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Research Article

Assessment of resilience of aromatic plants during the COVID-19 pandemic in Douala, Cameroon

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Abstract

Aromatic plants are one of the components of Cameroonian medicinal flora that seem to be an alternative to fight against the Covid-19 disease. The present study aims to establish chemical characterization of some aromatic plant organs used in the Douala IV sub-division during the COVID-19 pandemic. A semi-structured survey was carried out between September and December 2020 in order to identify aromatic plants used for health diseases during the Covid-19 pandemic. Due to their ethnobotanical index the selected plants were screened chemically through staining and precipitation methods to determine different bioactive compounds. Thirty-one (31) plant species belonging to 17 families were recorded with the dominated by Lamiaceae and Zingiberaceae being the dominant families and *Ocimum gratissimum* as the most cited species (28.57%) in the composition of recipes. Leaves (50.80%) were the most used organs to prepare the decoctions (33.33%) administered to patients orally. These plants were used in the treatment of 51 ailments diseases, notably malaria, cough and typhoid fever with 22, 21 and 12 citations respectively. Informant Consensus Factors (ICF) showed a relatively high agreement (0.75) for the use of species against respiratory diseases. *Zingiber officinale*, *Citrus limon* and *Cymbopogon citratus* had a good performance (Ip = 3) against cough, typhoid and malaria respectively. Extracts of aromatic plant organs were rich in alkaloids and phenolic compounds. These aromatic species showed their ability to treat respiratory and other infectious diseases, and could be an alternative to fight against Covid-19.

Keywords: Aromatic plants; Bioactive compounds; Douala IV; Drug recipes; Ethnobotanical index.

INTRODUCTION

The Cameroonian flora abounds in an important reserve of plants with edible, ornamental and medical characters estimated at more than 8500 species [1]. Apart from cultivated species, several lesser known wild species have great cultural importance and strong economic potential for food, care, energy, clothing and housing construction [2-3] Medicinal species represent a cultural heritage in developing countries and an invaluable resource for the pharmaceutical industry [4]. While it is true that plants have long been used in herbal medicine, their renewed interest among the public has been felt more during pandemic such as the Covid-19 pandemic. This specific interest obeys to the non-acceptance of pharmaceutical products and also to their high cost by population.

With the first contamination cases and the confinement recorded by March 29, 2020, population started to prepare themselves for preventive and curative measures to deal with the Covid-19. Actors of traditional medicine consequently got down to search plants as solutions to avoid the worst of the Covid-19 pandemic. Many herbal therapeutic protocols have therefore been put in place [5-6]. Following this, many habits, both dietary and therapeutic, involving plants have emerged, becoming a lifestyle and dietary rules. Spices, vegetables, and fruits were used for this goal. Aromatic plants formerly considered underused and neglected species have been given special attention.

Aromatic plants are ordinarily consumed for culinary and dietary uses due to their aromas as well as their essential oils and various bioactive metabolites for medicinal purposes [7-8-9]. In line with this, Kuete-Sezine *et al.* reported that Cameroonians relied on traditional medicine to counteract the Covid-19 pandemic [6]. Essential oil and phenolic compounds highlight the greatest interest of these plants such as in their abilities to inhibit oxidative reactions and the growth of many microrganisms [8-10]. These findings point to the aromatic plants as a therapeutic alternative for pharmaceutical products. Moreover, aromatic plants offer real opportunities for socio-economic development of farmers and neighbouring population to improve their incomes [7]. These plants constitute the main part of the therapeutic arsenal used by traditional healers to treat many diseases [11].

However, the lack of adequate scientific knowledge and management structures adapted to aromatic plants can lead to the endogenous treatment of the Covid-19 disease. On one hand, traditional healers operate usually alone and out of the scientific system without clear protocols that can be followed or repeated elsewhere. Each of them proposes its own protocols including the same or different plants. Secondly, cultural culinary habits are dominantly based on the common consumption of aromatic plants for their taste, easiest digestion and therapeutic values. The population consumes these plants usually without any perfect knowledge of their scientific components and effects. The pandemic due to the Covid-19 was associated with the denial by population to consume pharmaceutical drugs following various comments on their lethal capacities. The overall pauperisation of the population and the lack of insurance in Cameroon to take care of patients with the Corona virus constituted another obstacle to accessing the health system which itself is poorly equipped.

Most Cameroonian population, such as those of Douala IV sub-division, went back to the popular knowledge of the medicinal outcomes of aromatic plants and succeeded in facing this pandemic. The main objective of this study is to determine different bioactive compounds of aromatic plants used by the population of Douala IV sub-division.

MATERIAL AND METHODS

Douala IV sub-division is one of the urban Douala town that is composed of six urban sub-division municipalities, (Douala I, Douala II, III, IV, V, VI). It combines the urban and rural area with Bonassama as the headquarters. It is bounded to the north by the Moungo sub-division, to the South and East by the Wouri River and to the West by the Fako Division (Figure 1). Douala IV extends on 3.500 km^2 and host about 395.536 inhabitants in 2019 with as main neighbourhoods and villages, Bonamatoumbe, Bonendale and Bwadibo which chosen for this study on the basis of the scarcity of public and private health structures and also in the objective to complete an ethnobotanical study on medicinal flora.

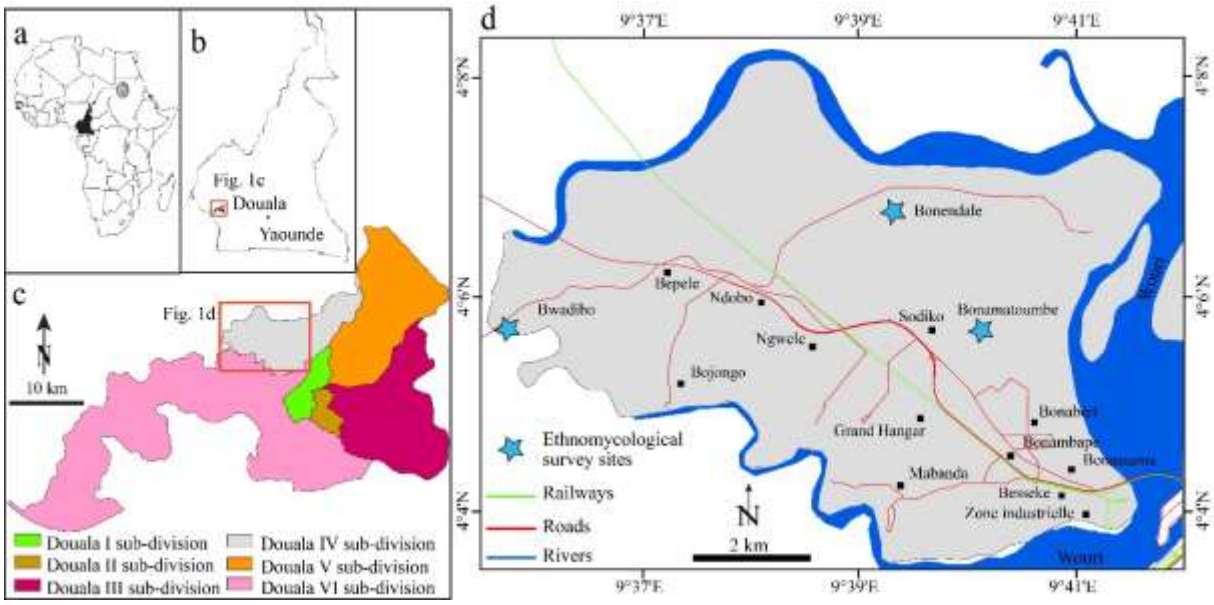

Figure 1: The study site for the ethnobotanical surveys

Ethnobotanical survey

We surveyed between September and December 2020, the Bonendale, Bonamatoumbe and Bwadibo villages in the Douala IV sub-division with the objective to assess on the base of the socio-demographic and cultural information of the respondents, information on traditional pharmacopoeia from the population on aromatic plants used to treat different diseases by the local population during confinement. The method consisted of interviewing in French and/or local languages (Bassa, Douala, Bamileke, Ewondo), the population about popular use of medicinal plants [12]. For each therapeutic indication, details of the recipe were carefully noted and the plant was filmed and harvested. This collection was facilitated by guides chosen from informants in each neighbourhood to facilitate the identification of species *in situ*. For each plant cited as aromatic, we noted the plant part used, the mode of preparation, the pharmaceutical form, the mode of administration, the places of supply, other uses, their availability or not as well as the harvesting methods practiced. Samples of aromatic plants were collected and identified at the Cameroon National Herbarium. Information on diseases and symptoms or physiological effects were collected from nurses and health workers in the Bonassama health district and supplemented by a bibliographic review [12-13]. For practical use of the data and harmonization with the international system, the health problems have been grouped into major groups of diseases according to the latest classification of diseases proposed by the World Health Organization WHO (1996; 2001) and adopted by the Organization of African Unity (OAU) for the Cameroon pharmacopoeia [13].

Assessment of use value and cultural significance

Among multiple indices used in quantitative ethnobotany to assess the importance of a species [14], we retained for the identification of aromatic plants with pharmaceutical interests:

- the contribution of each plant in the constitution of recipes (Cpr) as seen by Dassou *et al*. [15] calculated according to the formula:

$$Cpr = Nr/Nt \times 100 \quad (1)$$

where Nr is the number of recipes requesting the plant and Nt, the total number of recipes;

- the frequencies of citations of the different plants were determined according to the formula:

$$Fc = Nc/N \quad (2)$$

where Nc is the number of citations of the plant and N the total number of citations of aromatic plants listed;

- the therapeutic use value (VUT) of each species was calculated using the following formula:

$$VUT = U/Nenq \quad (3)$$

where U is the number of uses where the species is mentioned by each informant and Nenq, the number of informants who mentioned the species determining the significant use value of an aromatic plant in a given environment compared to others;

- the performance index (Ip) described by Betti [1] that represents the efficiency of a plant by pathology among all the registered pathologies that mention the plant in question according to the following difference:

$$IP = (Nc/N) - (Ncm/Nt) \quad (4)$$

where Nc is the number of citations of a plant in the treatment of a disease; N: the total number of citations of all plants used in the treatment of this disease; Ncm: the number of citations of the plant for all diseases and Nt: the total number of citations with:

- ✓ Ip = 0 if (Nc/N) - (Ncm/Nt) < 0 for zero performance,
- ✓ Ip = 1 if 0 < (Nc/N) - (Ncm/Nt) ≤ 1/3 for average performance,
- ✓ Ip = 2 if 1/3 < (Nc/N) - (Ncm/Nt) ≤ 2/3 for good performance,
- ✓ Ip = 3 if (Nc/N) - (Ncm/Nt) > 2/3 for very good performance;

- the divergence of indigenous knowledge on the treatments of the groups of diseases, evaluated by the consensus factor of use Informing consensus factor (ICF) that makes possible to evaluate the consensus on the phytoremedies used on the treatment of groups of diseases and to assess the degree of homogeneity of the information given by respondents [16-17] and calculated by the formula:

$$ICF = (Ncu - Neu) / (Ncu - 1) \quad (5)$$

where Ncu is the number of usage citations reported for each disease category, and Neu the number of species used for the treatment of each disease category. It varies from 0 to 1 [18]:

- ✓ the value 0 is the lowest degree and corresponds to different points of view on the part of respondents in the use of plants to treat a category of diseases,
- ✓ values below 0.5 are considered low and indicate a low consensus of plant use,
- ✓ the value 0.5 is the average degree of the factor and indicates an average consensus for the use of plants,
- ✓ values between 0.5 and 1 are relatively strong degrees and show a relatively high agreement in the use of plants to treat a category of diseases,
- ✓ the value 1 is the highest degree showing a total consensus in the use of plants to treat a category of diseases.

Chemical screening of aqueous extracts of aromatic plant organs

The phytochemical screening of extracts obtained after aqueous maceration of the aromatic plant organs used in the recipes was carried out qualitatively using standard colouring and precipitation methods [19-20]. Extracts were analysed for determining the composition of main secondary metabolites such as flavonoids (cyanidin test), alkaloids (Dragendorff test), saponins (foaming test), triterpenes and steroids (Liebermann-Buchard test), polyphenols and tannins (ferric chloride test) as well as coumarins in the organs of the most stressed aromatic plants [19].

Statistical analyses

The survey data was placed in the Excel spreadsheet in the form of citations and codes were assigned to the aromatic plants identified as well as to the groups of diseases treated by the aromatic plants. These data were edited allowing the calculation of frequencies in the number of citations.

RESULTS

Sociodemographic profile of respondents

One hundred and eighty-eight (188) people were interviewed, out of which. 113 informants distributed in three neighborhoods (39 in Bonendalé, 37 in Bonamatoumbé and 37 in Bwadibo) made their contributions on traditional knowledge and uses of medicinal plants. Women were the most represented respondents at 74.35%. Among them, those whose ages varied between 41-60 years represented 32.74%. Women originating from Littoral Region represented 20% and preferentially solicit plants such as: *Allium sativum*, *Annona muricata*, *Curcuma aromatica*, *Cymbopogon citratus*, *Daucus carota*, *Ocimum basilicum*, and *Zingiber officinale*. Men represented 25% of respondents and those whose age varies between 20-40 years represented 12%. Also, those originating from the Littoral Region represent 9% and solicit plants such as: *Ageratum conyzoides*, *Cymbopogon citratus*, and *Eremomastax speciosa* (Table I). Surveys showed 83 medicinal plant species grouped into 76 genera and distributed in 41 families. The Asteraceae family (6 species) was among the most represented, followed by the Lamiaceae family (4 species) and the Poaceae family (4 species). The species most requested by respondents were *Ocimum gratissimum* (48 citations), *Ageratum conyzoides* (31), *Cymbopogon citratus* (30), *Citrus limon* (28), *Allium sativum* (18), *Zingiber officinale* (15), *Annona muricata* and *Vernonia amygdalina* (14 citations each) (Table II).

Table I: Socio-demographic profile of respondents in the Douala IV Sub-Division

Gender	Age group	Effective (Percentage %)	Ethnicities (Work force)	Plants used
Men	[20 – 40]	13 (11.50%)	Littoral (10) (Douala and Bassa)	*Ageratum conyzoides, Cymbopogon citratus, Eremomastax speciosa, Musa paradisiaca, Ocimum gratissimum*
			West (2)	*Ageratum conyzoides, Alchornea cordifolia*
			North (1)	*Allium cepa*
	[41 - 60]	13 (11.50%)	Littoral (9) (Douala and Bassa)	*Carica papaya, Manihot esculenta, Chromolaena odorata, Daucus carota*
			East (1) (Beti)	*Alstonia boonei, Baillonella toxisperma*
			West (3)	*Ageratum conyzoides, Carica papaya, Citrus medica*
	> 60	3 (2.65%)	Littoral (3) (Douala)	*Casssia occidentalis, Dacryodes edulis, Vernonia amygdalina*
Women	[20 – 40]	32 (28.31%)	Littoral (17) (Douala and Bassa)	*Aframomum melegueta, Annona muricata, Cassia occidentalis, Manihot esculenta*
			West (13)	*Annona muricate, carica papaya, cassia occidentalis, Citrus medica, Musa paradisiaca, Psidium guajava*
			Northwest (1)	*Cassia alata, Ocimum gratissimum*
			East (1) (Beti)	*Zingiber officinale*
	[41 - 60]	37 (32.74%)	Littoral (23) (Douala and Bassa)	*Allium ampeloprasum, Allium sativum, Annona muricata, Curcuma aromatica, Cymbopogon citratus, Daucus carota, Ocimum basilicum, Zingiber officinale*
			West (13)	*Carica papaya, Eremomastax speciosa, Mangifera indica, Ocimum gratissimum, Psidium guajava*
			Center (1) (Ewondo)	*Alstonia boonei, Hibiscus rosa*
	> 60	15 (13.27%)	Littoral (12) (Douala and Bassa)	*Ageratum conyzoides, Cassia alata, Cassia occidentalis, Persea americana, Ricinodendron heudoleti*
			West (3)	*Alchornea cordifolia, Annona muricata, Carica papaya, Cymbopogon citratus, Dissotis rotundifolia*

The number in parenthesis in the ethnicity column indicated the number of respondents.

Table II: Most cited families in requested medicinal plant species in the Douala IV Sub-Division

Family	Genus	Scientific name of the species	Local name	Nc	Eff	Ne	Fc
Asteraceae	*Acmella*	*Acmella caulirhiza* Delile.	Ndonga balemba (Douala)	1	55	6	7.22
	Ageratum	*Ageratum conyzoides* L.	Ewuda nyo na nyo (Douala)	31			
	Bidens	*Bidens pilosa* L.	Ndondoka batuedi (Douala)	7			
	Chromolaena	*Chromolaena odorata* L.	Afat bikodgo (Ewondo)	1			
	Emilia	*Emilia coccinea* G. Don,	Efeng lapin (Dschang)	1			
	Vernonia	*Vernonia amygdalina* Delile.	Ndolé	14			
Euphorbiaceae	*Alchornea*	*Alchornea cordifolia (*Schumach. & Thonn.) Mull. Arg	Ngontsi (Bangangte) Aboé (Ewondo)	13	25	4	4.81
	Euphorbia	*Euphorbia hirta* L.	Ewuda manyongo (Douala)	1			
	Manihot	*Manihot esculenta* Crantz,	Kassala (Bafoussam)	7			
	Ricinodendron	*Ricinodendron heudoloti* (Baill.) Pierre & Heckel	Ezezang (Ewondo)	4			
Lamiaceae	*Ocimum*	*Ocimum basilicum* L.	Ossimb (Ewondo)	2	53	4	4.81
		Ocimum canum Sims.	Sima (Bassa)	2			
		Ocimum gratissimum L.	Massepu (Douala)	48			
	Mentha	*Mentha spicata* L.		1			

Ne=Number of species; NC=Number of citations of each species; EFF= Effective; Fc=Frequency of citations.

Medicinal aromatic plants

Thirty-one species were recognized and identified as aromatic plants by the population of Bonendalé, Bonamatoumbé and Bwadibo, representing 37.34% of the medicinal flora. The species of aromatic plants listed in Table III, belong to 17 families and are distributed in 23 genera. The most represented families were Lamiaceae and Zingiberaceae (4 species each), Rutaceae, Amaryllidaceae and Apiaceae (3 species each), Solanaceae and Annonaceae (2 species each).

Table III: Families of identified aromatic plant species in the Douala IV Sub-Division

Co	Species	Ver/Trad	Families	Co	Species	Ver/Trad	Families
Afe	*Aframomum exscarpum*	Mbongo	Zingiberaceae	Cyc	*Cymbopogon citratus*	Lemon grass	Poaceae
Afm	*Aframomum melegueta*	Guinea pepper	Zingibéraceae	Dac	*Daucus carota*	Carot	Apiaceae
Afl	*Afrostyrax lepidophyllus*	Rondelle/ Olom	Huaceae	Lan	*Laurus nobilis*	Bay laurel	Lauraceae
Alm	*Allium ampeloprasum*	Leek	Amaryllidaceae	Mes	*Mentha spicata*	Mentha	Lamiaceae
Alc	*Allium cepa*	Onion	Amaryllidaceae	Mon	*Monodora myristica*	Pêbai	Annonaceae
Als	*Allium sativum*	Garlic	Amaryllidaceae	Ocb	*Ocimum basilicum*	Basil	Lamiaceae
Anm	*Annona muricata*	Soursop	Annonaceae	Occ	*Ocimum canum*	Hoary basil	Lamiaceae
Apg	*Apium groveolens*	Celery	Apiaceae	Ocg	*Ocimum gratissimum*	Massep	Lamiaceae
Azi	*Azadirachta indica*	Neem	Meliaceae	Pes	*Petroselium sativum*	Parsley	Apiaceae
Cap	*Capsicum annuum*	Chili pepper	Solanacee	Pin	*Piper nigrum*	Black pepper	Piperaceae
Caf	*Capsicum frutescens*	Cay pepper	Solanaceae	Rih	*Ricinodendron heudoloti*	Djangssang	Euphorbia ceae
Cig	*Citrus grandis*	Sweet orange	Rutaceae	Sya	*Syzygium aromaticum*	Clove	Myrtaceae
Cil	*Citrus limon*	Lemon	Rutaceae	Tet	*Tetrapleura tetraptera*	Prekese/ Esese	Fabaceae
Cim	*Citrus medica*	Lemon	Rutaceae	Zio	*Zingiber officinale*	Ginger	Zingiberaceae
Con	*Cocos nucifera*	Coconut	Arecaceae	Zij	*Ziziphus jujuba*	Jujuba	Rhamnaceae
Cua	*Curcuma aromatica*	Turmeric	Zingiberaceae				

Co=Aromatic Plant Codes; Ver=Vernacular Names; Trad=Trade Names.

Ethno-medicinal characterization of aromatic plants

Traditional healers use aromatic plants in combination to prepare recipes against diseases and related symptoms. Among these plants, some are used both as main plants and/or as associated plants (*Allium sativum*, *Ocimum gratissimum*) whereas others are only requested as associated plants (*Aframomum exscarpum*, *Tetrapleura tetraptera*). A total of 168 recipes were recorded, including 89 recipes for plants in combination (52.97%) and 79 single-specific recipes (47.02%). Different organs were taken from the vegetative part of aromatic plants to prepare recipes against diseases and symptoms (Figure 2, Table V). These included leaves (114 citations, 50.80%), fruits (49 citations, 21.87%), bulbs (24 citations, 10.71%), rhizomes/roots (20 citations, 8.92%), flowers (11 citations, 4.91%), stems (4 citations, 1.78%) and bark (2 citations, 0.89%).

The extraction methods for facilitating the administration of the active ingredient of aromatic plants were: the decoction, trituration, maceration, infusion, grinding, calcination, poultice, chewing of the raw organ, drying followed by pulverization of the organ (Figure 2). The infusion (33.33%) was the most used method of preparation, followed by decoction (22.61%), and trituration after heating the organ (17.56%). Six (06) routes of administration were described by the population (Figure 3): oral route (75%), rectal route (7.02%), nasal route (5.88%), cutaneous route (5.93%), steam bath (5%) and ocular route (1.17%). For conservation, traditional medicines are mostly kept at an ambient temperature (53%) not exceeding 25°C, in a cool place (8%). A large part (39%) of the recipes that cannot be kept is thus used immediately after preparation.

Figure 2: Some organs of aromatic plants used by local population of Douala IV. a: Leaves of *Petroselium sativum;* b: Leaves of *Ocimum basilicum;* c: Fruits of *Capsicum frutescens;* d: Fruits of *Aframomum melegueta;* e: Seeds of *Ricinodendron heudoloti;* f: Fruits of *Allium sativum;* g: Leaves of *Ocimum gratissimum;* h: Seeds of *Piper nigrum*; i: Leaves of *Cymbopogon citratus;* j: Rhizomes of *Zingiber officinale;* k: Fruits of *Citrus limon*; l: Floral buds of *Syzygium aromaticum*

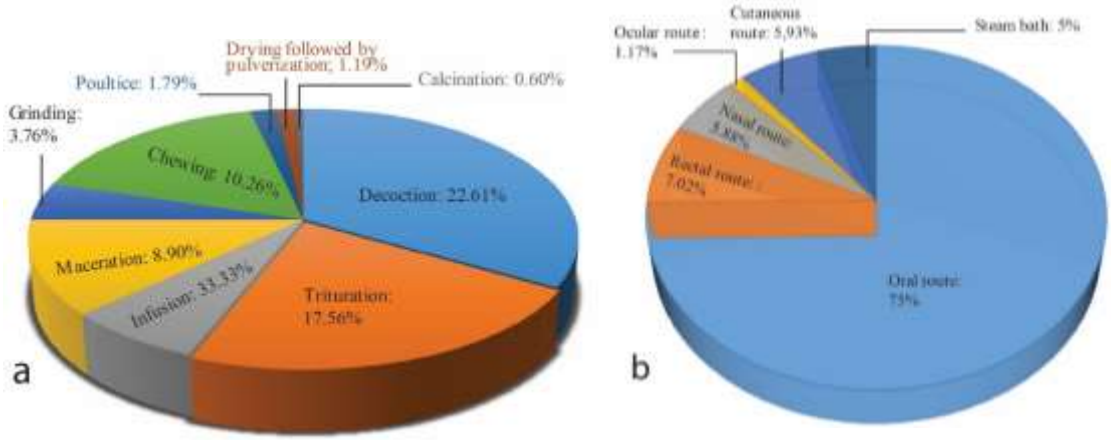

Figure 3: Different mode of (a) preparation and (b) administration of medicinal recipes in the Douala IV Sub-Division

Diseases cured by aromatic plants

The recipes prepared by the local population of Douala IV sub-division from aromatic plants were associated with the treatment of 51 diseases and related health problems (Table V and VI). Among these diseases, the most treated were: malaria (22 citations), cough (21 citations), typhoid (12 citations), colds (9 citations), diaper rash (8 citations), flu (6 citations), hypertension blood pressure (4 citations), nerve ache (4 citations), diabetes (3 citations), fontanel (3 citations), stomach ache (3 citations), spleen inflammation (2 citations), female worms (2 citations) and colic (2 citations). All these diseases have been grouped into 11 major groups, the most important of which are diseases of the respiratory system (38 citations) and infectious and parasitic diseases (35 citations).

Ethnobotanical indices

Aromatic plants with a high use value were determined. The use values vary between 0.22 (*Citrus limon*) and 1.5 (*Apium graveolens*). The calculation of the contribution of the plant in the constitution of the receipts (Cpr) showed that *Ocimum gratissimum* (28.57%), *Cymbopogon citratus* (17.85%), *Citrus limon* (16.66%) and *Allium sativum* (10.71%) were the aromatic plant species most involved in the preparation of recipes (Table VI). The analysis of the performance indices (Ip) by disease cited highlights three categories of species: good performance (Ip = 3), average performance (Ip = 2) and non-performing (0 ≤ Ip ≤ 1). *Zingiber officinale* (Ip = 3) was the most effective species in remedying cough problems. *Citrus limon* (Ip = 3) was the most efficient species for the treatment

of typhoid fever. *Cymbopogon citratus* (Ip = 3) has a good performance for the treatment of malaria. Some species mentioned have multiple uses both in the same group of diseases and for diseases of different groups. *Cymbopogon citratus* and *Citrus limon* display respectively an average performance for typhoid and malaria which are diseases of the same category (Table IV). *Ocimum gratissimum* showed a good performance against colds and an average performance against cough (diseases of the same group) and also showed a good performance for diaper rash and stomach ache. In order to assess the informant agreements on the therapies reported for each pathological group treated by the listed aromatic plants, the degree of consensus of use (ICF) of the plants was calculated. This degree of consensus revealed 5 categories of diseases: respiratory system (0.75), infectious and parasitic (0.73), skin and cellular tissue (0.72), digestive system (0.64), nervous system and sense organs (0.6) (Table V).

Table IV: Aromatic plants showing performance against some diseases in the Douala IV Sub-Division

Good performance (Ip=3)		Average performance (Ip=2)	
Plant codes	Diseases	Plant codes	Diseases
Als	Nervous ache, High blood pressure	Afm	Hyperglycaemia
Anm	High blood pressure	Alc	Angina
Cyc	Malaria	Als	Cold, Asthma
Cil	Typhoid fever	Anm	Malaria
Ocg	Colds, Amoebic dysentery, Diaper rash	Apg	Headaches
Pes	Obesity	Ocg	Cough
Zio	Cough	Pin	Loss of appetite
		Sya	Amoebic dysentery, Toothache

Table V: ICF of the diseases treated by the aromatic plants in the Douala IV sub-division

Disease groups	Codg	Ncu	Neu	ICFs
Diseases of the respiratory system	a	38	10	0.75
Infectious and parasitic diseases	b	35	10	0.73
Diseases of the digestive system	c	26	10	0.64
Diseases of the circulatory system	d	14	8	0.46
Diseases of the skin and subcutaneous cell tissue	e	12	4	0.72
Diseases of the nervous system and sense organs	f	11	5	0.6
Defined senility, symptoms and conditions	g	10	11	0
Diseases of the genito-urinary organs	h	9	10	0
Diseases of the blood and blood-forming organs	i	5	9	0
Diseases of bones and organs of movement	j	4	7	0
Endocrine, nutritional and metabolic diseases and immune disorder	k	4	7	0
Total		168	91	0.46

Codg=Disease group codes; Ncu=Number of usage citations reported in each disease category; Neu=Number of species used for the treatment of each disease category; ICF=Informant Consensus Factor.

Table VI: Characterization of recipes and calculation of ethnobotanical indices in the Douala IV Sub-Division

AroPlanSpe codes		Afe	Afm	Afl	Alm	Alc	Als	Anm	Apg	Azi	Cap	Caf	Cig	Cil	Cim	Con	Cua	Total
Organs used																		
Or Us	Ro/Rh	1															2	3
	Bulbs					6	18											24
	Stems								2									2
	Barks									1						1		2
	Leaves		3		1			14	1	1	1	1						22
	Flowers																	0
	Fruits		1	2								4	2	28	2			39
Groups of diseases cured by aromatic plants and ethnobotanical indices of said plants																		
Codg		h	c,h,i	h,j	g	a,d,f	a,c,d,f,i,j,k	b,d,f,k	a,c,g	b,d	g	b,c,j	a,b	a,b,e,h,i	a,k	b,c	e,h	43
Index	Nc	1	4	2	1	6	18	14	3	2	1	5	2	28	2	1	2	92
	Fc (%)	0.88	3.15	1.76	0.88	5.30	15.92	12.38	2.65	1.76	0.88	4.42	1.76	24.77	1.76	0.88	1.76	
	VUT	1	1	1	1	0.6	0.46	0.30	1.5	1	1	1	1	0.22	1	1	1	
	Cpr (%)	0.6	2.38	1.19	0.6	3.57	10.71	8.33	1.79	1.19	0.6	2.98	1.19	16.67	1.19	1.19	1.19	
AroPlanSpe codes		Cyc	Dac	Lan	Mes	Mon	Ocb	Occ	Ocg	Pes	Pin	Rih	Sya	Tet	Zio	Zij		Total
Organs used																		
Or Us	Ro/Rh		2												15			17
	Bulbs																	0
	Stems									2								2
	Barks																	0
	Leaves	30		1	1	2	2	2	48	6								92
	Flowers												11					11
	Fruits										3	4		1		2		10
Groups of diseases cured by aromatic plants and ethnobotanical indices of said plants																		
Codg			f	b	k	h,j	h,g	a,g	a,b,c,e,f,g,h,i,k	c,g,k	c,g	g,i	c,d,e,h,i	i	a,g,h,i,k	g,j		42
Index	Nc	30	2	1	1	2	2	2	48	8	3	4	11	1	15	2		132
	Fc (%)	26.54	1.76	0.88	0.88	1.76	1.76	1.76	42.47	7.07	2.65	3.53	9.73	0.88	13.27	1.76		
	VUT	0.23	0.5	1	1	1	1	1	0.23	0.42	1	0.5	0.5	1	0.33	1		
	Cpr (%)	17.86	1.19	0.6	0.6	1.19	1.19	1.19	28.57	4.76	1.79	2.38	6.5	0.6	8.93	1.19		

AroPlanSpe=Aromatic plant species; Ro=Root; Rh=Rhizome; OrUs=Organ used; Cpr=Contribution of each plant in the constitution of recipes; Nc=Number of citations of the plant; Fc=Frequencies of citations; VUT=Therapeutic use value of each species.

Therapeutic properties of bioactive metabolites of aromatic plants

The metabolites that might be responsible for the therapeutic properties of the selected aromatic plants were determined using standard methods of staining and precipitation. The results indicated the presence of alkaloids in all the organs of aromatic plants having undergone the Dragendorff test except the flower buds of *Syzygium aromaticum*. Phenolic compounds of the phenol class are also present in the organs of aromatic plants. Many classes of phenolic compounds were found in the organs of each of the aromatic plants including flavonoids, polyphenols, tannins and coumarins. Furthermore, terpenes, sterols and saponins were also present in the aqueous extracts of the organs of aromatic plants (Table VII).

Table VII: Bioactive metabolites of aromatic plants in the Douala IV Sub-Division

Extraits aqueux	Flav	Alcal	Tan	Cou	Polyp	Terp	Ste	Sapo
Fruit of *Aframomum melegueta*	+	+	+	+	+	+	-	+
Bulbs of *Allium cepa*	+	+	-	-	+	-	+	-
Bulbs of *Allium sativum*	+	+	-	-	+	-	-	+
Leaves of *Annona muricata*	+	+	+	+	+	-	-	+
Leaves of *Apium graveolens*	+	+	-	+	-	-	-	-
Fruit of *Capsicum frutescens*	+	+	-	-	+	-	-	+
Leaves of *Citron limon*	+	+	+	+	-	-	-	-
Leaves of *Cymbopogon citratus*	+	+	+	+	+	+	+	+
Leaves of *Ocimum basilicum*	+	+	-	+	+	+	+	-
Leaves of *Ocimum gratissimum*	-	+	+	+	+	-	-	+
Leaves of *Petroselium sativum*	+	+	+	+	+	-	+	+
Fruit of *Piper nigrum*	+	+	+	-	-	+	+	-
Fruit of *Ricinodendron heudolotii*	+	+	+	-	-	+	-	+
Flowers of *Syzygium aromaticum*	+	-	+	-	-	+	+	+
Rhizomes of *Zingiber officinale*	+	+	+	-	-	+	+	+

Flav=Flavonoids; Alcal=Alkaloids; Tan=Tannins; Cou=Coumarins; Polyp=Polyphenols; Terp=Terpenes; Sapo= Saponins; Ste=Steroids; (+: Present; -: Absent).

DISCUSSION

The popular knowledge admitted the use of medicinal plants to fight against several diseases [1-3-4-8-10-12-17]. The African population resumed some of them and aromatic plants notably as an alternative fight against this pandemic and many other diseases [5-6-9-40]. In the following lines, we discuss results from the ethnobotanical study of aromatic plants in the Douala IV subdivision, the associated receipts and indices as their pharmacological properties of bioactive metabolites used during the pandemic and possibly used for other diseases.

Ethnobotanical aromatic plants from the Douala IV sub-division

Aromatic plants are dominantly used in culinary arts and seem to be a prerogative of women and their strong involvement (75%) in this study. It shows the highest representation of adults with greatest experience in the practice of pharmacopoeia compared to young people who have less confidence in herbal medication and more often resort to modern medication [21-22].The great number of information on 83 plant species that included 31 species of aromatic plants used in the preparation of 168 recipes revealed different plant organs for medicinal preparations and different methods for extraction and administration of the active ingredient. This highlights the heterogeneous nature of ethnobotany [22-23-24]. The thirty-one (31) aromatic species identified defined 23 genera belonging to 17 families dominated by the Lamiaceae and Zingiberaceae (04 species each); Apiaceae, Rutaceae and Amaryllidaceae (03 species each). Mpondo Mpondo *et al*. [25] in a study carried out in the eastern part of Douala on coumarin plants already found that Apiaceae and Lamiaceae were part of the most represented families with Fabaceae and Asteraceae. Spices and condiments used to make traditional dishes with enormous therapeutic potential are mainly distributed in the Apiaceae, Lamiaceae, Amaryllidaceae and Zingiberaceae families in agreement with previous results [10-26-27-28-29-30].

Aromatic plant recipes

Florula of the listed aromatic plants is essentially made up of herbaceous plants (63.3%). The use of herbaceous plants could be explained by the premonitory function of aromatic plants, which are spices and condiments defined by their perennial character [20]. The use of leaves has importance linked to the morphological type that predominates in the florula of aromatic plants inventoried and also as the main composition of herbaceous plants. They are used in the culinary arts as spices or as flavourings, in herbal medicine for their active ingredients or essential oils extracted from organs as leaves and fruits of aromatic plants [8-25-26]. In the light of the results, it appears that the infusion of the leaves (33.33%) is the most widespread mode of preparation. In woody plants, the bioactive metabolites after synthesis in the leaves are stored in the fruits and barks, in herbaceous plants, large quantities of bioactive metabolites remain concentrated in the synthesis places which are mostly the leaves [31-32]. These results corroborate with those found by Fathia *et al*. [22] who reported

infusion as the most used method for relatively soft organs. Decoction and infusion, in addition to facilitating the extraction of the active ingredient, would make it possible to increase the body's temperature, thus weakening the wall of certain bacteria and thus facilitating the pharmacodynamics of the active ingredient [33-34].

Ethnobotanical indices of aromatic plants

Regarding the contribution of aromatic plants for the preparation of medicinal recipes, plants such as *Ocimum gratissimum*, *Cymbopogon citratus*, *Citrus limon*, *Allium sativum*, *Zingiber officinale*, *Annona muricate* and *Syzygium aromaticum* stand out as the aromatic plants most involved in medicinal preparations. The strong implication of these species suggests an additional contribution of these to obtain the expected therapeutic effect. Holders of ancestral knowledge make empirical associations of plants in the same recipe with the aim of seeking either a synergistic effect of the active ingredients, or an attenuating effect for the active ingredients deemed to be aggressive, irritating or even toxic for the body [23]. Therapeutic use values of the exploited species showed that plants do not benefit to the same credit or importance for the population surveyed. Some plants like *Citrus limon* (VUT=0.22), *Ocimum gratissimum* (VUT=0.23) and *Cymbopogon citratus* (VUT=0.23), although requested by several respondents, are used for the treatment of many diseases. They will therefore have a low use value [17-23]. *Apium graveolens* (VUT=1.5) cited by 3 informants for 3 different diseases is found to have the highest use value. Dassu *et al*. [15] showed that the importance given to a species does not depend exclusively on its availability but also on its ability to meet the needs of population in the different categories of uses when it is mentioned for several therapeutic uses by few informants. Some aromatic plants such *Allium sativum*, *Cymbopogon citratus*, *Ocimum gratissimum* showed a good performance for a given disease and an average performance for another disease. This could be justified by the fact that these plants are cited several times by various users to treat the same disease or find in the treatment of many other associated diseases or symptoms [9-32]. This is consistent with the relatively high agreement of the ICFs obtained on aromatic plants treating diseases of the respiratory system, infectious and parasitic diseases, skin diseases and cellular tissue, diseases of the digestive system as well as diseases of the circulatory system. High ICFs values for certain categories of diseases showed that the probability that a person living in the surveyed area is subject to one of the diseases of this group is high and provide sufficient information on the diseases affecting the studied population [17-35]. This index supports the fact that some species are unanimous among respondents used in medicinal recipes. This strong demand could lead to more pressure on the flora of aromatic plants, which therefore deserves conservation. The Ip and ICF also grouped aromatic plants according to their pharmacological effect, symptomatologies and treating plants treating similar diseases. Holders of ancestral knowledge do not have perfect control of the symptoms of the diseases for which they prescribe the treatments, equating the symptoms of malaria with those of typhoid and jaundice and justifying misadministration of medicinal plants. These diseases present similar health problems such as digestive disorders (dysentery) and fever are among the symptoms identified as associated with Covid-19. According to Sartoratto *et al*. [36], plant extracts, such as spices and aromatic herbs have antimicrobial properties because they are rich in phenolic secondary metabolites which are natural antioxidants and antimicrobials. Extracts of spices and aromatic herbs also have an inhibiting effect on the growth of several bacteria and fungi responsible for foodborne illnesses [36-37].

Pharmacological properties of bioactive metabolites of aromatic plants

The studied aromatic plants have even secondary metabolites that vary from one organ to another for the same plant in agreement with previous findings after e.g.: [24-31-32-38]. The abundance of these metabolites depends on the extraction solvent [24]. The seed extracts of *Ricinodendron heudolotii* reveal different secondary metabolites depending on whether the extraction solvents are Hexane, Ethyl acetate, Ethanol, Methanol and water [39]. The infusion of the mixture of aromatic plants consisting of garlic (*Allium sativum*), ginger (*Zingiber officinale*), onion (*Allium cepa*) and clove (*Syzygium aromaticum*) to which Lemon (*Citrus limon*) is added to it, was very popular and widely consumed by the population of Bonendalé, Bonamatoumbé and Bwadibo during the pandemic period. This mixture has been recognized with lemongrass leaf tea (*Cymbopogon citratus*) as having played a major role in strengthening the resilience capacities of consumers with Covid-19 disease. These results corroborate those of Kuete-Sezin *et al*. [6] who showed that out of 872 patients cured by medicinal plants during the pandemic, 244 were cured with "grandmother's potion", 224 with lemongrass leaf tea and 88 with neem leaf tea (*Azadirachta indica*). Fongnzossie Fedoung *et al*. [40] have shown that molecules such as Allicin from *Allium sativum*, Gingerol from *Zingiber officinale*, Hesperidin, Naringenin and Quercetin from *Citrus limon* are secondary metabolites whose beneficial effects against Covid-19 disease are significant. These molecules give to the plants antiviral, antibacterial, antiparasitic, antidiarrheal, anti-inflammatory, antioxidant and analgesic properties, thus helping to treat respiratory diseases, infectious and parasitic diseases to which the population of Douala IV are subjected to [41-42-43].

In medicine, alkaloids are used as major analgesics (morphine), antimalarial (quinine), to combat excess uric acid (colchicine) [38-44]. Alkaloids from the leaves of *Cymbopogon citratus* would play an antipyretic role to lower the fever induced by diseases such as typhoid and malaria. They have been recognized as having pronounced properties against parasites of the genera *Plasmodium* and *Entamoeba*. Yingyang *et al*. [44] already noted the importance of alkaloids from the Quinolin family (Quinine, Quinonine, Quinidine) and many indole alkaloids in the treatment of malaria and diarrhoea. Coumarin plants and more specifically those of the Apiaceae family have the ability to promote the expulsion of intestinal gas leading to a reduction in bloating and flatulence. They would stimulate the secretion of the digestive glands leading to a good degradation of food and limit undesirable fermentations. They increase stomach acid production contributing to good disinfection of the food bolus [28]. *Ocimum gratissimum* and *Ocimum basilicum* are said to have significant antispasmodic activity and marked antimicrobial properties [25-38]. Tannins are endowed with remarkable antibacterial and antifungal activities. Their importance in traditional medicine has been reported in the treatment of infantile diarrhea, bronchitis, and cough as well as in the treatment of venereal diseases [30-31]. This could explain the fact that *Syzygium aromaticum* and *Zingiber officinale* have very good performances in the treatment of some of these diseases. In addition, the ability of tannins to prevent and repair damage caused by Reactive Oxygen Species (ROS) gives them significant importance in activating the immune defense and the ability to reduce the risk of cancer and other degenerative diseases [29-30]. The flavonoids of *Annona muricata* and *Allium sativum* as powerful antioxidants allow the direct trapping of ROS, the inhibition of enzymes and chelation of the metallic traces responsible for the production of these ROS [32]. Vitamin C is a flavanic compound present in the fruits of *Citrus limon* [38]. According to Agbor Agbor and Ndjib; Dibong *et al*.; Mpondo *et al*.; Vandi *et al*. and Fongnzossie Fedoung *et al*. [9-23-29-30-40]

lemon juice when added to certain preparations to treat malaria, influenza, typhoid, diarrhea and Covid-19; would contribute to bring tone to the patient and to reinforce his immune defence.

CONCLUSION

We evaluated the knowledge on the Cameroonian medicinal flora, mainly on the species of aromatic plants in the purpose to determine the ethnobotanical knowledge and index as different bioactive compounds of aromatic plants used for health diseases during the pandemic due to Covid-19 in the Douala IV sub-division (Littoral region, Cameroon). From the semi-structured survey and the calorimetrically these aromatics, it appears at the end that the population used endogenous medicinal plants including aromatic ones for treating several diseases including the targeted Covid-19 and associated reparatory problems. Among the aromatic plants, the Lamiaceae and Zingiberaceae with the *Ocimum gratissimum* and *Zingiber officinale* were the most cited in the composition of recipes. Leaves (50.80%) were the most used organs to prepare the infusions (33.33%) and the decoctions (22.61%) that was administered by the oral route. These plants are recognised as capable in the treatment of many diseases including malaria, cough and typhoid with an ICF (0.75) against respiratory diseases and good performance (Ip = 3). Alkaloids and phenolic rich extracts of aromatic plant organs showed their ability to treat respiratory and other infectious diseases. They could be used as an alternative to fight against Covid-19 and represent serious candidates for the production of Improved MTA.

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REFERENCES

[1] Betti JL, "Rapport sur Stratégie/Plan d'action pour une meilleure collecte des données Statistiques sur les PFNLs au Cameroun et recommandations pour les pays de la COMIFAC" 2007.

[2] Koné Kamanzi A, "Inventaire ethnomédical et évaluation de l'activité antihelminthique des plantes médicinales utilisées en Côte d'Ivoire contre les helminthiases intestinales" Pharm. Méd. Trad. Afr., 2006; 14 :55-72.

[3] Priso RJ, Nnanga JF, Etame J, Din N, Amougou A, "Les produits forestiers non ligneux d'origine végétale : valeur et importance dans quelques marchés de la région du littoral-Cameroun" J. Appl. Biosci., 2011; 40:2715-2726.

[4] Jiofack T, Fokunang C, Guedje N, Kemeuze V, Fongnzossie E, Nkongmeneck BA, Mapongmetsem PM, Tsabang N, "Ethnobotanical uses of medicinal plants of two ethnoecological regions Cameroon" International Journal of Medicine and Medical Sciences, 2010 ; 2:60-79. http://www.acade mic jo urna ls.org/ijmms

[5] Fokouo Fogha JV, Noubiap JJ, "La lutte contre le COVID-19 au Cameroun nécessite un second souffle" Pan African Medical Journal, 2020; 37:14 p. https://doi.org/10.11604/pamj.supp.2020.37.1.23535

[6] Kuete-Sezine C, Banen JB, Foka-nkwenti C, Bedziga Bedziga S, Nguendo-yongsi HB, "Médecine traditionnelle et lutte contre la covid-19 au Camerounc" International Journal of Science Academic Research, 2021; 02:1051-1057.

[7] Neffati M, Sghaier M, "Développement et valorisation des plantes aromatiques et médicinales (PAM) au niveau des zones désertiques de la région MENA (Algérie, Egypte, Jordanie, Maroc et Tunisie) " Rapport principal du Projet MENA-DELP : Partage des connaissances et de coordination sur les écosystèmes désertiques et les moyens de subsistance au profit de l'Algérie, l'Egypte, la Jordanie, le Maroc et la Tunisie" 2014 ; 143 p.

[8] Ngoule C, Ngene J, Kidik P, Dibong S, Ndjib R, "Inventaire et caractérisation floristique des plantes médicinales à huiles essentielles des marchés de Douala Est"International journal of chemical sciences, 2015 ; 9:874-889. https://doi.org/10.4314/ijbcs.v9i2.26

[9] Agbor Agbor G, Ndjib RC, "Systematic Review of Plants Used Against Respiratory Diseases Related to Covid-19 in Africa" Journal of Drug Delivery and Therapeutics, 2021; 11:1-14. https://doi.org/10.22270/jddt.v11i4-S.4957

[10] Abdou Bouba A, Njintang YN, Scher J, Mbofung CMF, "Phenolic compounds and radical scavenging potential of twenty Cameroonian spices" Agric. Biol. J. N. Am., 2010; 1:213-224. https://doi.org/10.5251/abjna.2010.1.3.213.224

[11] Belakhdar J, "Plantes médicinales au Maghreb et soins de base, Précis de phytothérapie moderne" Editions Le Fennec, Casablanca-Maroc, 2006 ; 386 p.

[12] Betti JL, Lejoly J, "Les plantes indiquées comme antihelminthiques en thérapie traditionnelle dans la réserve de biosphère du Dja (Cameroun)" Revue Soma, 2010; 4-16 2 3:60-79. https://doi.org/10.4314/ijbcs.v4i1.54246

[13] Adjanohoun E, Aboubakar N, Dramane K, Sofowora A, Tamze V, Ebot E, Ekpere A, Kamanyi A, Kamsu J, Keita A, "Contribution to ethnobotanical and foristic studies in Cameroon" CSTR/OUA, Cameroon, 1996.

[14] Hoffman B, Gallaher T, "Indice d'importance en ethnobotanique" Ethnobotanique Recherche et applications 2007; 5:201-218. https://doi.org/10.17348/era.5.0.201-218

[15] Dassou HG, Ogni CA, Yedomonhan H, Adomou AC, Tossou M, Dougnon JT, Akoegninou A, "Diversité, usages vétérinaires et vulnérabilité des plantes médicinales au Nord-Bénin Int. J. Biol. Chem. Sci., 2014; 8:189-210.

https://doi.org/10.4314/ijbcs.v8i1.18

[16] Andrade-cetto A, Heinrich M, "Des approches utiles pour sélectionner des espèces en fonction des connaissances locales" Frontières en pharmacologie, 2011; 2:1-5.

[17] Ilumbe GB, Van Damme P, Lukoki FL, Joiris V, Visser M, Lejoly J, "Contribution à l'étude des plantes médicinales dans le traitement des hémorroïdes par les pygmées Twa et leur voisin Oto de Bikoro, en RDC" Congo Sciences, 2014; 2:46 - 54.

[18] Ugulu I, "L'enquête et l'évaluation ethnobotanique quantitative des plantes médicinales utilisées autour de la province d'Izmir, Turquie. Journal de recherche sur les plantes médicinales" 2009; 3:345-367.

[19] Sumitra C, Jigna P, Nehal K, "Evaluation of antibacterial activity and phytochemical analysis of Bauhinia variegate L. bark" Afr. J. Biomed. Res., 2006; 9 :53-56.

[20] Mangambou D, Mushagalusa KF, Kadima N, "Contribution à l'étude phytochimique de quelques plantes médicinales antidiabétiques de la ville de Bukavu et ses environs (Sud- Kivu, RD Congo) " Journal of Applied Biosciences, 2014; 75:6211-6220. https://doi.org/10.4314/jab.v75i1.7

[21] Kidik Pouka MC, Ngene JP, Ngoule CC, Mvogo Ottou PB, Ndjib RC, Dibong SD, Mpondo Mpondo E, "Caractérisation des plantes médicinales à flavonoïdes des marchés de Douala (Cameroun) " Int. J. Biol. Chem. Sci., 201 ; 9:1494-1516. https://doi.org/10.4314/ijbcs.v9i3.32

[22] Fathia A, Abderrahman B, Mohamed A, "Etude ethnobotanique des plantes médicinales de la région de |Tanger. Cas de Hjar nhal et Melloussa" Int. J. Adv. Res., 2017; 5:310-322. https://doi.org/10.21474/IJAR01/5772

[23] Dibong SD, Mvogo Ottou PB, Vandi D, Ndjib RC, Monkam Tchamaha F, Mpondo Mpondo E, "Ethnobotanique des plantes médicinales anti hémorroïdaires des marchés et villages du Centre

et du Littoral Cameroun" Journal of Applied Biosciences 2015; 96:9072-9093. https://doi.org/10.4314/jab.v96i1.5

[24] Mvogo Ottou PB, Etame Loe GM, Ngotta Biyon JB, Ebenye Mokake S, Bissemb OP, Owono Fouda LR, Ngouondjou Foze T, Priso RJ, Dibong SD, "Knowledge of tradi-practitioners on hemorrhoidal disease and anti-hemmoroidal plants in the southeast region of Cameroon: pharmacology and preliminary phytochemistry" Saudi Journal of Medical and Pharmaceutical Sciences, 2020; 6:321-333. https://doi.org/10.36348/sjmps.2020.v06i04.001

[25] Mpondo Mpondo E, Vandi D, Ngouondjou Foze T, Mvogo Ottou PB, Embolo EE, Dibong SD, "Contribution des populations des villages du centre Cameroun au traitement traditionnel des affections des voies respiratoires" Journal of Animal &Plant Sciences 2017; 32:5223-5242.

[26] Tchiégang C, Mbougueng PD, "Composition chimique des épices utilisées dans la préparation du Nah poh et du Nkui de l'ouest Cameroun" Tropicultura, 2005; 23:193-200.

[27] Abdou Bouba A, "Contribution à l'étude du développement d'un aliment fonctionnel à base d'épices du Cameroun : caractérisation physico-chimique et fonctionnelle" Thèse de Doctorat, Université de Ngaoundéré, Cameroun, 2009 ; 223 p.

[28] Filiat P, "Les plantes de la famille des Apiacées dans les troubles digestifs" Thèse de doctorat en pharmacie, Université de Joseph Fourier, Grenoble, 2012 ; 140 p.

[29] Mpondo Mpondo E, Dibong SD, Ladoh YCF, Priso RJ, Ngoye A, "Les plantes à phénols utilisées par les populations de la ville de Douala" Journal of Animal and Plant Sciences, 2012; 15:2083-2098.

[30] Vandi D, Nnanga Nga E, Betti JL, Etame Loe GM, Mvogo Ottou PB, Priso RJ, Ngouondjou Foze T, Ngo Boumsong PC, Dibong SD, Mpondo Mpondo, "Contribution des populations des villes de Yaoundé et Douala à la connaissance des plantes à tanins et à anthocyanes" Journal of Animal & Plant Sciences, 2016; 3:4797-4814.

[31] Sereme A, Millogo-Rasolodimby J, Guinko S, Nacro M, "Anatomie et concentration des tanins des plantes tannifères du Burkina Faso" Journal des Sciences, 2010; 2:24 - 32.

[32] Ngene J, Ngoule C, Mvogo O, Mpondo E, Dibong S, "Importance dans la pharmacopée des plantes à flavonoides vendues dans les marches de Douala Est (Cameroun) " Journal of Applied Biosciences, 2015; 88:8194-8219. https://doi.org/10.4314/jab.v88i1.6

[33] Lahsissene H, Kahouadji A, Tijane M, Hseini S, "Catalogue des plantes médicinales utilisées dans la région de Zaër (Maroc occidental)" Lejeunia BE ISSN, 2009; 0457-4184.

[34] Salhi S, Fadli M, Zidane L, Douira A, "Etudes floristique et ethnobotanique des plantes médicinales de la ville de Kénitra (Maroc) " Lazaroa, 2010; 31:133-146. https://doi.org/10.5209/rev_LAZA.2010.v31.9

[35] Ilumbe GB, "Utilisation des plantes en médecine traditionnelle par les Pygmées (Ba-twa) et les Bantous (Ba-Oto) du territoire de Bikoro, province de l'Equateur en RD Congo" Thèse Doct. Univ. Libre de Bruxelles, 2010 ; 237p.

[36] Sartoratto A, Machado ALM, Delarmelina C, Figueira GM, Duarte MCT, Rehder VLG, "Composition and antimicrobial activity of essential oils from aromatic plants used in Brazil" Brazilian Journal of Microbiology, 2004; 35:275-280. https://doi.org/10.1590/S1517-83822004000300001

[37] Sessou P, Souaïbou F, Guy A, Sébastien DT, Boniface Y, Paulin A, "Chemical Composition and Antifungal activity of Essential oil of Fresh leaves of Ocimum gratissimum from Benin against six Mycotoxigenic Fungi isolated from traditional cheese wagashi" I. Res. J. Biological Sci., 2012; 1:22-27.

[38] Bruneton J, "Pharmacognosie, phytochimie, des plantes médicinales 4e édition" Ed. Tec & Doc, Paris, 2009; 1269p.

[39] Oyono V, Fokunang C, Tembe-Fokunang E, Tsague M, Messi A, Assam J, Ngameni B, Kechia F, Nwabo Kamdje AH, Penlap V, Ngadjui B, "Phytochemical screening and biological cctivity studies of the extract from the bark of Ricinodendron heudoletti, Euphorbiaceae" Journal of Diseases and Medicinal Plants, 2016; 2:83-89. https://doi.org/10.11648/j.jdmp.20160206.14

[40] Fongnzossie Fedoung E, Biwole, Nyangono Biyegue CF, Ngansop M, Akono Ntonga P, Essono DM, Funwi FP, Tonga C, Nguenang GM, Kemeuze VA, Sonwa DJ, Nole Tsabang, Bouelet IS, Tize Z, Boum AT, Momo Solefack MC, Betti JL, Nouga Bissoue A, Lehman LG, Mapongmetsem PM, Ngono Ngane A, Ngogang Yonkeu J, "Searching nature-based solutions to emerging diseases: a preliminary review of cameroonian medicinal plants with potentials for the management of COVID-19 pandemic" Systematic Review 2020 ; 3-56. https://doi.org/10.21203/rs.3.rs-100548/v1

[41] Adem S, Eyupoglu V, Sarfraz I, Rasul A, Ali M, "Identification of Potent COVID-19 Main Protease (Mpro) Inhibitors from Natural Polyphenols: An in Silico Strategy Unveils a Hope against Corona" Preprints 2020; DOI: 10.20944/preprints202003.0333.v1.Available from:https://www.researchgate.net/publication/340095736_Identification_of_Potent_COVID19_Main_Protease_Mpro_Inhibitors_from_Natural_Polyphenols_An_in_Silico-trategy_Unveis_a_Hope_against_CORONA [accessed Apr 21 2020]. https://doi.org/10.20944/preprints202003.0333.v1

[42] Mohammadi N, Shaghaghi N, "Inhibitory Effect of Eight Secondary Metabolites from Conventional Medicinal Plants on COVID-19 Virus Protease by Molecular Docking Analysis" ChemRxiv. Preprint, 2020; https://doi.org/10.26434/chemrxiv.11987475.v1. 2020 https://doi.org/10.26434/chemrxiv.11987475.v1

[43] Zhang D, Wu K, Zhang X, Deng S, Peng B, "In silico screening of Chinese herbal medicines with the potential to directly inhibit 2019 novel coronavirus" J. Integr. Med., 2020; 18:152-158. https://doi.org/10.1016/j.joim.2020.02.005

[44] Yinyang J, Mpondo Mpondo E, Tchatat M, Ndjib RC, Mvogo Ottou PB, Dibong SD, "Les plantes à alcaloïdes utilisées par les populations de la ville Douala (Cameroun) " Journal of Applied Biosciences 2014; 78:6600-6619. https://doi.org/10.4314/jab.v78i0.7