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Orapuh Journal

ORIGINAL ARTICLE

Journal of Oral & Public Health

Ethnobotanical survey of anti-infective plants used by traditional healers in Brazzaville, Republic of Congo

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ARTICLE INFO

Received: *03 May 2024*
Accepted: *06 June 2024*
Published: *11 June 2024*

Keywords:
Ethnobotanical survey, antimicrobial, anti-infective, infectious diseases, traditional healer, medicinal plant

Peer-Review: *Externally peer-reviewed*

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To cite:
Muanga, C. K., Luzala, M. M., Landamambou, A., Kyana, J., Mayuwu, M. K., Kambale, E. K. K., & Memvanga, P. B. (2024). Ethnobotanical survey of anti-infective plants used by traditional healers in Brazzaville, Republic of Congo. *Orapuh Journal, 5*(3), e1129 https://dx.doi.org/10.4314/orapj.v5i3.29

ISSN: *2644-3740*

Published by Orapuh, Inc. (info@orapuh.org)

Editor-in-Chief: Prof. V. E. Adamu
Engelhardt School of Global Health & Bioethics, Euclid University (Pôle Universitaire Euclide)

ABSTRACT

Introduction

Infectious diseases are a real public health problem. Faced with the problem of antimicrobial resistance (AMR) in their treatments, it is essential to find alternative solutions.

Purpose

The present study aimed to gather more information about medicinal plants used to treat infectious diseases by traditional healers in two markets of Brazzaville City, in the Republic of Congo.

Methods

This ethnobotanical survey was carried out through individual interviews in the local language, using a semi-structured questionnaire.

Results

From August 24 to September 02, 2022, fifteen traditional healers were enrolled, 7 men and 8 women. The average age of respondents was 47 years old. The literacy level was 60%. Most of the traditional healers belonged to the Lari ethnic group. Their knowledge of plant use was largely derived from cultural heritage. Twenty-three plant species were identified. These were *Acacia nilotica*, *Chenopodium ambrosioides*, *Cyathula prostrata*, *Caladium bicolor*, *Hua gabonii*, *Aframomum stipulatum*, *Annona arenaria*, *Acanthus montanus*, *Asystasia gangetica*, *Alchornea floribunda*, *Milletia congolensis*, *Mangifera indica*, *Phaulopsis poggei*, *Anthonotha macrophylla*, *Dichrostachys glomerata*, *Heinsia crinita*, *Alstonia congensis*, *Acanthus montanus*, *Rauvolfia obscura* and *Carica papaya*. The most represented family was Acanthaceae (17.39%). *Carica papaya* (18.96%) was the most frequently cited species for the treatment of infections. The leaves represented the plant parts most used by the respondents (26.02%). Decoction (48%) was the preparation technique most frequently used to facilitate drug administration. The oral route was the most widely used (52%). Malaria and gonorrhea (22.8%) topped the list of infections treated by traditional healers.

Conclusion

These findings illustrate the wealth of indigenous knowledge of plants with anti-infectious properties in the Congolese flora. They also highlight the potential of traditional medicine plants as sources of new antimicrobial agents, which could play an essential role in combating antimicrobial resistance.

INTRODUCTION

Infectious diseases refer to disorders caused by pathogenic microorganisms, such as bacteria, viruses, parasites, or fungi. From 1941 onwards, the treatment of infectious

diseases represented a veritable revolution lasting around half a century, during which they were considered definitively vanquished (Baran et al., 2023; Hutchings et al., 2019). The situation has reversed with the emergence of antimicrobial resistance (AMR), as antibiotics have progressively lost their effectiveness due to increasing and sometimes inappropriate use, leading to infections and deaths that are increasingly difficult to treat (Gajdács et al., 2021).

AMR has become a growing concern every year. It threatens the ability to successfully treat infectious diseases worldwide, with the number of annual deaths reaching around 750,000 and expected to rise as high as 10 million by 2050 (O'Neill, 2016). In 2015, when infectious diseases were designated as the second leading cause of death worldwide after non-infectious diseases, infection conditions in Africa accounted for 5.2 million deaths or 56.4% of this toll (Mboussou et al., 2019; Tadesse et al., 2017).

The World Health Organization (WHO) has declared AMR to be one of the ten greatest public health threats facing humanity (World Health Organisation, 2014). It requires urgent action on the One Health approach, so that the achievement of some Sustainable Development Goals (SDGs) is not compromised (Destoumieux-garzón et al., 2018; Mboussou et al., 2019). These goals are to eradicate poverty, protect the planet, and ensure that all human beings live in peace and prosperity (Gajdács et al., 2021).

There is an urgent need for discovering new antimicrobial agents to prevent a return to the pre-antibiotic era, to halt the spread of resistant microorganisms, and to pave the way for effective new treatments against future resistant pathogens (Miethke et al., 2021).

The WHO welcomes innovations around the world, including the recycling of medicines, traditional pharmacopoeia, and the development of new therapies (World Health Organization, 2021a). It recognizes many benefits of traditional, complementary, and alternative medicine (Uchil et al., 2014).

Africa has a long history of traditional medicine, which plays an important role in people's health care (Abdullahi, 2011; Chaitanya et al., 2011). It is estimated that around 80% of the world's population uses traditional medicine (Kiefer et al., 2014). To date, 170 of WHO's 194 member states report using traditional medicine, and their governments have requested WHO's assistance in building up a body of reliable evidence and data on traditional medicine practices and products (World Health Organization, 2023).

Traditional medicine describes the total knowledge, skills, and practices that indigenous and diverse cultures have used over time to preserve health and prevent, diagnose, and treat physical and mental illness (Abdullahi, 2011; Yuan et al., 2016).

Currently, there is little published ethnobotanical literature dealing specifically with the categories of plants found in Africa in general and in the Republic of Congo in particular (Chisamile et al., 2023; Mbayo et al., 2016). Indeed, this country does not have a long experience in the study and inventory of its flora. In-depth documentation on the use of various available plant species must be expanded as the biodiversity of this region is rich and vast (Koubouna et al., 2015).

This study aimed to support the WHO in the fight against AMR through the discovery of new plant-based antimicrobial substances. It gathers information on medicinal plants used by Brazzaville's traditional healers to treat infectious diseases, with a view of converting local naturalist knowledge into scientific knowledge and thus highlighting the diversity and richness of Congolese flora.

METHODS

Study material

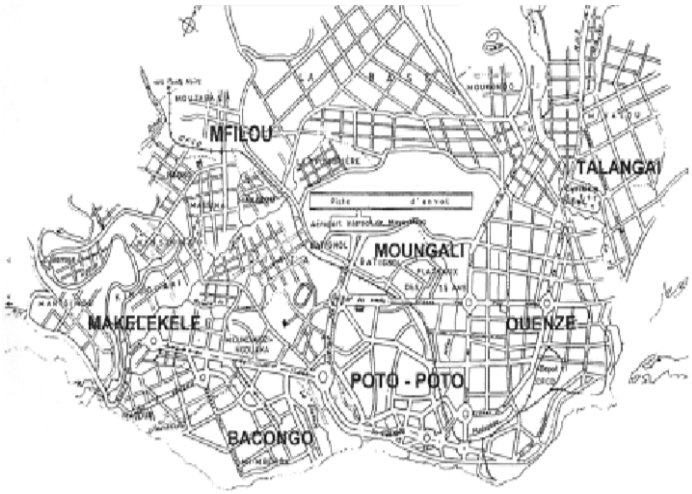
The technical material used for this ethnobotanical study consisted of a survey form pre-established in French and filled in during the visits. During the survey, questions were asked in the local language (Lari) for traditional healers belonging to the Lari ethnic group and in French for those from other ethnic groups. Data from traditional healers were collected using a semi-structured questionnaire. The survey was developed and approved following the guidelines established by Ranganathan et al. (2023). Briefly, the survey was written in French before being submitted to a pilot group of participants for prior validation to avoid any confusion in the questions asked. Subsequently, the survey was rewritten and presented to a group of internal experts for validation. The internal ethics

committee of the University of Kinshasa reviewed the approved questionnaire. To agree to participate in the survey, participants signed at the bottom of the questionnaire. This sheet included socio-demographic data indicating the identity of the interviewee (gender, age, level of education, marital status, ethnicity, origin of knowledge) and ethnobotanical data on anti-infective plants (vernacular names, parts used, traditional uses, preparation method, and route of administration).

Study area

This ethnobotanical survey was conducted in Brazzaville, in the Republic of Congo, in arrondissements 1 (Makélékélé) and 2 (Bacongo). Makélékélé is bordered to the North by arrondissements 4 Moungali and 7 Mfilou, to the South by the Congo River, to the East by arrondissement 2 Bacongo, and to the West by arrondissement 8 Madibou. It has a population of 74,815 and an area of 15.53 km². Bacongo has an area of 7.39 km² and a population of 80,000. It is bordered to the North by arrondissement 3 Poto-Poto, to the South and East by the Congo River, and to the West by arrondissement 1 Makélékélé. **Figure 1** below shows the main communes in the study area (Kempena et al., 2014; Mfoukou-Ntsakala et al., 2006).

Figure 1:
Map of Brazzaville's main districts (Mfoukou-Ntsakala et al., 2006)



Sample size and selection

This ethnobotanical survey is a descriptive observational study. The markets of Makélékélé and Bascongo bearing the same names as the districts in which they are located served as a study framework during the survey. These two markets were chosen because of their reputation for the sale of plant-based products in Brazzaville. The survey was planned to be carried out among all traditional practitioners working in these two markets. However, only fifteen traditional healers (seven men and eight women) agreed to participate in the survey.

Collection of information and conduct of the investigation

This study was conducted over one week, from August 24 to September 02, 2022. The approach consisted of interviewing traditional healers in their local language, explaining the purpose of the survey, helping them understand the questions on the survey form, and encouraging them to provide information about the plants they use to combat the various infectious diseases that affect this population.

Data processing and analysis

The ethnobotanical data collected on the survey sheets were further researched using botanical documents from the literature to determine the scientific names and plant families. This search was carried out using various keywords, such as (i) the vernacular name of the plant, (ii) the vernacular name of the plant accompanied by the pharmacological activity declared by the traditional healer, (iii) the vernacular name of the plant, the declared pharmacological activity as well as the location of the plant in the context of this survey (Congo, Brazzaville), etc.

Qualitative data were translated into quantitative data in a database, then processed and analyzed statistically using Excel 2019 and GraphPad software. A descriptive statistical method using frequencies and percentages was used to analyze the sociodemographic data of traditional healers, and the results of the ethnobotanical survey were analyzed using citation frequencies. To assess the distribution of botanical families, plant species, plant parts, and various antimicrobial properties of the identified medicinal plants, the citation frequency (CF) of each of these parameters was calculated as follows:

$$CF = \frac{NCP}{NCT} x\ 100$$

where NCP represents the number of citations for the parameter considered and NCT is the total number of citations of this parameter (Rehman et al., 2023).

RESULTS

Sociodemographic data

Table 1:
Socio-demographic profile of traditional healers

Factors	Category	Frequency	Percentage (%)
Sex	Male	7	46.6
	Female	8	53.3
Age (years old)	20-30	3	20
	31-40	3	20
	41-50	3	20
	51-60	2	13,3
	61-70	2	13,3
	>70	2	13,3
Marital status	Single	3	20
	Married	5	33,3
	Widower	4	26,6
	Divorced	3	20
Educationnel level	Illiterate	6	40
	Literate	9	60
Ethnicity	Lari	9	60
	Teke	1	6,6
	Vili	1	6,6
	Mboshi	2	13,3
	Bembe	1	6,6
	Yombe	1	6,6
Herbal medicine background	Knowledge	4	9,5
	Healers	7	16,6
	Cultural heritage	17	40,4
	Teaching	7	16,6
	Revelation	7	16,6

15 traditional healers, including 7 men and 8 women, were enrolled. The average age of traditional healers was 47 years old. There were more of them in the 20-30, 31-40, and 41-50 age groups, and fewer between 51-60, 61-70, and over 70-year-old groups. Most traditional healers were married. The literacy rate was 60%. The Lari ethnic group was massively represented among the traditional healers enrolled in this study. They claimed to know traditional plants through cultural heritage. **Table 1** below shows the socio-demographic data of the traditional healers who took part in the survey.

Ethnobotanical data

The ethnobotanical data of anti-infective plants identified by traditional healers of this study are shown in **Table 2** below.

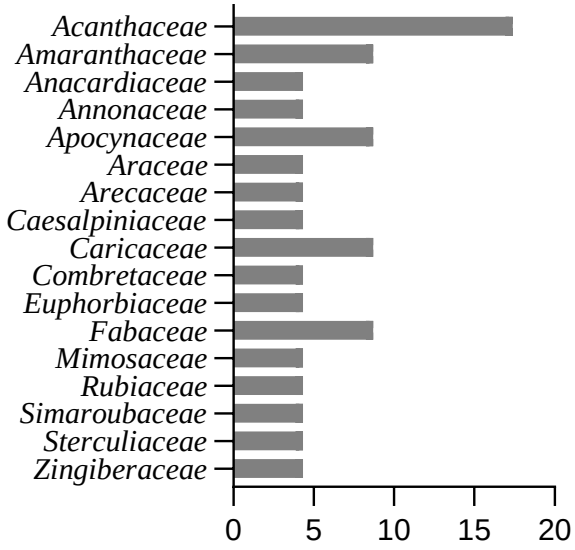
Table 2:
Data on anti-infective plants surveyed

N°	Scientific name	Vernacular name	Parts used	Family	Traditional uses	Number of species citations
1	*Acacia nilotica*	Bagana	Leaves, roots	*Fabaceae*	Intestinal parasite infections, malaria, gonorrhea	2
2	*Acanthus montanus*	Balingaya	Leaves	*Acanthaceae*	Gonorrhea, malaria	2
3	*Aframomum stipulatum*	Tondolo	Seeds, rhizome	*Zingiberaceae*	Urinary tract infections, malaria	1
4	*Alchornea floribunda*	Tienga	Stem, bark	*Euphorbiaceae*	Urinary tract infections, gonorrhea, malaria, tuberculosis	7
5	*Alstonia congensis*	Mutsugon	Latex	*Apocynaceae*	Gonorrhea	1
6	*Annona arenaria*	Kilolo	Leaves	*Annonaceae*	Urinary tract infections, gonorrhea, malaria	1
7	*Anthonotha macrophylla*	Mutiti	Stem, bark, roots	*Caesalpiniaceae*	Gonorrhea, urinary tract infections, skin infections	3
8	*Asystasia gangetica*	Singa nzala mwindo	Flowers, leaves	*Acanthaceae*	Gonorrhea	1
9	*Caladium bicolor*	Lilanga	Leaves, bulb	*Araceae*	Pulmonary infections, infectious diarrhea	3
10	*Carica papaya*	Papai	Leaves, seeds	*Caricaceae*	Malaria, pulmonary infections, gonorrhea, tooth decay, flu	11
11	*Chenopodium ambrosioides*	Nkaya lua nkuyu	Leaves	*Amaranthaceae*	Malaria, skin infections	3
12	*Combretum micranthum*	Kinkeliba	Leaves	*Combretaceae*	Genital herpes, gonorrhea, malaria, pulmonary infections	1

13	*Cyathula prostrata*	Nkolo nkoso	Stem, leaves	*Amaranthaceae*	Pulmonary infections, intestinal parasite infections	1
14	*Dichrostachys glomerata*	Sende mpangala	Stem, roots	*Mimosaceae*	Gonorrhea, urinary tract infections	2
15	*Elaeis Guineensis*	Nkandi	Nuts	*Arecaceae*	Intestinal parasite infections, malaria, pulmonary infections	2
16	*Heinsia crinita*	Misomikombo	Stem, bark, roots	*Rubiaceae*	Gonorrhea, malaria, pulmonary infections	1
17	*Hua gabonii*	Mupii-mpiti	Roots, bark	*Sterculiaceae*	Pulmonary infections, intestinal parasite infections, urinary tract infections	5
18	*Mangifera indica*	Mangoro	Roots, bark	*Anacardiaceae*	Intestinal parasite infections, malaria	3
19	*Millettia congolensis*	Basidi	Leaves	*Fabaceae*	Intestinal parasite infections	1
20	*Phaulopsis poggei*	Ondoko	Leaves, stem, bark	*Acanthaceae*	Skin infections, intestinal parasite infections, malaria, pulmonary infections	1
21	*Quassia africana*	Mumpesi	Bark	*Simaroubaceae*	Malaria	2
22	*Rauvolfia obscura*	Mukankala	Roots	*Apocynaceae*	Gonorrhea, urinary tract infections	1
23	*Thomandersia laurenti*	N'nuun ba kuyu	Leaves, stem, bark	*Acanthaceae*	Gonorrhea, intestinal parasite infections	3

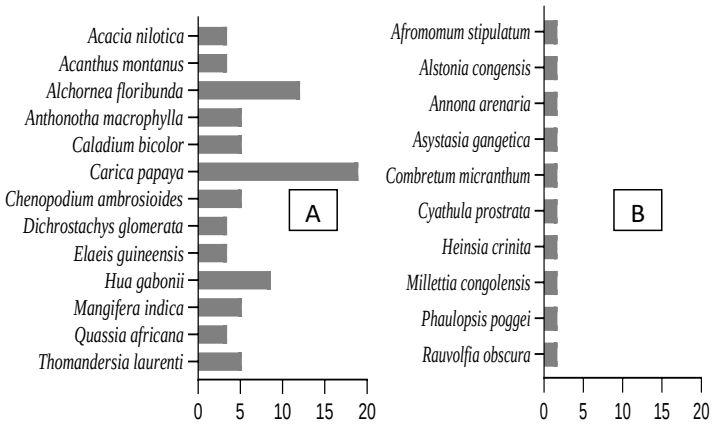
The survey of traditional healers identified twenty-three (23) plant species belonging to 17 botanical families, the most represented of which is the Acanthaceae (17.39%) (Figure 2).

Figure 2:
Citation frequency of botanical families used by traditional healers



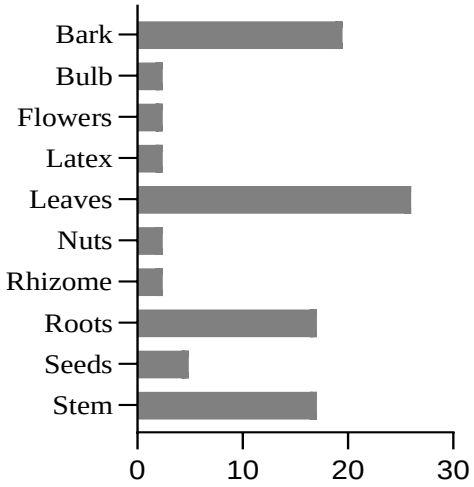
Carica papaya (18.96%) was the most cited species used by traditional healers to treat infections (Figure 3).

Figure 3:
Citation frequency of antimicrobial plant species used by traditional healers



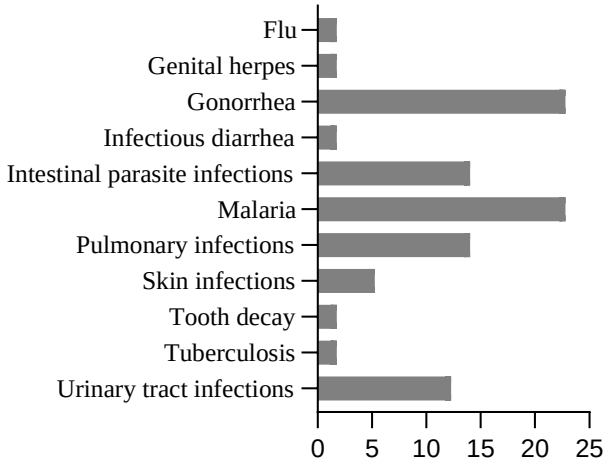
Leaves (26.02%) were the plant parts most used by traditional healers (Figure 4).

Figure 4:
Citation frequency relative to different parts of plants used by traditional healers



Traditional healers have reported several indications for medicinal plants, with malaria and gonorrhea leading the list (Figure 5). All these antimicrobial properties of plants identified and collected by traditional healers are recognized in traditional African pharmacopoeias.

Figure 5:
Citation frequency of antimicrobial properties of identified medicinal plants



Wild and cultivated plants are the two types used to treat infectious diseases by the traditional healers who took part in the survey (Figure 6). The plants used were in two states: dried (75%) or fresh (25%) (Figure 7).

Figure 6:
Type of plants used

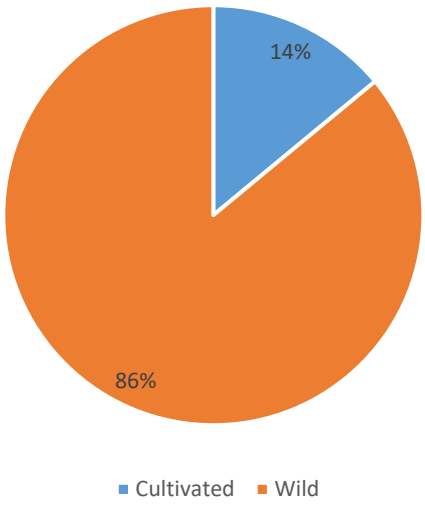
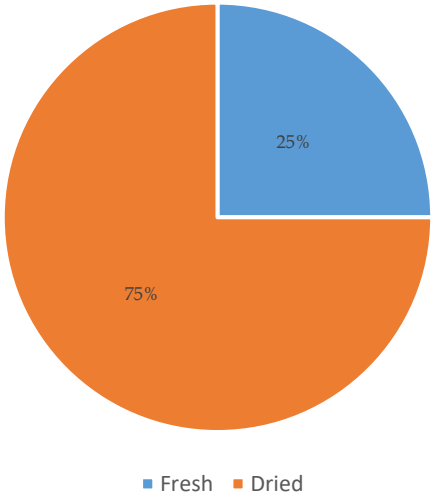
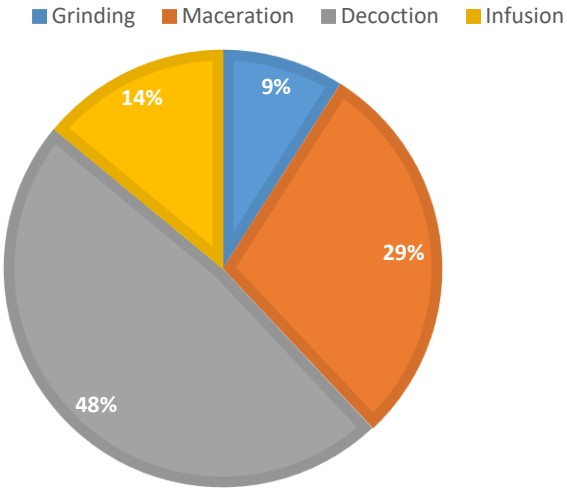


Figure 7:
State of plants used



Traditional healers have reported the use of different methods of preparing medicinal plants to facilitate their administration. Figure 8 shows that the most common method used to prepare the medicinal plants surveyed was decoction.

Figure 8:
Preparation of medicinal plants



Drinking, fumigation, and sitz baths were the three most common methods used by traditional healers to administer medicinal preparations (Figure 9). The oral route was the best among many for the administration of medicinal plants by traditional healers (Figure 10).

Figure 9:
Method of administration of medicinal plants

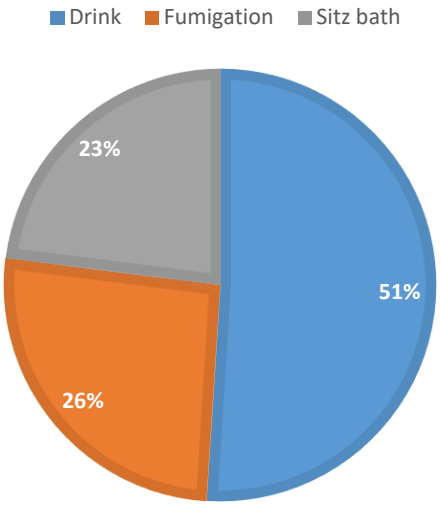
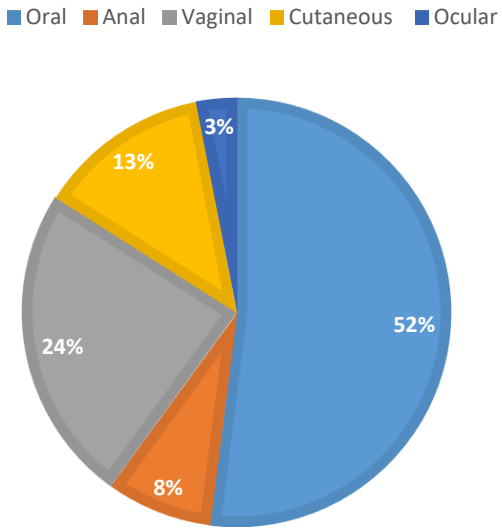


Figure 10:
Route of administration of medicinal plants



DISCUSSION

The use of traditional medicine and medicinal plants is currently recommended by the WHO in the discovery of new molecules with anti-infectious properties to tackle AMR, which represents a huge public health problem (De Luca et al., 2012; Palhares et al., 2015). With this in mind, the present study was initiated with 15 traditional healers from the Makélékélé and Bacongo markets, in the Republic of Congo.

The great difficulty of this survey was to convince traditional healers in these markets to participate in the survey. Despite all the explanations provided concerning the survey's objectives, which relate to the valorization of Congolese culture, some did not stop assimilating it to a competitive analysis, which led to several unsuccessful visits. Others agreed to be interviewed but did not readily give or confess to keeping some information about the plants. Therefore, it was not possible to interview more than 15 traditional healers in this area of the country, despite their small numbers. In addition, the absence of botanists among traditional healers could lead to the possibility of confusion of plants that are almost similar from a botanical point of view, etc. Indeed, two plants may have a similar botanical appearance, but one could be more effective and less toxic than the other.

This study enrolled more women than men. These results confirm those of Kimpouni et al. who explained that the preponderance of women and their better mastery of plants' virtues are elements that highlight the role and function of the female agent in this society (Kimpouni et al., 2019). It should be noted that it was the elder people who were responsible for transmitting knowledge about plants because they had an ancestral character (Sales et al., 2021). To date, we note the presence of traditional healers from younger age groups as observed in this survey. This can be explained by the fact that health problems have become numerous, the elderly alone cannot carry out this heavy work and are currently involving young people to help the population take care of themselves through nature. Baratti-Mayer et al. found similar results (Baratti-Mayer et al., 2019).

More than 50% of the traditional healers in this survey are educated, i.e., have at least a primary school education, and use medicinal plants to treat themselves. These results show that the use of plants is becoming increasingly popularized and is no longer confined to illiterate people as in the past. They therefore constitute a class capable of transmitting knowledge about traditional plants. Other authors have reached the same conclusion (Klotoé, 2013; Osseo-Asare, 2024).

The predominance of traditional healers belonging to the Lari ethnic group can be explained by the fact that it forms an ethnolinguistic sub-group of the large Kongo group of the Republic of Congo. Born towards the end of the 19th

century, they represent between 30 and 35% of the total population of the Congo (Tchicaillat-Landou et al., 2018).

In Africa, knowledge about medicinal plant uses and properties is first and foremost a family secret and generally passed down from one generation to the next through long experience, customs, and oral tradition (Ndou et al., 2023). This justifies the fact that the origins of knowledge most represented in this survey are cultural heritage.

The study of botanical data reveals that the Acanthaceae family is the most widely used in the treatment of infections among traditional healers included in this survey. This family has been the subject of several studies, which have demonstrated the antimicrobial power of several of its species (Awan et al., 2014; Nabèrè et al., 2013). These include the study of Tamoku et al. on the antimicrobial properties of *Brillantaisia lamium* (Tamokou et al., 2011), and the work of Khajure and Rathod on *Acanthus ilicifolius* (Khajure & Rathod, 2010). Moreover, these results are confirmed by the research of Gangaram et al. which asserts that species of this family are an important source of antimicrobial properties (Gangaram et al., 2022). These results once again confirm the expertise of Congolese traditional healers.

The citation frequency of each species was evaluated to assess the regularity in the distribution of the plant. *Carica papaya*, the species with the highest citation frequency in this survey, and therefore the most widely used by traditional healers, has been extensively studied by several authors for its antimicrobial properties (Anibijuwon & Udeze, 2009; Asghar et al., 2016; Dagne et al., 2021). The plants cited by traditional healers are important because they are easily accessible. In addition, some of the plants mentioned have already been studied for their composition as well as their antimicrobial or antiplasmodial properties (Ndukwe et al., 2023; Matos et al., 2022; Ogidi et al., 2021; Asanga et al., 2023). Thus, they constitute good candidates for further research for the rapid development of improved, safe, and effective traditional medicines. The same goes for the other plants mentioned during the survey.

The frequent use of leaves is justified by the abundance of chemical groups they contain as they are known to be the best synthesis site of secondary metabolites in the plant, but also for the ease and speed of harvesting (Ashande et al., 2023). Several studies have also reported similar results (Axiotis et al., 2018; Leso et al., 2017).

All these traditional recipes are mainly prepared in the form of decocts. This is because decoction allows the most active principles to be collected (Lara Reimers et al., 2018), and attenuates or cancels out the toxic effect of certain recipes (Asiimwe et al., 2013). Other authors have reported similar results (Azam et al., 2014; Bano et al., 2014).

This survey revealed that traditional healers prefer to use wild rather than cultivated plants. It's important to point out that wild plants function differently than cultivated plants. Cultivated plants are in a sense forced to grow in an environment that is not always suited to them, so they require much more care, are prone to disease, and may need external inputs to grow well. Wild plants, on the other hand, are survivalists and provide a more interesting energetic variety than plants that have grown out of the ground and fed on fertilizers (Güler et al., 2015; Monari et al., 2022). Traditional healers also explained the difficulty of preserving plants, as reported in the literature (Poós & Varju, 2017), which makes dried plants more popular than fresh ones on their shelves.

These anti-infective medicinal preparations are mainly prescribed orally and as drinks. This may be explained by the fact that traditional healers target pathologies that require the treatment to pass through the digestive tract to facilitate assimilation and reach the infection. Similar results have been confirmed by some authors (Ashande et al., 2023; Yapi & Kouadio, 2020).

This ethnobotanical analysis revealed that the majority of antimicrobial plant recipes are used to treat malaria and gonorrhea. Malaria is an endemic disease with devastating effects, affecting 229 million people worldwide every year, 94% of whom live in tropical areas, including the Congolese region (World Health Organization, 2021b). Moreover, the resistance of *Neisseria gonorrhea* (bacteria responsible for gonorrhea) to antibiotics has increased rapidly in recent years, reducing treatment options. As a result, millions of new cases of gonorrhoea occur every year, and most of these are in the African Region, among adults (Kirkcaldy et al., 2020).

Overuse and inappropriate use of antibiotics have led to the emergence of antimicrobial resistance, making many conventional antibiotics ineffective. Antibiotic resistance is a growing public health problem in both developed and developing countries and in the Republic of Congo in particular. For this reason, there is an interest in finding new antibiotic molecules to counter the AMR phenomenon. Therefore, research is currently focused on the isolation and identification of bioactive components from plants to combat antimicrobial resistance, considering that many pharmaceutical and nutraceutical products are currently based on natural products and their derivatives.

To highlight and maintain the results of ethnobotanical research, a program has already been put in place to develop traditional medicines prepared from plants grown or harvested locally (Pirintsos et al., 2022). Nevertheless, it is essential to conduct rigorous in vitro, preclinical, and clinical studies to evaluate the efficacy and safety of the identified plants. Future ethnobotanical research will therefore be interesting because it will make it possible to explore ethnopharmacology by identifying new active pharmacological substances that are probably promising for biomedical and therapeutic research (Chaachouay et al., 2019).

CONCLUSIONS

This ethnobotanical survey reveals the richness of Congolese biodiversity in anti-infective plants and confirms the important place of phytotherapy. The sociodemographic data of respondents showed that men and women of different age groups have varied knowledge about medicinal plants, with an advantage for women, especially those who are married. The cultural heritage continues to transmit to its people knowledge on the use of medicinal plants, which is increasingly popularized, and not only concerns people who have a high educational level. Even illiterate people are now interested in plants.

The ethnobotanical data provided by traditional healers of this survey identified 23 species of plants belonging to 17 botanical families, the most represented of which is Acanthaceae. *Carica papaya* represented the plant species most used as an anti-infective treatment considering its high citation frequencies. This survey also showed leaves were the most common organs used by traditional healers in many medicinal remedies, and decoction was the most common method of preparation for oral administration of recipes.

Malaria and gonorrhoea topped the list of infections treated by traditional healers in the study area. This study of the medicinal plants used in Brazzaville constitutes a reservoir of information that contributes to knowledge to protect the medicinal flora and safeguard local popular know-how. It will be interesting to associate with other actors of traditional medicine from the Congolese region to develop a more extensive plant repertoire. As medicinal plants are an excellent source of bioactive compounds and represent a hope for the discovery of new drugs, it is therefore interesting to conduct other surveys like this to explore medicinal plants used in the local population as antimicrobial treatments.

Acknowledgments: This work was supported by the Institut de la Francophonie pour le Développement Durable (IFDD/Canada)/Projet de Déploiement des Technologies et Innovations Environnementales (PDTIE) funded by the Organisation Internationale de la Francophonie (OIF), the Organization of African, Caribbean and Pacific States (OACPS) and the European Union (EU) (FED/2020/421-370).

Ethical Approval: Not applicable.

Conflicts of Interest: None declared.

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