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Phytopharmaceutical Diversity of Baka People in the Southern Cameroon

Natacha Nana Afiong[1], Pascal Billong Fils[1], Jean Lagarde Betti[2], Eloge Kambale Muhesi[1], Guillermo Ros Brull[3], Julia E. FA[4], Stephan Michael Funk[5]

[1]Department of Biology and Physiology of Plant Organisms, University of Douala, Cameroon
[2]Higher Institute of Agriculture, Wood, Water Resources and Environment, University of Bertoua, Cameroon
[3]Zerca y Lejos ONGD, Madrid, Spain
[4]Department of Natural Sciences, School of Science and the Environment, Manchester Metropolitan University, United Kingdom
[5]Nature Heritage, Jersey, Channel Islands, United Kingdom
Corresponding Author: Natacha Nana Afiong; Email: nanaafiongharmellenatacha@gmail.com

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ABSTRACT

Medicinal plants take a fundamental place in people's livelihoods. They seem to be a palliative therapeutic option for health problems. The knowledge of traditional uses of plants for healing held by indigenous people is an asset to the valorization of traditional medicine, which is increasingly solicited for the treatment of many diseases. The aim of this research is to improve know-how on plant species employed in the traditional pharmacopoeia practiced by the Baka people, recognized as great healers. Data were collected between 2018 and 2019 from 75 households distributed in five villages in the Mintom subdivision, Southern Region of Cameroon. The so-called popular ethnobotanical survey method was used. One thousand six hundred and thirty-five (1 635) citations and six hundred and five (605) recipes were recorded, involving 210 plant species, distributed in 183 genera and 75 families. A total of 69 health problems were identified and distinguished in 13 groups of diseases. Results reveal that for the same diseases, each village uses its own list of plants. The study area is highly diverse in terms both flora and uses. This paper can therefore be seen as a continuation of the research and development of plants-based medicines. It is also in the line with the import-substitution policy for valorization of Cameroonian.

INTRODUCTION

Forests are invaluable reserve of plant biological diversity. They are a capital importance to human beings with a significant impact on social, ecological and cultural aspects, particulary for forest dependent populations (Hermann, 2006; Awasthi et al., 2022). Biodiversity is essential for human survival and economic well-being and for the ecosystem function and stability (Htun et al., 2011; Gosain et al., 2015; Baboo et al., 2017). Plants are recognized as potential therapeutic options used by pharmaceutical firms and traditional health services to provide health care for more than 50% of world's population (Parihaar et al., 2014; Padalia et al., 2017).

Hunter-gatherer populations are distributed throughout the Congo Basin in Africa. They constitute several genetically and ethnolinguistically distinct groups (Bahuchet, 2014), broadly subdivided into western groups such as the Baka and Aka, and eastern groups including the Efe and Asua. Although the preeminent traditional lifestyle of these groups remains associated with hunting and gathering in the forest, most contemporary groups have adopted some form of agriculture. A typical example is the Baka of the western Congo Basin who are spread across four different countries, with the majority living in Cameroon and numbering approximately 40,000 individuals (Leclerc, 2012). Since the 1950s, the Baka have become sedentary as a result of missionary activities and post-

independence state "development assistance" programs (Leclerc, 2012); the adoption of agriculture and the semi-sedentary lifestyle has been mostly voluntary (Froment, 2014). The development of "improved traditional medicines" can be driven by different approaches including: targeting a botanical family, targeting a specific area, or the ethnobotanical approach. Of all these approaches, the ethnobotanical approach seems to be the most reliable. Ethnobiology refers to the biology of societies. It focuses on man's interaction with his biological environment. It can be man-animal (ethnozoology), man-plant (ethnobotany), or man-fungus (ethnomycology) relationships. The ethnobiological method is recognized as the safest (Betti, 2001) and least expensive (Balick, 1994) way to develop drugs and other types of manufactured products from natural resources. The study of the popular pharmacopoeia of the Baka and related tribes contributes to the cultural vulgarization of these peoples who are often stifled. But for this method to be successful, it is necessary to ensure that informants have prescribed exactly what they use in their daily work as herbalists.

The proposal for sustainable development strategy is based on consideration of three aspects intimately linked: social, economic and ecological (Strange and Bayley, 2008). So then, sustainable development includes three complementary pillars that interact and complement each other, namely the social, economic and environmental dimensions. It includes 17 goals (SDGs) approved in 2015 by the United Nations (www.undp.org). Among them, those relating to the eradication of poverty (goal 1) and promotion of health for all (goal 3) as outlined in our study.

This article aims to document the knowledge on the traditional use of medicinal plants by the Baka populations in the treatment of health problems as a basis for valuing and developing "ethnomedical tourism" among these great healers. The specific objectives are: (1) to list the plant species used by the Baka; (2) to highlight the diversity of uses; and finally (3) characterize the traditional usages of medicinal plants.

MATERIALS AND METHODS

Study Site

The study region is located in the eastern part of the Division of Dja and Lobo in south-eastern Cameroon, south of the Dja Faunal Reserve, and the Dja Biosphere Reserve. Four study villages were selected near the provincial capital Mintom. Mintom has about 6000 inhabitants and is located about 30 km South of the Dja Reserve and 300 km east of the State capital Yaoundé: Assok (15 km East of Mintom), Bemba I, Bemba II, and Abing-Nkolemboula (20 and 15km north, respectively), and Doum (8 km west). Population censuses conducted by us recorded 76 inhabitants in Assok, 62 in Bemba II, 59 in Abing-Nkolemboula, and 109 in Doum during the study period. The Bantus, the Kako and the Baka are the ethnic groups mainly found in the area. Bantus include the Fang-Nzaman. The Baka and the Kako farmers live mostly scattered in small settlements, mainly in the forest at some distance from the Bantu villages and roads. Both these groups get most of the resources they need to survive from the forest that borders them, with a density of almost 2 inhabitants per kilometer. Hunting and gathering are practiced by all, but more intensively by the Baka people (Betti, 2001). After relocation from the forest, Baka have opened their own plots to grow subsistence crops such as plantain, banana, and cassava (Yasuoka, 2012).

This change in lifestyle has been associated with a marked decline in physical and mental health (Dounias and Froment, 2006). Farming has increased in recent years in our study villages, particularly as a result of agricultural programs initiated by our study partner Zerca y Lejos (ZyL) (Zerca Y Lejos, 2020a; Zerca Y Lejos, 2020b), a Spanish NGO working on development and providing health support to Baka communities in the region. Supplementing their life in the village with time in forest camps has led to reduced stress and has helped them maintain better nutritional status (Hagino et al., 2014). Hunting, fishing, and gathering depend on both the agricultural timetable and season (Duda, 2020). Mintom is a bimodal rainfall.

The climate is equatorial and humid. Rainfall averages between 1500 and 2000mm per year, and some precipitation is common even during the dry seasons (WWO, 2020). Mean annual temperature is 25 °C, fluctuating slightly between seasons. There are four seasons: a major dry season is from December to March, a minor rainy season from March to May, a minor dry season in August, and a major rainy season from September to November

(Gallois et al., 2020). The terrain of the region is sloping with gently rolling hills ranging between 250 and 800. The major vegetation type is a mixture of evergreen and semi-deciduous forests (Letouzey, 1985). Three broad categories of forests can be distinguished in the Mintom area: forests on rocks, forests on firm soil, and aquatic or hydromorphic forests. Forests on firm soil are divisible into primary and secondary forests. The study villages are located within the Mintom subdivision in Dja and Lobo division, south-eastern Cameroon, in the periphery of the Dja Biosphere Reserve. The main town, Mintom, is found about 30 km of the Dja Reserve and 300 km of Yaoundé, the political capital of Cameroon. The Mintom subdivision is covered by evergreen Cameroonian-Congolese forest, classified as the Dja Congolese botanical district.

Data Collection

Data collection started with an information and sensitization meeting of rural communities to obtain their consent. Before starting the survey in each village, we held meetings to inform the villagers of the objectives of our work and also to set appointments. The information was collected from anyone who voluntarily agreed to receive us on the plants and medicinal recipes they are often used to treat any illnesses. Information related to medico-magical effects was not requested, so as to generate much more audience with informants. During the interview, we thought it best to start from the diseases to the plants, rather than going the other way around. By showing our interlocutor a sample of a plant and asking about its uses, we risked encouraging him to invent recipes (Betti, 2001). Data concerning the details of the recipes were collected according to a standardized framework and inspired by the files proposed in the database of Traditional Medicine and Pharmacopoeia in acronym Pharmel (Adjanohoun et al., 1994). This sheet is composed of 5 parts, namely: - the identification of the informant - the therapeutic indications - the characteristics of the plant material used - the methods of preparation and administration of the remedy - and the comments.

Information on the diagnosis of diseases was collected from local doctors, nurses or health workers and supplemented by a bibliographic review (WHO, 1978). To standardize the data collected according the international system, the identified health problems and distinguished into groups of diseases in this case study were transposed in accordance to the classification of diseases proposed by the World Health Organization (WHO, 1994) and adopted by the Organization of African Unity (OAU) for the Cameroonian pharmacopoeia (Adjanohoun et al., 1996). This classification groups together diseases mainly by system or device, without insisting too much on their modes of transmission or their evolutionary processes.

The constitution of a sample collection is fundamental in any floristic inventory work. In addition to the specimens collected here and there during the interviews, we conducted expeditions in each area in the company of botanists and guides (here the same respondents). This enabled us to determine many plant species in the field. The main floristic works of Central Africa were used to ensure the correct determination of plants, in particular the flora of Cameroon, Gabon, Belgian Congo and Rwanda-Urundi, and also other works of a purely ethnobotanical nature. (Letouzey, 1976). The plant identifications were completed and finalized by the plant databases available on the internet (https://uses.plantnetproject.org/fr/; https://www.ville-ge.ch/musinfo/bd/cjb/africa/research.php?language=fr). In the field, we benefited from the help of Mr. Ngangsop Eric, technician of the National Herbarium of Cameroon (HNC), Mr. Djendj miasse Manager of forestry operations of the Mbeth II community forest and Mr. Medock selema Célestin, Botanical technician for the determination of plants. The plant samples were collected at least in two copies and sent for conservation at the National Herbarium of Cameroon in Yaoundé.

Data Processing and Analysis

The sample is assumed to be random: the presence of information in the sample has no influence on the probability of the presence of other information. It is this hypothesis which seems possible to us on the collection of data and on the population studied (that is to say all plants used by Baka people in the Mintom subdivision). Therefore, non-parametric statistical techniques will be used (Dagnelie, 1998).

Methodology for the Individualization of Groups

A plant or a recipe is subject of a convergence of use, when it is used by at least two persons to

treat the same disease/ailment. The information is supposed to have been collected in a homogeneous manner (standard protocol for all households) even if the people met have different qualities (healers, village chief). The distinction between the uses of plants can be made according to the simple presence / absence of plants or according to the importance (number) of quotation (citation). In this case, the groups (village) studied must be compared in pairs (Dagnelie, 1998). The 2 x 2 chi-square test will be used to see whether or not for a health problem (malaria for example) the two groups to be compared use the same plants or not. However, the x^2 appears to us to be much more reliable than the S∅rensen coefficient, since it takes into account all the plants mentioned in all the groups (including those which are absent in the two groups to be compared). Let 4 numbers a, b, c and d be defined as in Table 1.

Table 1. X^2 Contengency Table 2 x 2

		Group I		
		Presence	Absence	Total
Group II	Presence	a	b	a + b
	Absence	c	d	c + d
	Total	a + c	b + d	a + b + c + d

a: number of species common to the 2 groups;
b: number of species specific to group II;
c: number of species specific to group I;
d: number of species absent in groups I and II.

From the previous table, X^2 observed is calculated using formula:

X^2 obs. = n (ad-bc) ^{2} / (a + b) (c + d) (a + c) (b + d). If X^2obs < X^2 theoretical, we reject the hypothesis of independence of the groups compared; in other words, the two groups use the same plants. In this work, the threshold used is a = 5%; and therefore X^2 (1-a) at the degree of freedom of 1, is equal to 3.84.

The relative importance of uses, plants or recipes is assessed through the number of citations. By comparing the population of an area or site with that of the forest, it is possible to transpose the parameters of systematic botany into ethnobotany (botany of societies) (Table 3). This transposition of parameters is done at 5 levels in decreasing order: the forest, the block, the plot, the plant species and the individual or stem for botany on the one hand; the surrounding population, the village, the respondent or interviewee, the plant species, the citation for ethnobotany on the other. The smallest unit of analysis is the citation. The population of each site is overlapped in several villages; each village is composed of several respondents; each respondent indicates or provides several plant species; and each plant species can be mentioned in various quotations or uses (Betti et al., 2020, Billong et al., 2020). The diversity indices used in this thesis will therefore be those often used to assess diversity in systematic botany or forest ecology (Peet, 1974), namely Shannon weaver (H), Simpson (D) and Pielou's regularity or equitability (E) indices.

Table 2. Transposition of the Parameters of Systematic Botany to the Ethnobotanical Context

Levels	Botanic	Ethnobotanic
Level 1	Forest	Site
Level 2	Block	Village
Level 3	Plot	Respondent or interviewee
Level 4	Specie plant	Specie plant
Level 5	Individual or Stem	Citation

Shannon Weaver Index (H')

In our case, the Shannon index (H') makes it possible to evaluate the level of diversity of each group (village) by taking into account the proportion of each plant in the indicated groups. It is expressed in bits and is calculated with the following formula:

$$\mathbf{H'} = -\sum_{i=1}^{S} Pi \log_2 Pi$$

In this formula, Pi = Ni/N with

Ni = number of times a plant (i) or recipe (i) is cited;
N = total number of citations of all plants or recipes cited.

The Shannon index is sensitive to variations in the importance of rare species (Peet, 1974). It is equal to 0 when there is only one species; and a maximum value (Log2s) when the species have the same dominance (Dajoz, 2006).

Simpson's Index

Simpson's index (D) measures the probability that two randomly selected citations belong to the same plant or recipe (Dajoz, 2006):

$$D = 1 - \sum_{i=1}^{S} Pi^2$$

With Pi: number of individuals of species i; S: total number of individuals of all species; D: varies from 0 to 1. Simpson's index is sensitive to variations in the importance of species dominance or abundance (Peet, 1974); and takes into account both richness and equity. It reaches the maximum value in monospecific groups; and the minimum value when species (or recipes) have the same dominance.

Pielou Regularity or Equitability

Pielou's regularity or equitability allows us to observe the relative disorder within the population. It measures the degree of diversity reached by a group compared to its maximum level of diversity. It compares two groups with different numbers of individuals (Grall and Coïc, 2005); or citations in our case. The regularity is calculated as follows:

$$E = H'/Log_2 S$$

S is the total number of species or recipes (Dufrêne and Legendre, 1997).

The regularity index tends towards 0 when almost all citations are concentrated on a single plant (or recipe). While it tends towards 1 when all species (or recipes) have the same abundance. A low regularity illustrates the importance of a few dominant species. S is a total number of species and recipes (Dufrêne et Legendre, 1997).

RESULTS AND DISCUSSION

Sociodemographic Characteristics of the Respondents

A total of 75 households were interviewed in five Baka villages found in the Mintom Subdivision. These households are distributed as follows in different village: Assok (19 households), Bemba I (8), Bemba II (17), Doum (15) and Nkolemboula (16).

A total of 1,635 citations were obtained from the interviews. The characteristics of survey informants are shown in Table 3. For each person, we have specified in appendix 1: the code, name, age, sex and village. Men represent 72% of the workforce. The respondents can be grouped into 6 age groups dominated respectively by individuals of [20 - 50] years (69.3%).

Table 3. Sociodemographic Characteristics of Respondents (N= 75)

Variables	Categories	informants		Citations		
		Number	%	Number	%	Citations/person
Villages	Assok	19	25.33	338	20.67	17.8
	Bemba I	8	10.67	219	13.40	27.4
	Bemba II	17	22.67	499	30.52	29.35
	Doum	15	20	307	18.77	20.5
	Nkolemboula	16	21.33	272	16.64	17
Sex	Male	54	72	1288	78.78	
	Female	21	28	347	21.22	
Age (years)	< 20	4	5.33			
	20 - 30	17	22.7			
	30 - 40	19	25.3			
	40 - 50	16	21.3			
	50 - 60	6	8			
	> 60	13	17.3			

Groups of Diseases

Thirteen (13) categories of diseases were identified (Table 4). The group of parasitic diseases (other than those related to the digestive system) appears to be the most cited (21.35%); followed by the group of digestive system (18.23%) and specific symptoms (15.17%). Sixty-nine (69) diseases/ ailments were identified. The twelve (12) most represented are illustrated in figure 2. Malaria is the most treated disease according to the respondents (18.65% of citation); followed by diarrhea (7.16%), Cough (5.75%) and headaches (5.75%) (Figure 1).

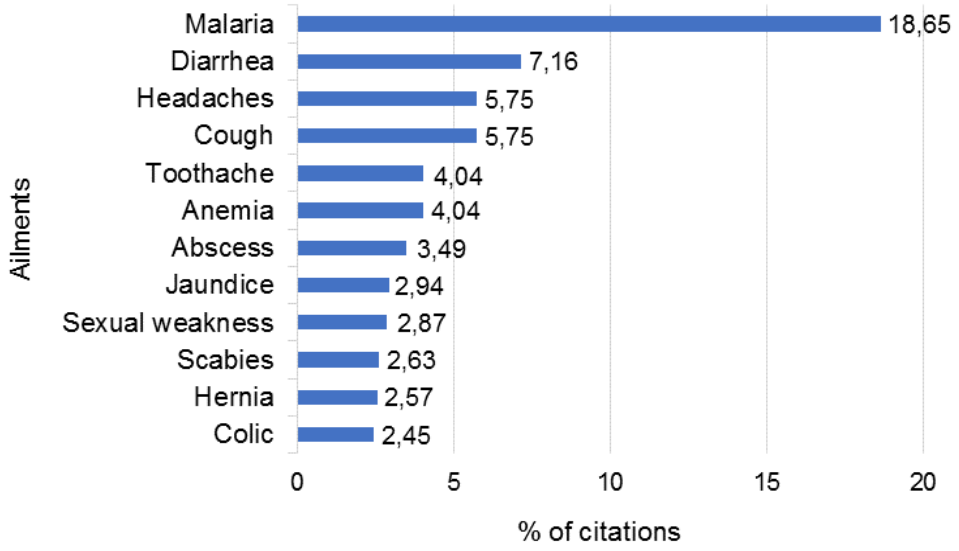

Figure 1. Twelve ailments most cited by Baka people in the Mintom subdivision

Table 4. Relative Importance of Disease Groups (% of Number of Citations)

Group of diseases	Ailments	Number of ailments	% of citations
Parasitic diseases (other than those related to the digestive system)	Malaria, malaria/fever, scabies	3	21,35
Digestive system	Colic, constipation, diarrhea, dysenteriform diarrhea, intestinal worms, red diarrhea, stomach pain, toothache, typhoid fever	9	18,23
Specific symptoms	Anemia, chest pain, haedache, injury, jaundice and thorn sting	6	15,17
Respiratory system	Common cold, cough, flu, sinusitis and tuberculosis	6	8,75
Specific diseases and conditions	Abscess, antipoison, panari, scorpion bite and snake bite	5	6,85
Female reproductive system: obstetrics and gynecology	Abscess, dysmenhorrea, easy delivery, female sterility, fibroma, fortifying the baby in the womb, galactogen, postpartum, salpingitis, trim during menstruation, vaginal laxity	11	6,30
Muscular and skeletal system	Aches, fracture, limb pain, lumbago, back pain, rheumatism, sprain	7	6,24
Childhood diseases and conditions	Aches, child mobility delay, convulsion,	7	5,50

Group of diseases	Ailments	Number of ailments	% of citations
	hernie, mumps, red buttock and spleen disease		
Male genitourinary system	Gonococcal disease, sexual weakness	2	5,26
Disease of the skin and subcutaneous cell tissue	Lice, tic tac toe, supurative otitis, conjunctivitis, eyelid disease, sore eyes	6	4,34
Cardiovascular system	Chest pain, hemorhage and hypertension	3	1,35
Nervous system and mental disorders	Alcoolisme, epilepsy, vertigo	3	0,43
Infectious diseases	Tetanus	1	0,24

Diversity of Medicinal Plants Used by Baka in Mintom Subdivision Medicinal Flora Composition

The inventory of plant used in Baka pharmacopoeia revealed two hundred and ten (210) species. These species are distinguished as follows: 183 genera and 75 botanical families. The most diverse families are: Euphorbiaceae (19 species), Rubiaceae (11), Apocynaceae, Malvaceae, Asteraceae and Moraceae (9 each other). On the contrary, the most cited families are: Apocynaceae (17.37%), Euphorbiaceae (6.42), Marantaceae (6.24), Annonaceae (5.81), Arecaceae (5.38) and Solanaceae (5.08). The twelve (12) most important plant species in terms of number of citation and ailments are illustrated in Figure 2. Alstonia boonei is the species most mentionned (7.28% of citations; 12 ailments), followed by Elaeis guineensis (4.77%; 23) and Picralima nitida (4.77%; 6).

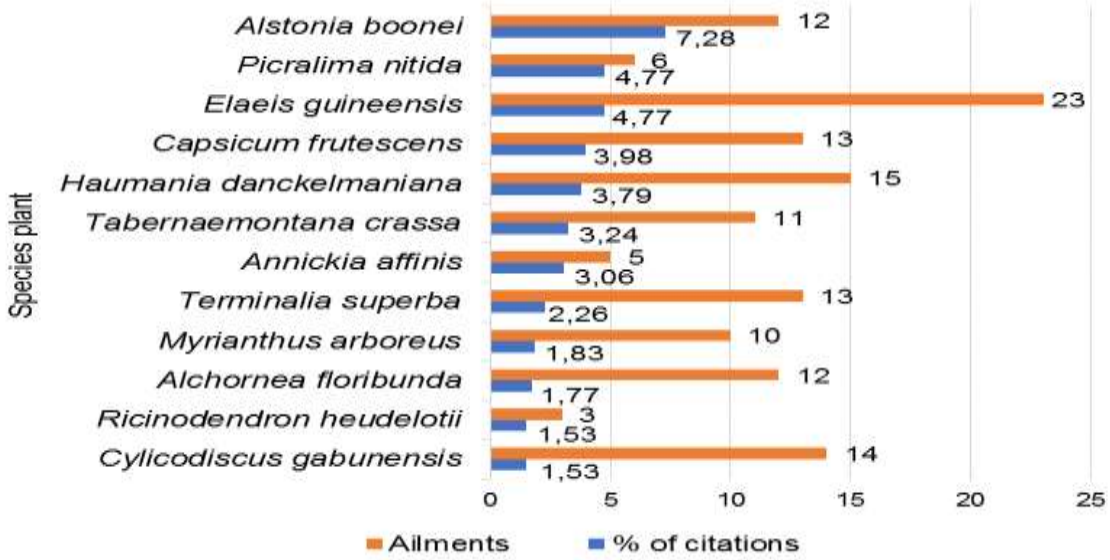

Figure 2. Relative importance of the twelve most cites plants in the Baka pharmacopoeia

Similarity in Use of Medicinal Plants for the Same Ailments between the Different Villages

We would like to verify the hypothesis H0 according to which "All areas use the same plant species to treat the same diseases or that there is a similarity in the use of the same plants for the same ailments treated between the different sites". Hypothesis H1 verifies that each site has its own list of plants to treat the same ailments. It will be necessary to compare the ailment-plant combinations used between the different sites. The chi-square test was used at two levels. It revealed that not only are the plants specific to each site (X-squared = 1470.3, df = 836, p-value < 2.2e-16), but also one village to another (X-squared = 3748.3, df = 2664, p-value < 2.2e-16). These results allow us to reject the H0 hypothesis.

Ethnobotanical Use Diversity

Ethnobotanical diversity of use is determined by transposition of botanical indices into

ethnobotanical indices. These are Shannon Weaver (H), Simpson (D) and Pielou's regularity or equitability (E) indices. Table 5 summarizes value of these indexes for the five villages. The overall diversity of medicinal plant uses is high in the five areas surveyed among the Baka (H = 6.55).

Table 5. Ethnobotanical Use Index Values

Villages	C	S	H'	D	E	Ni	DC	DP
Assok	338	83	5.37	0.95	0.84	19	17.8	4.4
Bemba I	219	81	5.77	0.97	0.91	8	27.4	3,72
Bemba II	499	141	6.34	0.98	0.88	17	29.35	8.3
Doum	307	102	4.11	0.98	0.61	15	20.5	7
Nkolemboula	272	88	5.78	0.97	0.89	16	17	5.5
Global value	1635	210	6.55	0.97	0.84	75	22	3

C = Citations, S = Species, Ni = Number of informants, DC = Density of citation, DP = Density of plant

Characterization of Recipes Used in the Baka Pharmacopoeia

A total of 1,635 citations was reported, distributed in 210 plant species. Appendix 2 presented recipes cited. The ratio plant/recipe gives 210/605= 0.35. This ratio is lower than 1, and reflects the fact that some recipes are composed of more than one plant species. In other words, more than one species is involved in the preparation of some recipes. Each recipe is represented by one code composed of three groups of elements including: the scientific name of the plant cited which is composed of the two first letters of the genera and the species, the plant part comprising the two first letters, and the pharmaceutical form which is also composed of the two first letters.

Figure 3 represents the fifteen most elaborated recipes for the treatment of diseases; and number of ailments treated with these recipes. Based on the recipes mentioned by the populations, [Albo-Sb-Ma] (12.3), [Elgu-Po-Po] (9) and [Pini-Sb-Ma] (5.3) are the most important. While the recipes used in more cases of disease are in descending order: [Elgu-Po-Po] (16), [Tesu-Sb-De] (11), [Albo-Sb-Ma] and [Elgu-Fr-Po] (10 each other).

Fifteen plant organs were recorded without any consideration of their state of use (fresh, dry and young). The stem bark is the most used (53% of citation), followed by leaves (23) and Fruit/Seed (10) (Figure 4). A total of 23 pharmaceutical forms were recorded. Maceration and decoction are the most used with 29.41% and 27.6% respectively (Table 6).

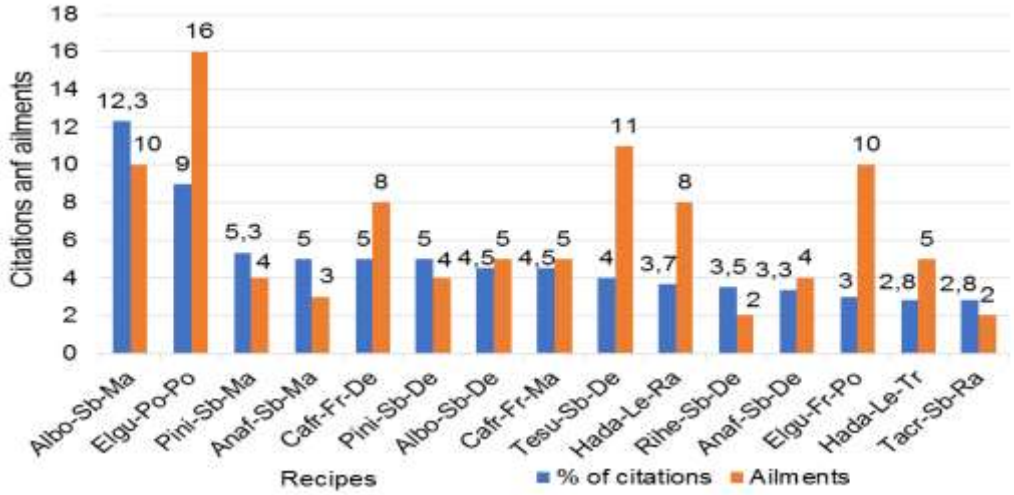

Figure 3. Relative Importance of Recipes Used in the Baka Pharmacopoieia

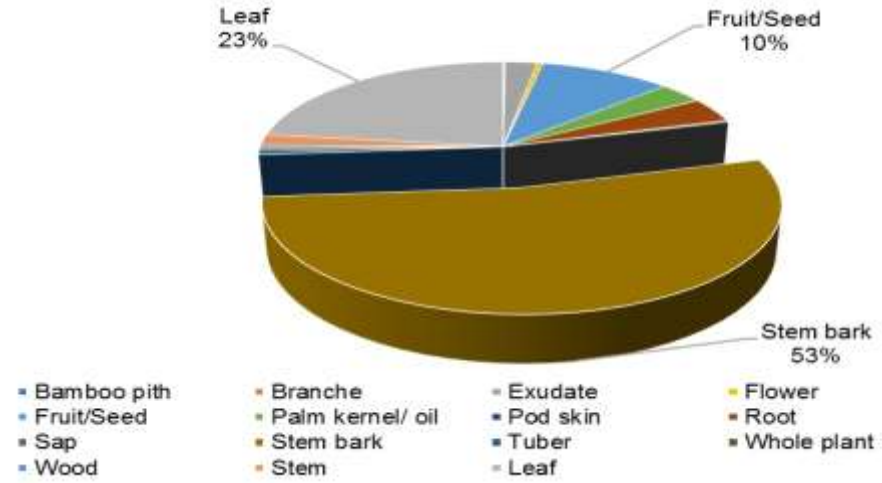

Figure 4. Plant Organs Used in the Recipes

Table 6. Pharmaceutical Forms Used in Recipes

Pharmaceutic forms	Citations (%)	Pharmaceutic forms	Citations (%)
Macerated	29.42	Suppository	0.43
Decocted	27.65	Masticate	0.37
Pomade	9.17	No prepared	0.31
Rapture	8.69	Smoke	0.24
Softened	5.81	Stem	0.18
Triturated	4.65	Ash	0.12
Juice	4.46	Belt	0.12
Exsudate	2.69	Infused	0.12
Pounded	2.02	Pill	0.12
Powder	1.65	Garnish	0.06
Pastry	1.10	Oil	0.06
Meal	0.55		

Characteristics of the Sample

The present study made it possible to highlight the potential therapeutic plants used for health care uses identified in the Mintom subdivision. The characterization of the respondents shows a predominantly male population. Men are largely represented, accounting almost 2/3 of the population covered by the survey. The low number of women could be justified by the fact that women feel more embarrassed than men during exchanges. It is important to note, however, that the surveys were conducted on the basis of consent. This compares with the work of Tajeukem et al (2021) in Gribé (East Cameroon) who found 68.10% of men; and Ngoule et al (2015) who also found a majority of men (60.41%) during surveys in the markets of Douala. Similar results were obtained by Mogode Debete (2005) in Chad, where 91% of respondents were male. Mpondo et al (2017) also had a proportion of 54.55% in Upper Nyong (East-Cameroon).

The majority of respondents are in the age range of]20 - 50] which can be justified by the fact that these age acquired through years of experience and inherited through filiation. According to Ngbolua et al. (2019), the use of medicinal plants is a common practice in the age groups ranging from 18 to 65 years with a predominance of those aged 26 to 33 years. For Mpondo et al (2017), it varies from 25 to 81. Studies conducted in Togo conclude that the practice of traditional medicine is the preserve of middle-aged men (Gbekley et al., 2015). According to study carried out in Bangladesh, people aged between 30 to 40 years know more about herbal remedies (Rakib et al., 2020 et Eloge et al., 2023).

Groups of Diseases and Ailments

Thirteen (13) categories of diseases were identified. The group of parasitic diseases (other

than those related to the digestive system) group mentioned as the most quoted (21.35%), followed by the group of digestive system (18.23) and specific symptoms (15.17). For Kidik et al. (2015) in the markets of Douala (Cameroun), the most represented disease group is infectious and parasitic diseases (19.34%) followed by the digestive system disease group (17.41). Same as Koulibaly et al. (2016) in Ivory coast, who found that infectious and parasitic diseases were largely cited (42.10 %), followed by the group of digestive system (10.52%). In Morocco, Mehdioui and Kahouadji (2007) reported that 50% of medicinal species are used mainly against diseases of the digestive system.

Sixty-nine (69) ailments were identified. This result differs from those obtained by Betti et al. (2013a) and Betti (2004) who found 24 and 22 diseases respectively in Ipassa-Makokou Biosphere Reserve (Gabon) and Dja Biopshere Reserve (Cameroun). It also differs from Ladoh et al (2016) in Douala markets (18 diseases) and Betti (2002b) in Yaoundé markets (12 diseases). The most common conditions in Mintom are Malaria (18.65% of citations); followed by diarrhea (7.16%), headaches (5.75%) and Cough (5.75%). Malaria, sexual dysfunction, and diarrhoea were the most cited ailments in Gabon (Betti et al. 2013a). In Côte d'Ivoire malaria was known as the most common disease (Koulibaly et al., 2016; Trabi et al. 2008). The convergence of the results testifies to the proximity of the countries investigated and their belonging to zone C, considered as a high-risk area for malaria (Betti, 2002a; Muhindo et al, 2022).

The chi-square applied at two levels on the plants used for the various ailments in the Mintom district, reveals that each village has its own list of plants. Also, there is a dependence between the village and the specific plant used to treat the same disease. In other words, each village has its own way of using of plants or recipes to treat the same disease. This result further confirms the diversity of the subdivision in terms of the wide range of active molecules presents in these plants that can be used to treat many diseases.

Diversity of Ethnobotanical Use

The transposition of the ecological indices into ethnobotanical indices made it possible to appreciate the diversity of ethnobotanical uses within the different sites investigated. The Shannon index reveals a high diversity both in the overall and in each village through the scores obtained. This is justified by the precarious condition in which the populations live, obliging them to depend essentially on the plants that surround them for their health care. Similarly, to Shannon's index, Simpson's index and pielou's equitability index values for all sites are high, indicating abundance of individuals/citations and equitable distribution within the plant species cited. Billong et al. (2020) also indicate a high overall diversity; with Shannon index values of 4.96 and pielou equitability (0.84) for edible wild plants used by Baka people in the same area (Mintom). Likewise, at the North Gabon where Betti et al. (2020) has also found indexes values of diversity (H=4.96) and Pielou equitability (E=0.89). These high values of the diversity indices reveal the level of expertise of local communities in medical plants and their traditional uses.

The number of citations issued is higher for households surveyed in Bemba II village. The same is true of the density of citations, which is 29 per household. This finding not only justifies the level of knowledge acquired about medicinal plants by the respondents in this village. But also because of the receptivity of the people in these areas to our questionnaires compared to the others. Generally, informants are often reserved and there is a lot of reluctance, especially with regard to medicinal plants (Betti, 2001). The distribution of species within villages shows a high diversity in the village Bemba II (141 species). Regarding the density of plants, each household cited about 3 plants in the surveys overall. In contrast to Billong et al. (2020), who found in Mintom, average use densities of 1.2 for wild edible plants. Same to Betti et al. (2020), who found in North Gabon a density of 1.76. The plant density/citation density ratio highlights the level of knowledge of the different uses of plants for health problems. It is 0.14 for all sites. However, this ratio is lowest (0.13) in the village of Bemba I, which indicates a greater mastery of the different uses of plants by the people of this village than in the others. The lower the ratio, the greater the mastery of the different uses of plants.

Diversity of Medicinal Plants Used for Treatment of Ailments in Mintom Subdivision

Surveys on traditional uses of plants conducted in the five villages in a sample of 75 households baka, allowed us to collect 210 species used 605

recipes in the management of 69 conditions. The high number of recipes indicates the pertinence of the traditional knowledge and know-how of the Bakas people. Baka people are still considered to be great healers (Betti 2002a). The 210 plant species recorded are distributed in 183 genera and 75 botanical families. This gives a ratio plant/informant (P/I) of 2.8. The high number of species shows that the medicinal flora of the study area is rich and varied. In Gabon, Betti et al. (2013a) recorded 71 plant species distributed in 69 genera and 38 families among 60 informants based in the periphery of the Makokou biosphere Reserve (P/I = 1.18). In the Upper Nyong (Mpondo et al., 2017), a total of 90 medicinal plants were recorded among 90 people among Baka and Maka people (P/I = 1).

The most diverse and cited families are: Euphorbiaceae (19 species; 6.42% of citations), Rubiaceae (11; 3.97), Apocynaceae (9; 17.37), Malvaceae (9; 1.71), Asteraceae (9; 2.01) and Moraceae (9; 4.09). The Asteraceae, Euphorbiaceae and Rubiaceae were also noted as the predominant families in the Daloa region (Koulibaly et al., 2016). Betti (2004) on the other hand, found Apocynaceae (7 species), Euphorbiaceae (6) and Asteraceae (4) among the 7 most represented families in the Dja biosphere Reserve. The floristic inventory in the upper Nyong also shows the predominance of the Euphorbiaceae and Asteraceae families (Mpondo et al., 2017). Similarly, Etame-Loe et al. (2018) found the same families: Asteraceae (11.2%) and Euphorbiaceae (8.81%) during the survey conducted in three villages of Lom and Djerem departement (East region). The Asteraceae and Euphorbiaceae families are also reported as dominant in several other works on medicinal plants (Ladoh-Yemeda et al., 2016; Béné et al., 2016) respectively in the markets of the city of Douala (Cameroon) and the department of Transua (Ivory Coast). In one region of Uganda, the Asteraceae was recorded as the most represented family (Hamill et al., 2013). The preponderance of Asteraceae and Euphorbiaceae would be linked to the presence of flavonoids, terpens and alcaloids (Mpondo et al. 2017; Nga et al. 2016). They are responsible for their therapeutic properties and confirm the health problems obtained from the surveyed populations. Also, Rubiaceae are one of the six most common botanical families in angiosperms (Karou et al., 2011).

Characterization of recipes of medicinal plants

The characterization of the recipes for this study was based on the organs and the pharmaceutical form used to prepare the remedy. Among plants organs identified, the stem bark is mainly quoted followed by the leaves in general (dry, young and mature). This result is in line with Betti et al. (2013a) and Tajeukem et al. (2021) who reported on bark and leaves as the most employed organ in recipes. Ilumbe et al. (2014) also found Trunk bark (30.1%) followed by leaves (25.6%) as the most used organs. As opposed to Bené et al. (2016) who found that aerial parts (leaves) are most frequently used in the various therapeutic preparation. This preference could be justified, on the one hand, by the fact that the bark is the seat of transport of the raw sap, the substance containing the bioactive molecules that induce the biological activity of the plant from which it comes; and on the other hand, because of its accessibility and availability compared to the other vegetative organs for the treatment of diseases. The preference for bark and leaves is explained by their facility to be harvested (Trabi et al., 2008). The perennial character of the species allowing at least one organ in each season, influences the choice of populations towards these woody plants (Adomou et al., 2012). And also, by the abundance of chemical groups they contain, as they are known to be the site of synthesis of secondary plant metabolites (Mpondo et al., 2017). The interest in bark is due to its richness in secondary metabolites responsible for the biological properties of the plant (N'Guessan et al., 2009). The variations reported here in the modes of preparations depend on the diseases, area of infection, experience of traditional healer, intensity of sickness and availability of plant species or alternatives (Johnny et al., 2022). Maceration (29.41%) and decoction (27.6%) are the most common methods of preparation in the included studies; with macerated and decocted as pharmaceutical forms. Frimpong et al., 2021) reported decoction largely cited as method of preparation. Decoctions (40%) are generally easy to prepare and inexpensive, which is why they are predominantly employed by THPs in the management of diseases (Younis et al., 2018).

CONCLUSION

Traditional medicine is expanding considerably with the introduction of pandemics, emerging diseases and the resistance of certain germs to conventional medicines. As a result, the exploitation of plant resources to overcome various health problems is a palliative. This is also because of their accessibility, but also and above all because of the inexhaustible and renewable active ingredients contained in these plants. This paper confirmed the potential of ethnobotanical surveys in five villages of Baka People based in the Mintom Subdivision, South Cameroon. It is permit to highlight the potential therapeutic plants used in the treatment of the diseases identified in the Mintom subdivision. All the uses and recipes listed will help to convert Baka folk oral knowledge into transcribed knowledge by establishing a compendium of medicinal plants and characterizing their therapeutic uses. However, the various usages of plants identified on the basis of the results of this survey clearly indicate that the populations concerned fully exploiting the plant resources around them to the full for their daily living needs. This recommends a rational use of these natural ecosystems to ensure a regular and sustained supply. This requires a better knowledge of the availability of the resource, followed by a description of the harvesting techniques of this tradipharmaceutical resource used by the populations. And finally, sensitizing these populations on the benefits or importance of the preservation of the resource.

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