Scientific Research Publishing

Advances in Biological Chemistry, 2024, 14, 121-144
https://www.scirp.org/journal/abc
ISSN Online: 2162-2191
ISSN Print: 2162-2183

Ethnobotanical and Phytochemical Study of Medicinal Plants Sold in the Markets of the City of N'Djamena

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How to cite this paper: Djibrine *et al.* (2024) Ethnobotanical and Phytochemical Study of Medicinal Plants Sold in the Markets of the City of N'Djamena. *Advances in Biological Chemistry*, **14**, 121-144.
https://doi.org/10.4236/abc.2024.144011

Received: June 30, 2024
Accepted: August 5, 2024
Published: August 8, 2024

Abstract

The use of medicinal plants occupies an important place in traditional Chadian medicine, this study was carried out with the aim of listing the medicinal plants sold in the markets of the city of N'Djamena, and knowledge of the medicinal flora Chad, such as the leaves of Guiera senegalensis in Arabic called Khibeche, the roots of Cassia occidentalis called Am kwala-Kinkéliba in Arabic; the bark of Khaya senegalensis (Desv) A. Juss called Muraï in Arabic and the seeds of Trigonella foenum-graecum called Helbé in Arabic in order to treat the most frequently cited diseases such as malaria, the common cold, mother and newborn care, and typhoid. Ethnobotanical surveys were conducted from September to December 2022, in three markets in the city of N'Djamena, based on individual interviews using a semi-structured questionnaire, with 30 herbalists and traditional practitioners. Phytochemical screening analyses of the organs of four plants were carried out in the chemistry and biology laboratory of the Faculty of Exact and Applied Sciences (FSEA) following a standard protocol established by [1] and slightly modified by [2] [3]. The results of the surveys identified 68 species divided into fifty-five (55) genera and twenty-seven (27) families, the most represented of which were Caesalpiniaceae (10 species), Mimosaceae (5 species) and Combretaceae (4 species). The leaves were the most commonly used parts (43%), with decoction (70%) the most frequently used method of preparation. The oral route was the most popular with 73% of recipes. The phytochemical study revealed a wealth of secondary metabolites such as Trapezoidal Sterols,

Alkaloids, Tannins, Flavonoids, Free Quinones, Anthocyane, Anthraquinones, Saponosides and Heterosides. These results can be considered as a source of information for scientific research in the field of phytochemistry and pharmacology.

Keywords

Chad (N'Djamena), Medicinal Plants, Ethnobotany, Screening, Phytochemistry

1. Introduction

Living beings have always sought to use plants to ensure their survival and to derive remedies from them to treat their diseases [4]. Medicinal plants are an important source of healthcare worldwide [5] [6]. More than 80% of the African population still rely on traditional medicines for their medical security. Demographic growth and the inaccessibility of modern medicines in developing countries are contributing to an increase in demand for traditional medicines [7]. These plants are sought after to treat a variety of conditions (malaria, haemorrhoids, rheumatism, dermatitis, febrile illnesses, sexual impotence, etc.) [8]. Medicinal plants are still a source of medicinal care in developing countries in the absence of a modern medicinal system [9]. Today, aromatic and medicinal plants are no longer just a remedy for impoverished communities in developing countries, but also a source of bioactive molecules that are in great demand in the pharmaceutical, agri-food, cosmetics and perfume industries. Numerous ethnobotanical surveys have been carried out in markets elsewhere in the world [10] and in Côte d'Ivoire [11]. Ethnobotanical studies carried out throughout Chad have identified species used to treat diabetes and high blood pressure [12].

Research hypothesis:

In N'Djamena, there are many herbalists and traditional therapists. They sell, advise on and often promote medicinal plants, which leads us to ask the following questions: What are the most commonly used medicinal plants? How are these medicinal plants prepared? How and against what diseases are they used?

These are the different aspects of our problem, which we want to answer through an ethnobotanical survey of medicinal plants.

The main objective of this study is to develop medicinal plants sold on the outskirts of the city of N'Djamena for their potential to cure illnesses. To achieve this, it is necessary to carry out an ethnobotanical survey, chemical screening and assessment of certain secondary metabolites.

2. Materials and Method

2.1. Study Area and Setting

In order to gather as much information as possible on the traditional therapeutic

uses of plants, we carried out an ethnobotanical survey, through a series of visits to markets in various districts of the city of N'Djamena, among sellers of medicinal plants and plant collectors. The city of Ndjamena is the largest city in the Republic of Chad, the capital and administrative city located in the centre-west of the country, 12˚07' north latitude and 15˚03' east longitude, at an altitude of 288 - 299 m. It is bordered to the north by the sub-prefecture of N'Djamena-Farah, to the south by the sub-prefecture of Koundoul in the Chari Baguirmi region, to the east by Bakara and to the west by Cameroon at the confluence of the Logone and Chari rivers. It covers an area of 39,500 hectares, or 395 km^2 of urbanised land. Administratively, the commune of N'Djamena is divided into 10 arrondissements, which are subdivided into neighbourhoods and squares (Figure 1).

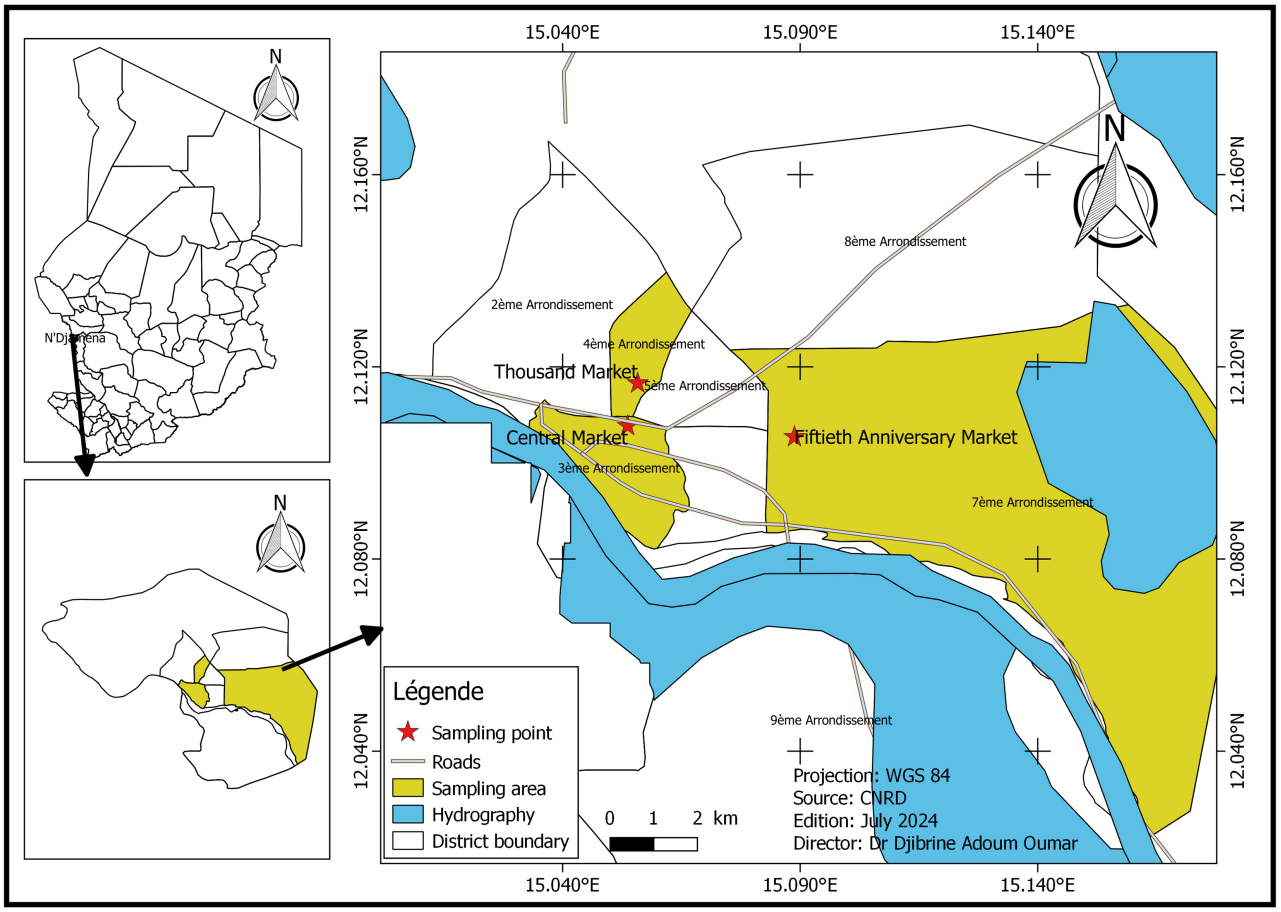

Figure 1. Map of the city of N'djamena (study area).

2.2. Ethnobotanical Survey and Phytochemical Study

2.2.1. Ethnobotanical Survey

This was a study carried out in the markets of the town of N'Djamena, over a period of four (4) months from September to December 2022.

2.2.2. Study Population

The study population consisted of medicinal plant sellers, plant collectors and

traditional health practitioners in the town of N'Djamena. Our sample consisted of 30 individuals, including 14 traditional practitioners, 12 herbalists and 4 harvesters. The criteria for choosing plant traders or herbalists were their availability, the wealth and volume of their stalls and the large number of visitors.

2.2.3. Sampling

The sampling method used was stratified probability sampling, which consisted of dividing the study area into different strata, represented here by the markets. In each stratum, different markets were visited and 30 individuals were interviewed. These interviews were combined to form an overall sample of 30. Ethnobotanical surveys based on the semi-structured interview method [13] [14]. Were conducted in three (3) markets. Each interview was accompanied by the purchase of medicinal plants, marketed. These purchases constituted collections of specimens that were identified at the Faculty of Exact and Applied Sciences Farcha (FSEA). The taxonomic identification of species was carried out by comparison with the analytical flora of Chad [15].

2.2.4. Equipment

1) Survey tool

The ethnobotanical study was carried out following a series of surveys using a questionnaire in the form of a survey sheet consisting of two parts:

- Part 1: information on the people questioned: Age; Sex; Level of education; Professional experience; Method of acquiring knowledge; Ethnic group.
- The 2nd part asks questions about the plants, their vernacular names and uses, how they are used, the parts of the plants used, how they are prepared and how they are used, how medicinal plants are administered and the diseases treated.

2) Laboratory equipment

The technical equipment used was as follows: plastic basket, rucksacks, axe, hoe, herbarium press, digital camera, computer, printer, ream of blank sheets, conservation bag, pen, pencil, isothermal bag. Erlenmeyer, Büchner, vacuum flask, volumetric flask, 25 ml, 50 ml, 100 ml test tubes, pipettes, cups, capsules, watch glasses, crystallizer, single funnel, 250 ml Pyrex bottles, water jug, 50 ml, 100 ml and 100 ml beakers, rotavapor, lift, electronic balance, UV lamp, oven, hot plate, magnetic stirrer, electric hoover, water hoover, filter paper, cotton wool, adhesive tape, scissors, magnetic bars, drop counters, canister, tweezers, spatulas.

2.2.5. Reagents

The reagents used are as follows:

- Liebermann; Salkowski; Dragendrorff; Wagner; $FeCl_3$; HCl; Stiasny; Chloroform; Acetic anhydride; Magnesium chips; H_2SO_4. Water, petroleum ether, 90˚ ethanol.

2.2.6. Biological Material

The plant material consists of the different organs of the plant. These in clude

leaves, stems, roots, bark, fruit, bulbs and rhizomes. Leafy branches with or without fertile parts (flowers, fruit), etc. of species encountered during harvesting were used for the herbarium and chemical screening.

2.2.7. Study Variables

1) Socio-demographic variables of the populations surveyed

These are: Age, gender, level of education, professional experience, method of acquiring knowledge, ethnicity and nationality.

2) Ethnobotanical study variables

These are: Plants; vernacular names, and their uses, mode of use, frequency of quotation, parts of plants used; mode of preparation and forms of use; mode of administration of medicinal plants; pathologies treated.

3) Variables related to the main chemical groups of plant ex tracts

These are: The yield of crude extracts; Sterols and terpenoids; Alkaloids; Flavonoids; Saponosides; Free quinones; Anthraquinones; Anthocyanins; Tannins; Heterosides.

2.3. Phytochemical Study

Phytochemical screening of the organs of four plants used in the treat ment of at least five diseases was carried out in the chemistry and biology laboratory of the Faculty of Exact and Applied Sciences (FSEA) following a standard chemical screening protocol established by [16]. And slightly modified by [2] [3]. These are the leaves of Guiera senegalensis; the roots of Cassia occidentalis; the bark of Khaya senegalensis (Desv.) A. Juss; and the seeds of Trigonella foenum-graecum. Samples of these plants were harvested and dried at laboratory temperature away from the sun and ground to a powder. Preliminary characterisation tests were based in part on qualitative analysis, either on the formation of insoluble complexes using precipitation reactions, or on the formation of coloured complexes, using staining reactions. Phytochemical screening protocol.

Efficiency

1) Extractions

The powdered plant material was macerated, then filtered and evaporated in the rotavapor. The crude extract was then air-dried in the laboratory. The crude extract was used to calculate the yield according to the following formula:

$$\text{Efficiency}(\%) = \frac{M_2 - M_1}{M_0} \times 100$$

M_1 = masse de bécher vide en g;

M_2 = masse de bécher contenant de résidu de l'extrais;

M_0 = masse de la poudre utilisée.

2.4. Identification of Secondary Metabolites

Phytochemical screening protocol, the plant material taken (approximately 250 g) will be dried away from the sun, crushed then pulverised and stored in a

clean, dry container for each species the test will be carried out [16].

2.4.1. Sterols and Terpenoids

Test carried out on the ethereal extract of the plant material 1 g of the plant is macerated in a stoppered bottle in 20 ml of ether for 24 h00. LIEBERMAN test: a few drops of the ether solution are evaporated on a watch glass and the residue is dissolved in 2 drops of acetic anhydride. Add a drop of concentrated sulphuric acid. The presence of sterols or terpenoids is shown by the mauve colour which turns green. SALKOWSKI test: Add chloroform and concentrated sulphuric acid to the residue. Stirring turns the upper layer red and the lower layer yellow, indicating the presence of sterols or terpenoids [17].

2.4.2. Alkaloids

To 0.5 g of plant material 15 ml of ethanol is added. After shaking for 30 minutes, the extract is filtered, 5 ml of the extract is taken, 3 ml of HCL1N and a few drops of the following reagent are added: Mayer or Dragendorf or Wagner [18].

Positive test: formation of a strong precipitate in suspension or with im mediate flocculation.

2.4.3. Flavonoids

Test carried out on the 10% infusion: to 5 g of plant powder, add 50 ml of boiling water; leave to infuse for a few minutes and filter. To 3 ml of the filtrate, add 3 ml of the HCl-CH_3OH-H_2O mixture (1/1/1) and a few shavings of magnesium. If the solution is colored [19].

- **Orange: Flavones;**
- **Red: flavonols;**
- **Purple: flavonones.**

2.4.4. Saponosides

2 g of plant material is put in 100 ml of water. Make a decoction for 30 minutes. After cooling and filtration, the volume is readjusted to 100 ml. From this stock solution, 10 16 × 160 mm tubes are prepared, with volumes of solution ranging from 1 to 10 ml. These volumes were readjusted to 10 ml with distilled water. Each tube was shaken vigorously in a horizontal position for 15 seconds. After resting for 15 minutes in a vertical position, the height of the persistent foam was measured in cm. If the height of the foam is close to 1 cm in the third tube, then the foam index is:

I: (5 × height of foam in cm in the ith tube/i) × 100.

2.4.5. Free Quinones

1 g of plant material was placed in a tube with 20 ml of petroleum ether. After shaking and standing for 24 h, the extract was filtered and concentrated. The presence of free quinones is confirmed by the addition of a few ml of NaOH1/10, when the aqueous phase turns yellow, red or purple [20].

2.4.6. Antraquinones

Moisten 2 g of plant powder with 2 ml of a 10% HCl solution. Add 20 ml of chloroform and leave to macerate for 24 hours. Filter. Take ml of the chloroform solution and treat with 1 ml of 10% NaOH. A red colour indicates the presence of quinons [21].

2.4.7. Tannins

Test carried out on the 5% infusion.

- Action of $FeCl_3$: Add a few drops of FeCl to the infusion. If there is coloration with a precipitate, this indicates the presence of tannins.
- Blue-black colouration: gallic tannins,
- Greenish brown colour: catechic tannins. Disadvantage: test also positive with phenols.
- Stiasny reaction: Add the HCl/formaldehyde mixture (1/5) to the infusion. Heat in a bain-marie for a few minutes. If a precipitate forms, this indicates the presence of catechic tannins. Filter the infusion, treat and add a few drops of FeCl If there is precipitation, the gallic tannins are present.
- Action of HCl: Add pure Hcl to the infusion, then heat. If a red colour is formed, the tannins are catechic [22].

2.4.8. Anthocyanins

Test carried out on 5% infused. (0.5) of plant material in 10 ml boiling water 15 minutes filter. Carry out hydrolysis with 3 mL alcoholic HCl (HCl + OH v/v) on the infusion by heating for a few minutes at 50˚C in a water bath. The formation of a purplish red colour indicates the presence of anthocyanins.

2.4.9. Cardiotonic Heterosides

1 g of plant material is macerated in 10 ml of chloroform for 15 minutes. After filtration, 4 ml of extract is placed in a test tube; 2 ml of acetic anhydride is added and left to cool for a few minutes in an ice bath. Slowly add 1 mL of concentrated H_2SO_4 to the wall of the tube. The change in colour from violet to blue or green indicates the presence of the aglycone of the cardiotonic glycosides.

2.5. Plant Citation Frequency

The citation frequency (*CF*) of each plant was determined by the following formula:

$$CF = Nc/Nt \times 100$$

where:

Nc: Number of citations for the plant in question.

Nt: Total number of respondents.

2.6. Statistical Analysis and Data Processing

The data collected was recorded on cards to be analysed and studied at the end. The data was then entered and analysed using Microsoft Excel 2019 and the results presented in the form of tables and figures.

3. Results

3.1. Socio-Demographic Characteristics of the Populations Surveyed

3.1.1. By Sex

A total of 30 people were included in the study, with men accounting for 60% (18 men) of the study population, compared with 40% (12 women) (Figure 2).

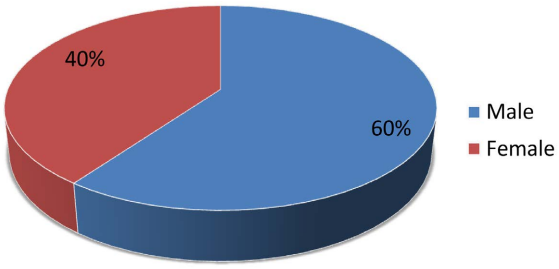

Figure 2. Breakdown of respondents by gender.

3.1.2. Age Range

The age extremes of the survey population ranged from 22 to 73 years, with an average age of 44.5 years, the majority of whom were in the [40 - 50] age bracket (Figure 3).

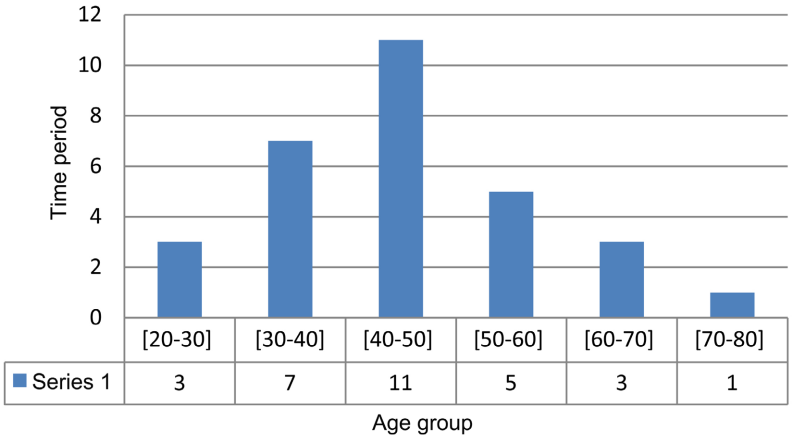

Figure 3. Distribution of respondents by age group.

3.1.3. Ethnicity

The Mandara ethnic group was the most represented in this study with 29.03% (Table 1).

Table 1. Ethnicity of respondents.

Ethnicity	n	%
Mandara	8	29.03
Ngambaye	7	22.58
Kanembou	5	16.13

Continued

Haussa	3	9.68
Kanouri	2	6.45
Arabe	1	3.23
Marba	1	3.23
Mbaye	1	3.23
Moussey	1	3.23
Lélé	1	3.23
Total	30	100.00

3.1.4. Level of Education

Half of the respondents (67.74%) had no formal education (Table 2). The level of education of the population surveyed was low, with only 19.35% having primary education and 67.74% being illiterate.

Table 2. Breakdown of respondents by level of education.

Level of study	n	%
Non-literate	20	67.74
Primary	6	19.35
Secondary	4	12.90
Superior	0	0
Total	30	100.00

3.1.5. Number of Years of Experience

The majority of respondents had been in practice for more than 10 - 20 years (38.71%) (Table 3). In this study, 38.71% of respondents had been practising for more than 10 years.

Table 3. Breakdown of respondents by years of experience.

Experience (year)	n	%
≤5	4	12.90
5 - 10	11	38.71
10 - 20	11	35.48
30 - 40	2	6.45
40 - 50	1	3.23
≥60	2	6.45

3.1.6. Speciality

The majority of respondents practising as tradipraticians were in the majority in the study, with a percentage of 48.39%. The survey showed that the majority of

the traditherapists interviewed were men, while the majority of herbalists were women (Table 4).

Table 4. Speciality of respondents.

Specialities	n	%
Tradi practitioner	14	48.39
Herbalist	12	38.71
Harvester	4	12.90
Total	30	100.00

3.1.7. How Knowledge Is Acquired

The majority of informants (70.97%) acquired information through ancestral knowledge. Whereas (29.03%) of the population studied received their information through experience (Table 5).

Table 5. Breakdown by mode of knowledge acquisition.

Transmission mode	n	%
Hereditary	21	70.97
Empirical	9	29.03
Total	30	100.00

3.1.8. Frequency of Botanical Families

Our survey revealed 68 plant species belonging to 27 different families, of which the most represented are: Caesalpiniaceae (14.71%), Mimosaceae (7.35%), Combretaceae (5.88%), Asclepiadaceae and Euphorbiaceae, Fabaceae, Myrtaceae, Rubiaceae (4.44%) (Figure 4).

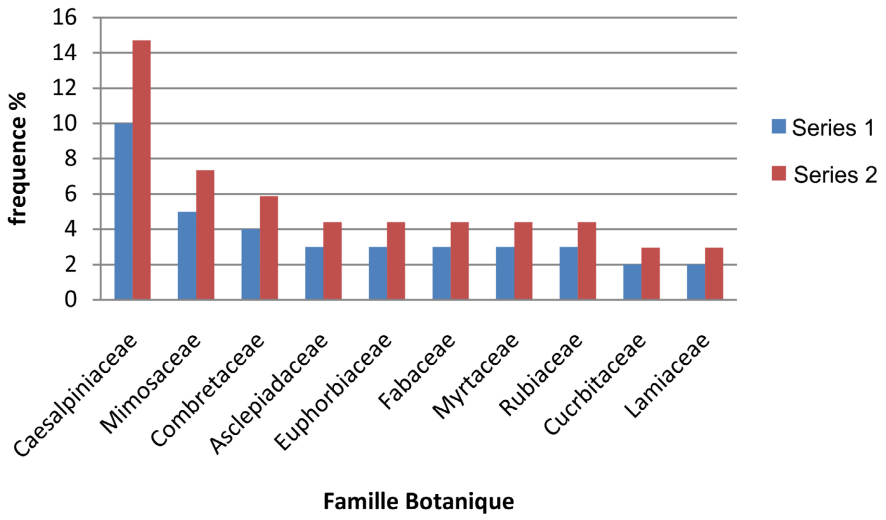

Figure 4. Frequency of botanical families.

3.1.9. Parts of Plants Used

A total of 10 plants parts are used in the preparation of traditional recipes. Leaves are the most commonly used part, accounting for 43%, followed by bark (24%), roots (10%), leafy shoots (8%), seeds (6%), fruit (4%) and other parts (pods, clous, rhizomes, nails) (5%) (Figure 5).

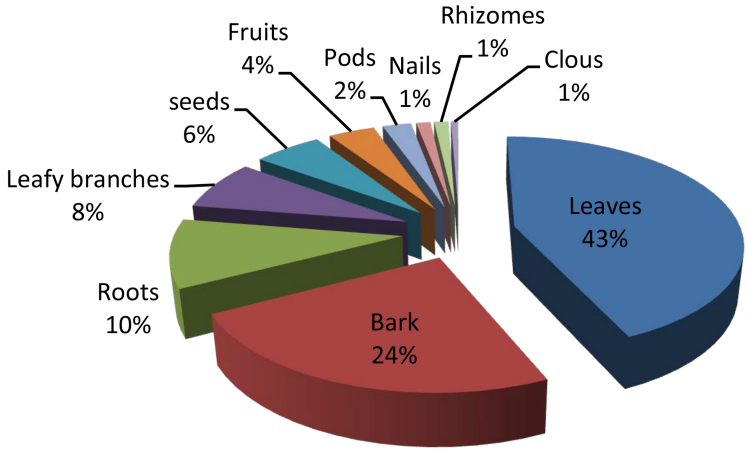

Figure 5. Distribution of plants according to the parts used.

3.1.10. Distribution According to Method of Preparation and Form of Use

The most commonly used method of preparation is decoction (70%), followed by crushed plants (powders) (18%) and macerations (only 6%) (Figure 6).

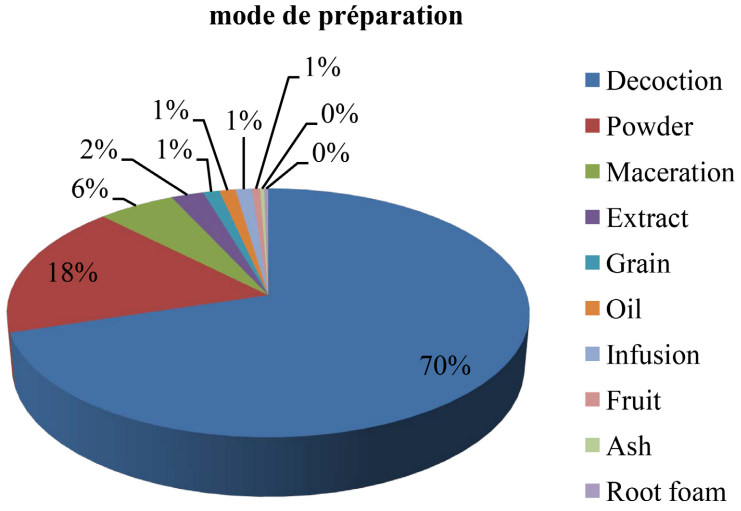

Figure 6. Distribution of medicinal plants according to preparation method.

3.1.11. Method of Administration of Medicinal Plants

Figure 7 shows that most of the recipes prepared are described orally with a high percentage (73%), because it is very effective and fast, then the other modes of administration bath (14%), massage (4%), then Suppository; fumigation; drop (2%). The least used method is gargarism, poultice or brush (1%).

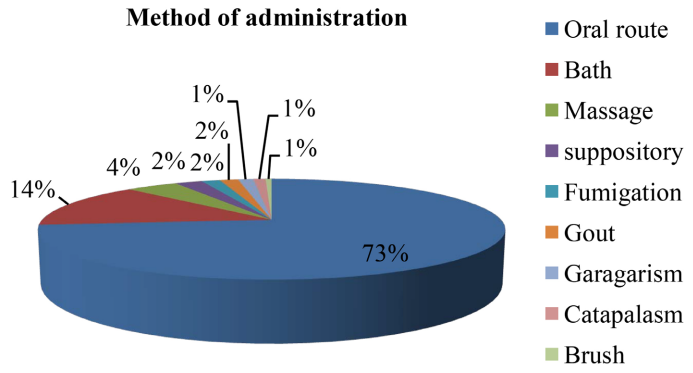

Figure 7. Distribution of medicinal plants by mode of administration.

3.1.12. Distribution According to Diseases Treated

The most frequently cited diseases are malaria, colds, mother and new born care, and typhoid. The results show that 68 species identified in this study are used in the treatment of 50 diseases or conditions, with a high frequency of use (**Figure 8**).

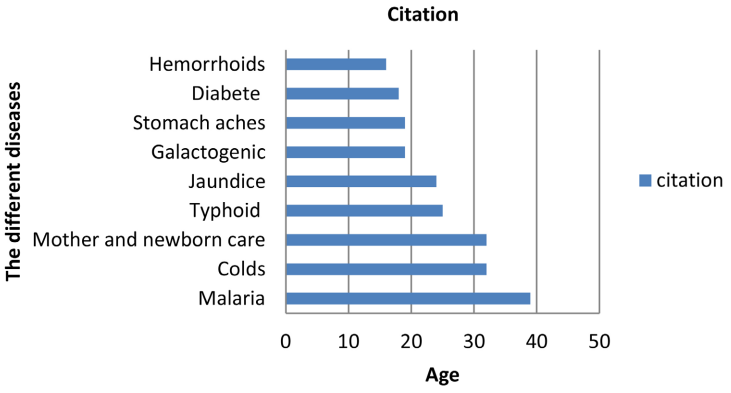

Figure 8. Distribution according to the diseases treated.

3.1.13. List of Plants Inventoried

The ethnobotanical survey enabled us to identify 68 species. (See Appendix 1) in the tables list of plants inventoried with their scientific name, family, parts used (ailments treated, symptoms and therapeutic effects), preparation and administration methods (**Table 6**).

Table 6. List of plants inventoried.

N°	Species	Family	Common name	Number of citations	Frequency %
1	*Anogeissus leiocarpa* (*DC.*) *Guill. & Perr.*	Combretaceae	Saba (Arabi), ida (Ga)	21	30.88
2	*Mitragyna inermis* (*Willd.*) *O. Ktze.*	Rubiaceae	Angato (Ar), Nde (Ga)	17	25.00
3	*Cassia italica* (*Mill.*) *Lam. ex F. W. Andr.*	Caesalpiniaceae	tor azrak	16	23.53
4	*Guiera senegalensis J. F. Gmel.*	Combretaceae	Khibeche (Ar), Kamda (Ga)	14	20.59

Continued

5	*Bauhinia rufescens Lam.*	Caesalpiniaceae	koulkoul	13	19.12
6	*Khaya senegalensis* (*Desv.*) *A. Juss.*	Meliaceae	Mouraï	13	19.12
7	*Acacia nilotica* (*L.*) *Willd. ex Del.*	Mimosaceae	Garade	12	17.65
8	*Ficus platyphylla Delile*	Moraceae	djimez ahmar	12	17.65
9	*Diospyros mespiliformis Hochst. ex A. DC.*	Ebenaceae	Djoghan, kam kok	11	16.18
10	*Tamarindus indica L.*	Caesalpiniaceae	Ardeb, massi	11	16.18
11	*Piliostigma thonningii* (*Schum.*) *Milne-Redhead*	Caesalpiniaceae	Karum, môme	10	14.71
12	*Citrullus Colocynthis* (*L.*) *Schrad.*	Cucrbitaceae	Handal	9	13.24
13	*Tinospora bakis* (*A. Rich.*) *Miers*	Menispermaceae	Irgal-hadjar	9	13.24
14	*Cassia occidentalis L.*	Caesalpiniaceae	Am kwala, Kinkéliba	8	11.76
15	*Indigofera aspera Perr. ex DC.*	Fabaceae	Am kechew	8	11.76
16	Leptadenia lanceolata (Poir.) Goyder	Asclepiadaceae	Hab el-rachad	8	11.76
17	*Azadirachta indica A. Juss.*	Meliaceae	nime	7	10.29
18	*Eucalyptus camaldulensis Dehn.*	Myrtaceae	Eucalyptus, Safarmot	7	10.29
19	*Moringa oleifera Lam.*	Moringaceae	Moringa, hallom	7	10.29
20	*Balanites aegyptiaca* (*L.*) *Del.*	Zygophyllaceae	hidjilije	6	8.82
21	*Cassia siamea Lam.*	Caesalpiniaceae	acacia	6	8.82
22	*Euphorbia hirta L.*	Euphorbiaceae	Amal-Laban, Neimba	6	8.82
23	*Cucumis prophetarum L.*	Cucurbitaceae	fagus-el keleb	5	7.35
24	*Cymbopogon citratus* (*DC.*) *Stapf*	Poaceae	Citronnelle	5	7.35
25	*Manihot esculenta Crantz*	Euphorbiaceae	Le manioc	5	7.35
26	*Mimosa pigra L.*	Mimosaceae	Am sinené	5	7.35
27	*Ocimum basilicum L.*	Lamiaceae	Am rihané	5	7.35
28	*Sclerocarya birrea* (*A. Rich.*) *Hochst.*	Anacardiaceae	Himede -lobo	5	7.35
29	*Trigonella foenum-graecum*	Menispermaceae	Helbé	5	7.35
30	*Zingiber officinale Rosc.*	Zingiberaceae	Gingembre	5	7.35
31	*Artemisia annua*	Asteraceae	chie	4	5.88
32	*Cassia obtusifolia L.*	Caesalpiniaceae	kawal	4	5.88
33	*Mitracarpus hirtus L DC*	Rubiaceae	dawa hana gouha	4	5.88
34	*Waltheria indica L.*	Sterculiaceae	irgal-nar	4	5.88
35	*Boscia senegalensis* (*Pers.*) *Lam. ex Poir.*	Capparaceae	Mikhete	3	4.41
36	*Calotropis procera* (*Ait.*) *Ait. f.*	Asclepiadaceae	achorow	3	4.41

Continued

37	*Cassia mimosoides L.*	Caesalpiniaceae	ardeb-algoz	3	4.41
38	*Cochlospermum tinctorium A. Rich.*	Cochlospermaceae	Rawaya -mbay	3	4.41
39	*Faidherbia albida* (*Delile*) *A. Chev.*	Mimosaceae	haraz	3	4.41
40	*Psidium guajava L.*	Myrtaceae	Goyave	3	4.41
41	*Ziziphus mauritiana Lam.*	Rhamnaceae	Nabak	3	4.41
42	*Allium cepa L.*	Liliaceae	Basale	2	2.94
43	*Allium sativum L.*	Liliaceae	Tom	2	2.94
44	*Bergia suffruticosa* (*Del.*) *Fenzl*	Elatinaceae	rimte	2	2.94
45	*Capsicum frutescens L.*	Solanaceae	Chété dogag	2	2.94
46	*Cassia nigricans Vahl*	Caesalpiniaceae	sanepa	2	2.94
47	Ceratotheca sesamoides Endl.	Pedaliaceae	Ambono-gomo	2	2.94
48	*Citrus limon* (*L.*) *Burm. f.*	Rutaceae	limon	2	2.94
49	*Combretum glutinosum Perr. ex DC.*	Combretaceae	habil	2	2.94
50	*Crossopteryx febrifuga* (*Afz. ex G. Don*) *Benth.*	Rubiaceae	gupu	2	2.94
51	*Cymbopogon giganteus Chiov.*	Poaceae	ka-Bra	2	2.94
52	Dichrostachys cinerea (L.) Wight & Arn.	Mimosaceae	Mbergang	2	2.94
53	*Hibiscus sabdariffa L.*	Malvaceae	Angara	2	2.94
54	*Lepidium sativum L.*	Brassicaceae	Chaloub-russa	2	2.94
55	*Mentha x piperita*	Lamiaceae	nana	2	2.94
56	*Nigela sativa L*	Ranunculaceae	Kammoun	2	2.94
57	*Prosopis africana* (*Guill. & Perr.*) *Taub.*	Mimosaceae	Girli-Sam	2	2.94
58	*Salvadora persica* L.	Salvadoraceae	Sewaque	2	2.94
59	*Solenostemma argel* (*Del*)	Asclepiadaceae	Baki	2	2.94
60	*Syzygium aromaticum* (*L.*) *Merr. & Perry*	Myrtaceae	Gronfol	2	2.94
61	*Carica papaya L.*	Caricaceae	papaye	1	1.47
62	*Cassia sieberiana* DC.	Caesalpiniaceae	allala	1	1.47
63	*Combretum collinum Fresen.*	Combretaceae	Romè	1	1.47
64	*Dalbergia melanoxylon Guill. & Perr.*	Fabaceae	babanous	1	1.47
65	*Datura innoxia Mill.*	Solanaceae	Am damaro	1	1.47
66	*Flueggea virosa* (*Roxb. ex Willd.*) *Voigt*	Euphorbiaceae	Kartja kartja	1	1.47
67	*Lonchocarpus laxiflorus Guill. & Perr.*	Fabaceae	Mikhete, Kamtour	1	1.47
68	Securidaca longepedunculata Fres.	Polygalaceae	Allélé	1	1.47

3.2. Results of Phytochemical Screening

Table 7 shows the list of plants selected for phytochemical analysis.

Table 7. List of plants selected for phytochemical analysis.

Species	Family	Local name	Part tested	Usage
Cassia occidentalis	(Caesalpinaceae)	Am kwala-Kinkéliba	root	Jaundice, malaria, stomach ache, vomiting, insomnia
Guiera senegalensis	Combrétacée	Khibeche (Arabe)-Kamda (gambeye)	sheet	Care for mothers and newborns, used as a galactogen or to improve the quality of breast milk, icterus-burns, dermatitis, malaria, stomach aches, fatigue.
Khaya senegalensis (Desv.) A. Juss	(Meliaceae)	Muraï (Arabe)-Mbaque (gambay)	stem bark	Anal fissure, intestinal worms-vaginal infections, tummy ache haemorrhoids, diarrhoea, constipation, tooth decay
Trigonella foenum-graecum	Menispermaceae	Helbé	grain	Painful period - galactogenic or to improve the quality of breast milk, tummy ache, dermatitis (spider veins)

3.2.1. Plant Extract Yield Results

The yields of extracts in aqueous decoctate and ethanoic macerate of *Cassia occidentalis* and *Guiera senegalensis*, *Khaya senegalensis* and *Trigonella foenum-graecum* were expressed as a percentage in relation to the weight of the dry starting plant material, the initial mass of each sample being 50 g. Table 8 showed that the aqueous decoctates and ethanoic macerates gave a good yield of dry extract. Water and ethanol were the most commonly used solvents for high recovery of alkaloids, flavonoids, saponosides and tannins.

Table 8. Yield of plant extracts as a function of solvents.

Plants	Alcohol (R %)	Water (R %)
Cassia occidentalis	89.5	90
Guiera senegalensis	74	106
Khaya senegalensis	16.5	380
Trigonella foenum-graecum	89	1146

3.2.2. Phytochemical Screening

Phytochemical analyses were carried out on dry plant matter. These analyses are related to the intensity of the precipitate, cloudiness and colouring is proportional to the quantity of the substance sought. The results of the preliminary tests for the presence or absence of (alkaloids, flavonoids, tannins, anthocyanins, free quinones, heterosides and saponosides) in extracts of dry plant matter are shown in Table 9.

Table 9. Results of phytochemical screening.

Chemical groups	Teste	Species			
		Guiera senegalensis	*Khaya senegalensis*	*Senna occidentalis*	*Trigonella foenum-graecum*
Sterols and terpenoids	Libermann	+	+	−	+
	Salkowski	+	+	+	++

Continued

Alkaloids	Mayer	−	+	+	−
	Dragendorff	+	++	++	++
	wagner	+	−	+++	+
flavonïdes		flavonones	flavons	flavons	−
saponides		90%	95%	65%	50%
Open pinions		+	+	+	+
Antraquinones		−	−	+	−
Tannins	Catéchiques	−	+	+	+
	Galiques	+++	−	−	−
Anthocyanins		−	−	+	+
Cardiotonic heterosides		+	+	+	+

(−) Absence, (+): Presence, (++): Abundant, (+++): Very abundant.

4. Discussion

4.1. Socio-Demographic Characteristics of the Populations Surveyed

The surveys carried out in the three markets identified 30 traditional healers and herbalists, 60% of whom were men and 40% women. The difference in percentages could be explained by the fact that in most African societies, secrets and knowledge are passed on much more to men than to women. These results are comparable to those of [23] who found in an ethnobotanical survey in Moundou and N'Djamena that 38.7% were female and 61.3% male.

4.2. Age Range

The age range of the population surveyed varied between 22 and 73 years, with an average age of 44.5 years. Most of them were in the 50 - 60 age group, because knowledge of the uses of medicinal plants and their properties is generally acquired through many years of experience and passed on from one generation to the next, in [10]. in Chad and Nguémadjibaye in 2016 in Chad, who reported that a large proportion of the TPS interviewed are over forty and have an average age of 48.87 and 49.4 years respectively.

4.3. Ethnic Group

The Mandara ethnic group was the most represented in this study with 29.03%. This high number could be explained by the fact that the city of N'Djamena is a cosmopolitan city that has received many foreign cultures.

4.4. Level of Education

Half of the respondents (67.74%) had a non-literate level of education. The level of education of the population surveyed was low, with only 19.35% having pri-

mary education and 67.74% being illiterate, 2020) who found that the level of schooling of the population surveyed was low, with only 12.25% having primary education, 32.65% being illiterate but 55.10% having attended Koranic school, and [24]. Who also found this low level of schooling among traditional healers, with 38% being illiterate, 14% having attended school, 7% being illiterate and 41% having attended Koranic school only. This result shows that traditional healers and herbalists start learning traditional medicine from their parents and teachers at an early age, and are therefore unable to continue their studies.

4.5. Years of Experience

The majority of respondents had been in practice for more than 10 - 20 years (38.71%). In this study, 38.71% of respondents had been working for more than 10 years. This result is similar to those of [25]. In Côte d'Ivoire and [26] in the DRC, who found 10 to 40 and 10 and more respectively. This is because knowledge of the uses of medicinal plants and their properties is generally acquired after many years of experience and passed on from one generation to the next [4].

4.6. Speciality

With the majority of respondents practising as Tradipraticians (48.39%), the tradithérapeutes surveyed were mostly men, while the herbalists were mostly women. The predominance of women among herbalists has already been reported in similar studies carried out in Côte d'Ivoire by [27]. On markets in Abidjan, with 96.00% women, and by [28]. On markets in southern Benin, with almost 100% women.

4.7. Method of Acquiring Knowledge

The majority of informants (70.97%) acquired information through ancestral knowledge. While (29.03%) of the population studied received their information through experience, which brings this result closer to those of [29]-[31]. this study showed that the mode of acquiring knowledge through family inheritance was dominant at 66.67%. Knowledge of the uses of medicinal plants and their properties is generally acquired as a result of long experience accumulated and passed on from one generation to the next. Experience accumulated with age is the main source of information.

4.8. Classification of Plants According to Their Citation

The results of the survey enabled us to list (68) plant species. Of the 68 plants listed, we note that they are cited between 1 and 21 times. The most cited plant is *Anogeissus leiocarpa*, with a citation of 21 times, followed by *Mitragyna inermis*, *Cassia italica*, *Guiera senegalensis*, *Bauhinia rufescens*, *Khaya senegalensis* with: 17, 16, 14, 13, 13 each respectively, *Acacia nilotica*, *Ficus platyphylla* (Delile) are cited 12 times each, and *Diospyros mespiliformis*, *Tamarindus indica* with a ci-

tation of 11 times, are the plants most used by the population. In Cameroon, [32] identified 84 species in 78 genera and 50 families, while identified 30 species (25 families and 29 genera) and 35 species (33 genera and 27 families) respectively in three Douala markets. In Côte d'Ivoire, [34] inventoried 58 species (56 genera and 33 families) in 3 communes of the city of Abidjan. The number of species inventoried is therefore significant, and complements previous work already carried out in the markets of this African city [35].

4.9. Frequency of Botanical Families

This survey revealed 68 plant species belonging to 27 different families, of which the most represented are: *Caesalpiniaceae* (9.33%), *Mimosaceae* (7.35%), *Combretaceae* (5.88%), *Asclepiadaceae* and *Euphorbiaceae*, *Fabaceae*, *Myrtaceae*, *Rubiaceae* (4.44%). In other African regions, revealed a predominance of *Asteraceae* and *Fabaceae* and *Lamiaceae*, the Asteraceae family in Uganda by [36] and in South Africa by [37], while [38] obtained a predominance of Asteraceae and Lamiaceae in Brazil [39].

4.10. Parts of Plants Used

A total of 10 plant parts are used in the preparation of traditional recipes, leaves being the most commonly used part with a percentage of 43%, followed by barks 24%, roots 10%, leafy shoots 8%, seeds 6%, fruit 4% and then the other parts (pods, bulbs, rhizomes, nails) with a percentage of 1%. The predominance of leaves has also been observed, the frequent use of leaves is justified by the abundance of chemical groups they contain, as they are known to be the site of synthesis of secondary plants [40].

4.11. Breakdown by Method of Preparation and Form of Use

The most commonly used preparation method is decoction (70%), followed by crushed plants (powders) (18%) and macerations (only 6%). This result is similar to those in Cameroon [41].

4.12. How Medicinal Plants Are Administered Method of Administration of Medicinal Plants

Most preparations are prescribed as a drink (oral route). Studies [42] have shown that drinking is the most popular method of administration in traditional medicine, with most of the recipes prepared being described orally in a high percentage (73%), as it is very effective and quick, followed by the other methods of administration: bath (14%), massage (4%), then suppository, fumigation, drop (2%). The least used method is gargarism, poultice or brush (1%).

4.13. Distribution According to Diseases Treated

This result could be explained by the fact that malaria is a parasitosis that is rife in tropical regions, particularly in sub-Saharan Africa. These results reflect the health profile of the populations of the city of N'Djamena. The results showed

that 68 species identified in this study are used in the treatment of 60 diseases or conditions, with a high citation frequency.

4.14. Yield Results for Plant Extracts Plant Extract Yield Results

The yields of extracts in aqueous decoctate and ethanoic macerate of *Cassia occidentalis* and *Guiera senegalensis*, *Khaya senegalensis* and *Trigonella foenum-graecum* were expressed as a percentage in relation to the weight of the dry starting plant material, the initial mass of each sample was 50 g. The aqueous decocts and ethanoic macerates gave a good yield of dry extract. Water and ethanol were the most commonly used solvents for high recovery of alkaloids, flavonoids, saponosides and tannins. The yields of aqueous decoctate and ethanoic macerate extracts gave good dry extract yields. Water and ethanol were the most commonly used solvents for high recovery of alkaloids, flavonoids, saponosides and tannins. This result is similar to that of [43] who showed that water and ethanol were the solvents that gave good yields.

4.15. Phytochemical Screening

Characterisation tests for flavonoids, sterols, terpenoids and heterosides were positive in all the plant extracts tested, but flavonoids were absent in the *Trigonella foenum-graecum* extract. We also found an abundance of catechic tannins in all the extracts tested, with the exception of those from *Guiera senegalensis*. Gallic tannins were only present in the *Guiera senegalensis* extract. Anthraquinones were detected in Cassia occidentalis but not in the other species. A more or less variable presence of saponosides. We found that saponosides were more present in the extract of *Khaya senegalensis* (Desv.) A. Juss and *Guiera senegalensis* with percentages of 95% and 90%, followed by *Cassia occidentalis* and *Trigonella foenum-graecum* with 65% and 50%. All the plants subjected to the phytochemical screening were rich in tannins, flavonoids, alkaloids and saponosides, with only the flavonoids showing scant precipitates in the *Trigonella foenum-graecum* extract. Extraction of Cassia occidentalis root showed the presence of sterols and terpenoids, alkaloids, flavonoids, free quinones, saponosides, anthraquinones, anthocyanins and heterosides. Several scientific studies have shown that cassia occidentalis has antibiotic, anti-inflammatory, vermifuge, abortive, cholagogue, healing, diuretic, laxative and tonic properties [44]. According to the results of phytochemical screening, *Guiera senegalensis* leaves are rich in alkaloids, sterols and terpenoids, heterosides, anthraquinones, saponosides, free quinones and gall tannins. The use of the leaves against fever is justified by the antipyretic and febrifuge properties reported by [45]. The use of leaves against jaundice is justified by the antiviral properties of the flavonoids reported , The use of leaves against dysentery could be justified by the antimicrobial properties reported, And by the antibacterial and astringent properties of the tannins reported by [40]. This result is similar to that of [46]. According to the results of phytochemical screening, the bark ex-

tract of *Khaya senegalensis* is rich in catechic sterols and terpenoids, alkaloids, flavonoids, free quinones, saponosides and heterosides. Local application of ointments based on hydroalcoholic extracts of the bark to laboratory animals has shown that the plant has anti-inflammatory activity. An extract of the bark also showed antiproliferative and pro-apoptotic effects on cancer cell lines [47]. Antifungal, antioxidant, anti-inflammatory, antiproliferative, antimalarial, antimicrobial, anthelmintic *Trigonella foenum-graecum*: grain extract is rich in catechic tannins, sterols and terpenoids, alkaloids, anthocyanins, free quinones, saponosides and heterosides [48] [49].

5. Conclusion

The ethnobotanical study carried out in the markets of the town of N'Ndjamena (Chad) enabled an inventory to be made of the medicinal plants used in traditional medicine. It has thus contributed to a better understanding of medicinal flora and the safeguarding of local folk know-how. Analysis of the results of this study enabled an assessment to be made of the diversity of medicinal plants sold on the markets and used in the traditional treatment of various ailments. Among the species listed, *Anogeissus leiocarpa*, *Mitragyna inermis*,*Cassia italica*, *Guiera senegalensis*, *Bauhinia rufescens* and *Khaya senegalensis* were predominant. The leaves are the main organs used in the preparation of medicinal recipes, with decoction and oral administration the most common methods of preparation and administration respectively. The curative effects induced by the plants studied are due to various chemical groups (alkaloids, flavonoids, glycosides, etc.) which form the scientific basis for their traditional use. This study may also provide a database for the development of medicinal plants, with a view to discovering new active ingredients that can be used in pharmacology, and helping to validate their traditional use.

Acknowledgments

This research was supported by University of N'Djamena and Ministry of Higher Education, Scientific Research and Innovation (MHESRI) of Chad. The authors are thankful to them.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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