rapid absorption of the active ingredients (Bamba *et al.*, 2020). This distribution of modes of administration reflects the adaptation of therapeutic practices to the types of pathologies targeted and the nature of the remedies prepared. It also highlights the importance of the transmission of traditional knowledge for the proper use of medicinal plants (Konaté *et al.*, 2024).

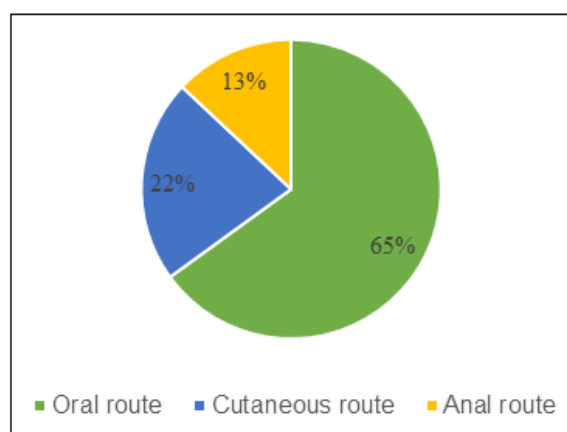


Fig. 4. Proportions of revenue delivery channels.

Medicinal plant sellers in the markets of Daloa reveal that recipes based on several plants are the most common (67% of cases). Single-species recipes are rarely recommended, accounting for only 33% of cases. This predominance of plant mixtures is a well-documented feature of traditional medicine systems in Côte d'Ivoire, particularly in the Adjamé market (Ouayogode, 2021) and in the Department of Agboville (Kipré, 2017). Our investigations show that sellers and users often believe that combining several species creates therapeutic synergy, enhancing the effectiveness of the treatment while broadening the spectrum of action of the remedies. Similar observations have been made by Traoré *et al.* (2022).

According to these authors, people perceive compound recipes as being more effective due to the synergistic effect between the different plants used. Furthermore, the use of recipes containing several plants responds to the complexity of the pathologies being treated, particularly chronic or infectious diseases, which are rarely due to a single cause. This justifies the use of several species with complementary properties (Yao *et al.*, 2021). However, poorly matched plant combinations can sometimes be dangerous (Bla, 2015). On the other hand, single-species recipes remain important for targeted treatments and are often used for simple pathologies or by users with a good knowledge of the plant (N'Guessan *et al.*, 2023). This diversity of practices therefore reflects both the richness of traditional knowledge and the adaptability of sellers to the needs of their customers.

Malaria is the most frequently treated disease by medicinal plant traders in Daloa for several reasons. First, this frequency reflects the high prevalence of this disease in tropical areas as well as the importance of traditional medicines in its local management (Rasmane *et al.*, 2023). Malaria remains endemic in Côte d'Ivoire, particularly in humid tropical areas such as Daloa. Furthermore, according to Ouayogode (2021), this disease is one of the main causes of morbidity, particularly among children and pregnant women. The use of several plants in its treatment could be justified by the fact that in some areas, health facilities are remote or overwhelmed, and medical services are expensive. As a result, people turn to plants, which are more accessible and culturally rooted. Indeed, traditional remedies made from many local species such as *Dalium dinklagei* and *Cnestis ferruginea* are known for their antimalarial properties, which encourages their frequent use (Tuo, 2015).

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