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Ethnobotanical and Ecological Studies of Plants Used in the Treatment of Diabetes in Kwango, Kongo Central and Kinshasa in the Democratic Republic of the Congo

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Abstract: Non-communicable diseases represent new challenges for the mankind in the fight for health improvement. Among these diseases, diabetes is a major contributor. Diabetes is a serious chronic disease that occurs when the pancreas does not produce enough insulin or when the body is unable to use the insulin produced effectively. This survey was performed in Kwango, Kongo-Central and Kinshasa provinces respectively between October 2016 and September 2017. A questionnaire was administered to the target population in order to collect relevant data. Plant identification was carried out at the herbarium of University of Kinshasa. The findings revealed that the inventoried medicinal flora is made up of 68 species which are divided into 34 families of 58 genera; the leaf is the most commonly used part in the treatment of diabetes while maceration is the most commonly used method of preparation. The use of medicinal plants is reported in almost all age groups from 20-89 years of age but with a predominance among people aged 40-49 years. Trees and phanerophyte species predominate in the flora studied; the majority of users of these medicinal plants have a primary level of education. In-depth phytochemical and pharmacological studies need to be carried out on these plants with a view to their scientific validation in the diabetes management.

Keywords: Diabetes, Challenge, Medicinal Plants, Ethnobotany, Kongo Central, Kwango, Kinshasa, DRC

1. Introduction

Non-communicable diseases represent new challenges for the mankind in the fight for health improvement. Among these diseases, diabetes is a major contributor because it is considered to be one of the four priority non-communicable diseases targeted for intervention by world leaders [1, 2]. Diabetes is a serious chronic disease that occurs when the pancreas does not produce enough insulin or when the body is unable to use the insulin produced effectively [3]. However, numerous studies have shown that phytotherapy can be associated with any anti-diabetic treatment and in the case of non-insulino-dependent diabetes, its place may be important as a complement to the diet which has a major role and possible drugs [4]. This is why people are turning to traditional herbal medicine which is less expensive and which they consider as effective as modern therapy. To this end, World Health Organization (WHO) reports that in

Africa, more than 80% of the population uses traditional medicine to provide primary health care in both urban and rural areas [5-10].

The Democratic Republic of the Congo (DRC) is a reservoir of both faunal and floristic biodiversity [6-15]. Its flora is full of medicinal plants of biopharmaceutical interest and capable of providing new lead molecules. Thus, ethno-pharmacological studies for the scientific validation of these plants are very encouraging, as evidenced by the research results of the last ten years [11-16]. The overall objective of this study was to contribute to the knowledge of the plants used in Kinshasa, Central Kongo and Kwango for the management of diabetes. The specific objectives are to conduct an ethnobotanical survey of the population, to identify and give their ecological characteristics (morphological types, biological types, phytogeographic distributions and biotope) and to highlight their therapeutic virtues.

2. Material and Methods

2.1. Study Area

The city of Kinshasa is located between 4° 18' and 4° 25' South latitude and between 15° 18' and 4° 22' East longitude. It is bounded to the North and East by Kwango, to the South by Kongo Central and to the West by the Republic of Congo, with an average altitude of 300 m above the sea level. The city is built on the left bank of the Congo River called the Pool Malebo and is crossed by many rivers called allogenic and the three most important are N'djili, N'sele and Mai-Ndombe. The climate of Kinshasa city is of the Aw_4 type, i.e. a tropical climate. It is characterized by a large 8-month rainy season (often interspersed with a small dry period straddling between January and February) and between mid-September and mid-May, and a dry season during the rest of the year precisely between mid-May and mid-September [17, 18].

Kwango is located between 6°32'31" South latitude and 17°2 24" East longitude, over an area of 89.974 Km^2 with a population of 1.994.036 inhabitants, consisting of Yaka, Suku, Tchokwe, Holo, Lunda Hungana, Mbala, Ngongo tribes. Kwango is divided into five territories namely: Feshi, Kahemba, Kasongo Lunda, Kenge and Popo Kabaka. Kwango is located in a tropical climate zone with two distinct seasons, an 8-month rainy season and a 4-month dry season with a minimum temperature of 20°C and a maximum of 27°C. The vegetation is made up of savannahs, prairies, galleries and forests depending on the territory [19].

Kongo Central is between 4° and 6° south latitude and 12 and 16° East longitude over a 53 920 km^2 area. With a population of 3 615 504 inhabitants, there are the Yombe, Nianga, Ndibu peoples. The population is unevenly distributed in space. Matadi, the chief town of this province, represents 7%, so much so that the Bas Fleuve and Cataractes represent 28% and 36% respectively of the population. Boma 10% and Lukaya 2.3% and the other populations are found in villages and chiefdoms. The climate in Kongo Central is of a tropical Sudanese type climate, subdivided into two types: a first one that extends along the coast, is a steppe type climate with very high variability that lasts for months (from May 15 to September 15) while the other tropical climate that lasts 8 months. Bas-Fleuve is an area where the risk of drought is very high. An ecological niche of Mangrove is observed off the coast. The minimum temperature can be between 15°C and 17°C in the coastal zone and then the maximum at 27°C, in other territories the minimum 20 °C and maximum 27°C [19].

2.2. Methodology

An ethnobotanical study was carried out between October 2016 and September 2017 using a survey approach mainly among traditional medicine stakeholders who market their products in different markets of these aforementioned provinces, of which 68 people were interviewed directly using a predefined survey form.

The identification of plants was carried out at the herbarium of the Department of Biology, Faculty of Science, University of Kinshasa by comparison with the available specimens and/or the herbarium of the Jardin Botanique de Kisantu.

At part from the questionnaire used, the ethnobotanical data collected were then supplemented by information on ecological types as follows: Morphological types: Tree (T), Shrub (Sh), Annual grass (AG), Perennial grass (Pg), Liana (Li) and Rhizome (Rh) while the Biological types were: Bulbous geophyte (Gbu), Rhizomant geophyte (Grh), Tuberous geophyte (Gtu), Mesophanerophyte (Msph), Megaphanerophyte (Mgph), Microphanerophyte (Mcph), Nanophanerophyte (Nph), Lying Phanerophyte (Lph), Upright Phanophyte (Thd), Climbing Theophyte; Phytogeographic distribution: pantropical (Pan), afro-tropical, Sarcochores (Sarc), guinea-congolian (GC), Balochores (Bal), Palio-tropical (Pal), pterochores (Pte), cosmopolitan (HC) and sclerochorous (Scl), Lower Guinea (BG), Central Guinea-Congolian (CGC), African-American (Aa), Lower Guinea-Congolian (BGC), Guinean and Zambézian (GS-Z) and Biotope Type: Crop (Crop), Forest (Fo), Savannah (Sa), Ruderal (Rud), Parasite (Para).

2.3. Data Analysis

The data collected in the field were analyzed using SPSS software version 20.0 for descriptive statistics.

3. Results

The ethnobotanical data and the ecological characters of listed plants are presented in the table below.

Table 1. *Ethnobotanical data and ecological characters of listed plants.*

N°	Scientific Names (Famillies)	Local names	Used parts	Mode of preparation	Ecological characteristics			
					M.T	B.T	P.D	Biotope
01	*Albizia adianthifolia* (Schum) W.Wight (*Leguminosae*)	Sela	Leaves	Infusion	T	Msph	At	F
02	*Allium cepa* L. (*Amaryllidaceae*)	Litungulu	Bulb	Maceration	PG	Gb	Paléo	Cult
03	*Allium sativum* L. (Amaryllidaceae)	Aïl	Bulb	Maceration	PG	Gb	Paléo	Cult
04	*Alchornea cordifolia* (Schumach. & Thonn.) Müll.Arg. (Euphorbiaceae)	Liboto	Leaves	Decoction	Shrub	Mcph	At	F
05	*Mangifera indica* L. (*Anacardiaceae*)	Manga	Leaves	Decoction	T	Msph	Pan	Cult
06	*Spondias mombin* L. (*Anacardiaceae*)	Mingenge	Leaves	Decoction	T	Msph	Pan	F
07	*Annona senegalensis* Pers. (*Annonaceae*)	Mulolo	Bark	Decoction	Shrub	Mcph	GC	F
08	*Xylopia aethiopica* (Dunal) A.Rich. (*Annonaceae*)	Nsombo	Bark	Decoction	T	Mgph	At	F
09	*Catharanthus roseus (L.) G.Don (*Apocynaceae*)*	Kilungu	Leaves	Decoction	PG	Chdr	Sarco	Cult
10	*Rauvolfia vomitoria* Afzel. *(Apocynaceae)*	Isumbululu	Bark	Decoction	Shrub	Mcph	Méso	F
11	*Raphia gentiliana* De Wild. (*Arecaceae*)	Bankulu	Fruit	Decoction	T	Msph	Sarco	Cult
12	*Calendula officinalis* L. (*Compositae*)	Mundudi ndudi	Bark	Decoction	AG	Thdr	Bal	Cosmo
13	*Vernonia amygdalina* Delile (*Compositae*)	Nkulu nkasi	Bark Leaves	Decoction	Shrub	Mcph	At	Fa
14	*Gymnanthemum coloratum* (Willd.) H.Rob. & B.Kahn	Kilulukunju	Bark, Leaves	Decoction	Shrub	Msph	Pan	F
15	*Betula pendula Roth* (*Betulaceae)*	-	Leaves	Infusion	T	Msph	Sarco	Cult
16	*Brassica oleracea L.* (Brassicaceae)	Choux	Leaves	Decoction	AG	Thdr	Bal	Cult
17	Carica papaya L. (Caricaceae)	Payipayi	Leaves	Infusion	A	Msph	Pan	Cult
18	*Senna alata (L.) Roxb.* (Leguminosae)	Mbau mbau	Leaves	Decoction	Shrub	Nph	Pan	Rud
19	*Senna timoriensis* (DC.) H.S.Irwin & Barneby (Leguminosae)	Mapalata	Leaves	Decoction	T	Nph	Bal	Rud
20	*Dysphania ambrosioides* (L.) Mosyakin & Clemants (Amaranthaceae)	Nkasi kindongo	Bark	Maceration	AG	Thd	Scl	Cult
21	*Terminalia chebula* Retz. *(*Combretaceae*)*	Madame	Leaves	Infusion	T	McPh	Paléo	Cult
22	*Costus phyllocephalus* K.Schum. (Costaceae)	Minkeni	Leaves, Root	Decoction	PG	Grh	GC	F
23	*Momordica charantia* L. (Cucurbitaceae)	Lumbusu	Leaves, fruit	Infusion	PG	Thgr	GC	Cult
24	*Dioscorea praehensilis* Benth. (Dioscoreaceae)	Bandindi	Leaves	Decoction	L	Ggr	Pte	F
25	*Bridelia ferruginea* Benth. (Phyllanthaceae)	Kimuindu	Root	Decoction	T	Mcph	At	Sav.
26	*Maprounea africana* Müll.Arg. (Euphorbiaceae)	Kiseyi kiseyi	Leaves	Infusion	Shrub	MsPh	AT	F
27	*Caesalpinia bonduc (L.)* Roxb. *(*Leguminosae*)*	-	Leaves	Decoction	T	Phgr	Bal	Cult
28	*Cyamopsis tetragonoloba* (L.) Taub. (Leguminosae)	-	Leaves	Decoction	AG	chdr	Pan	Cult
29	*Erythrina abyssinica* DC.*(*Leguminosae*)*	Kikumbu	Leaves	Decoction	T	Msph	Bal	Sav
30	*Pterocarpus marsupium* Roxb. (Leguminosae)	Nkila	Leaves	Decoction	T	Msph	Pte	F
31	*Pterocarpus angolensis* DC. (Leguminosae)	Nkula	Seed	Decoction	T	Msph	At	F
32	*Trigonella foenum-graecum* L. (Leguminosae)	Kiwaya	Leaves	Maceration	AG	Thdr	Pan	Cult
33	*Scorodophloeus zenkeri* Harms (Leguminosae)	Kiwaya	Leaves	Decoction	T	MsPh	BG	F
34	*Phaseolus vulgaris* L. (Leguminosae)	Haricot	Leaves, Bark	Decoction	AG	Chgr	Cos	Cult
35	*Gnetum africanum* Welw. (Gnetaceae).	Mfumbwa	Leaves	Decoction	PG	Phgr	CGC	F
36	*Ocimum gratissimum* L. (Lamiaceae)	Dinsunsu nsusudinene	Leaves	Infusion	Shrub	Chd	Paléo	Sav.
37	*Ocimum minimum* L. (Lamiaceae)	Dinsunsu nsusu difioti	Leaves	Infusion	AG	Chd	Scl	Cult
38	*Persea americana Mill.* (Lauraceae)	Divoka	Leaves	Decoction	T	Msph	Pan	F, Cult
49	*Viscum album* L. (Santalaceae)	-	Leaves	Infusion	Shrub	Thd	Sarco	Para
40	*Punica granatum* L. (Lythraceae)	-	Flower	Infusion	T	Msph	Sarco	Cult
41	*Abelmoschus esculentus* (L.) Moench (Malvaceae)	Dongo dongo	Fruit	Maceration	AG	Thd	Pan	Cult
42	*Urena lobata* L. (Malvaceae)	Pungala	Leaves, root	Decoction	PG	NPh	Pan	Cult
43	*Azadirachta indica* A.Juss. (Meliaceae)	Nime	Leaves	Decoction	T	Mcph	Sarco	Cult
44	*Ficus benghalensis* L. (Moraceae)	Nsanda	leaves, bark	Infusion	T	Mcph	Sarco	Cult
45	*Moringa oleifera* Lam. (Moringaceae)	Moringa	Leaves	Decoction	T	Msph	Pan	Cult
46	*Eucalyptus globulus* Labill. (Myrtaceae)	Bikalubitus	Leaves	Infusion	T	Msph	Sarco	Cult
47	*Psidium guajava* L. (Myrtaceae)	Mapela	Leaves	Decoction	T	MsPh	Pan	Cult
48	*Syzygium cumini* (L.) Skeels (Myrtaceae)	Telezia	Seed	Infusion	T	MsPh	Sarco	Cult
49	*Olea europaea subsp. cuspidata* (Wall. & G.Don)	Olivier	Leaves	Infusion	T	Msph	Sarco	Cult

N°	Scientific Names (Famillies)	Local names	Used parts	Mode of preparation	Ecological characteristics			
					M.T	B.T	P.D	Biotope
	Cif. (Oleaceae).							
50	*Millettia eetveldeana* (Micheli) Hauman (Leguminosae)	Mbwenge	Root	Decoction	T	Msph	Ballo	F
51	*Millettia laurentii De Wild.* (Leguminosae)	Kiboto	Bark	Decoction	T	Msph	BGC	F
52	*Sesamum indicum* L. (Pedaliaceae)	Wangila	Seed	Decoction	AG	Thd	GC	Cult
53	*Phyllanthus amarus Schumach. & Thonn.(*Phyllanthaceae*)*	-	Leaves	Infusion	PG	NPh	Pal	Rud
54	*Phyllanthus niruri L. (*Phyllanthaceae*)*	-	Seed	Infusion	PG	Chdr	Bal	Rud
55	*Cymbopogon citratus* (DC.) Stapf (Poaceae)	Sinda	Leaves	Infusion	PG	Hcès	AT	Cult
56	*Cymbopogon densiflorus* (Steud.) Stapf (Poaceae)	Lusangu sangu	Leaves	Infusion	PG	Hcès	Hc	Cult
57	*Oryza sativa* L. (Poaceae).	Loso	Leaves	Decoction	PG	Thd	Pan	Cult
58	*Polygala acicularis* Oliv. (Polygalaceae)	Lunsambi nsambi	Leaves	Decoction	Shrub	NPh	AT	Cult
59	*Morinda lucida* Benth (Rubiaceae)	Nsiki	Leaves	Decoction	T	Msph	GC	PF
60	*Morinda morindoides* (Baker) Milne-Redh. (Rubiaceae)	Kongobololo	Leaves	Decoction	L	Lph	At	SF
61	*Sarcocephalus pobeguinii Hua ex Pobég. (*Rubiaceae*)*	Kenga kimansa	Leaves	Decoction	T	Mcph	Sarco	W
62	*Sarcocephalus latifolius (Sm.) E.A.Bruce* (Rubiaceae)	Kilolo	Leaves	Decoction	T	MsPh	GC	F
63	*Solanum aethiopicum* L. (Solanaceae)	Solo	Fruit	Decoction	AG	Thdr	At	Cult
64	*Solanum melongena* L. (Solanaceae)	Mbolongo	Fruit	Decoction	AG	Thdr	Pan	Cult
65	*Schwenckia americana L. (*Solanaceae*).*	Ntumpu, dinkombo	Leaves	Decoction	AG	Chdr	Aa	Sav
66	*Cola acuminata* (P.Beauv.) Schott & Endl.(Malvaceae)	Makasu	Leaves	Decoction	T	Msph	GC	PF
67	*Lippia multiflora* Moldenke (Verbenaceae)	Bulukutu	Leaves	Infusion	T	Chdr	AT	Sav
68	*Vitex madiensis* Oliv. (Lamiaceae)	Kifilu	Root, Leaves	Infusion	T	MsPh	GSZ	Sav

Legend: M. T: Morphological types, B. T: Biological types, P. D: Phytogeographic distribution, Tree (T), Annual grass (AG), Perennial grass (PG), Liana (L), Rhizome (Rh), Bulbous geophyte (Gbu), Rhizomant geophyte (Grh), Tuberous geophyte (Gtu), Mesophanerophyte (Msph), Megaphanerophyte (Mgph), Microphanerophyte (Mcph), Nanophanerophyte (Nph), Lying Phanerophyte (Lph), Upright Phanophyte (Thd), Climbing Theophyte, Pantropical (Pan), afro-tropical, Sarcochores (Sarc), guinea-congolian (GC), Balochores (Bal), Palio-tropical (Pal), pterochores (Pte), cosmopolitan (HC), Sclerochorous (Scl), Lower Guinea (BG), Central Guinea-Congolian (CGC), African-American (Aa), Lower Guinea-Congolian (BGC), Guinean and Zambézian (GS-Z), Crop (Crop), Forest (F), Savannah (Sa), Ruderal (Rud), Parasite (Para), Cosmopolite (Cosmo), Fallow (Fa), Primary Forest (PF), Secondary Forest (SF), Woodland (W).

4. Discussion

The different families of listed plants are presented in figure

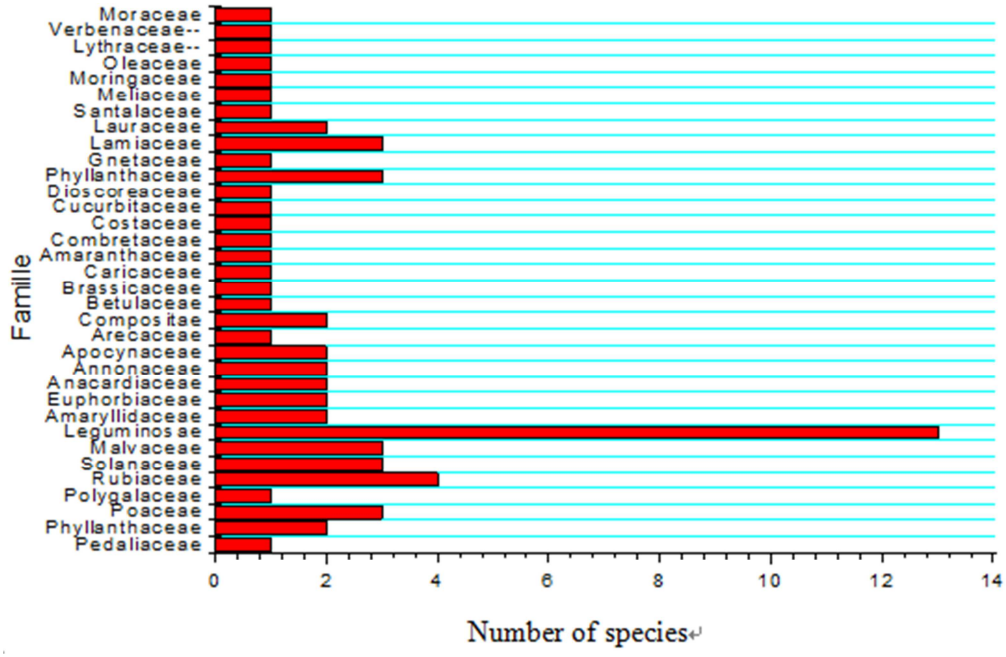

Figure 1. *Different families of inventoried plants.*

In total, 34 families were listed, and of these families, the Leguminosae has 38.2% of species of this area, followed by Rubiaceae (11.76%), Poaceae, Solanaceae, Malvaceae, Phyllanthaceae, and Lamiaceae (8.82% each) respectively. These results are similar to recent data indicating that Leguminosae is one of the six most represented angiosperms families [20].

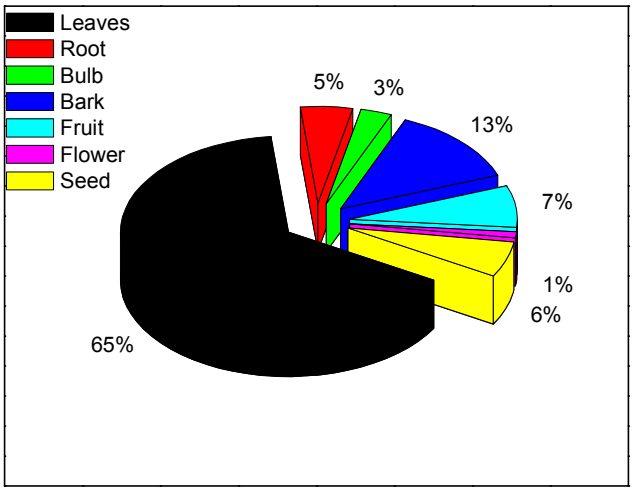

Figure 2. *Different parts used.*

From the investigation, it was shown that the leaves are the most commonly used part in the treatment of diabetes. The bark was indicated at the second position (13%) followed by fruit (7%), seed (6%) and root (5%) respectively. At last, it was observed that flower and bulb are the least used. These findings are similar to Ndjouondo *et al.* [21] who reported that the leaves were the most commonly used part in traditional medicine. On the other side, others researchers reported that the root was much used [10, 18].

The different modes of recipes preparation are presented in the figure below.

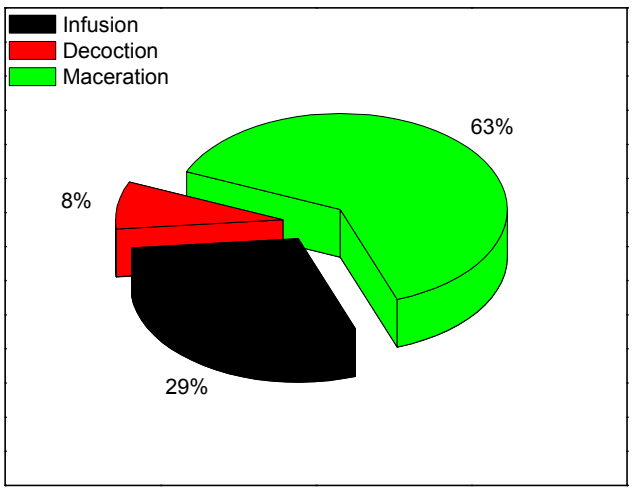

Figure 3. *Different modes of recipes preparation.*

As demonstrated above, three different modes for recipe preparation of medicinal plants were reported. The maceration (63%) was reported as the most commonly used method, followed by the infusion (29%) and decoction (8%).

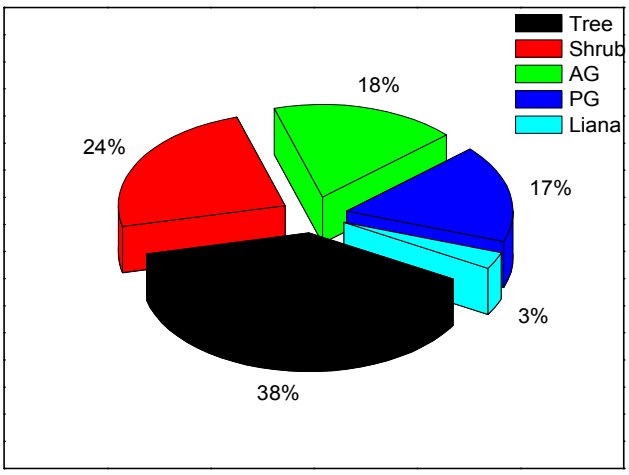

Figure 4. *Morphological types of listed plants.*

Trees present a higher value (38%), followed by shrubs (24%), annual grass and perennial grass (18% each) knowing that liana species are less represented in this study area. This predominance of trees shows that this ecosystem is more species-diversified than other non-forest ecosystems [10, 22].

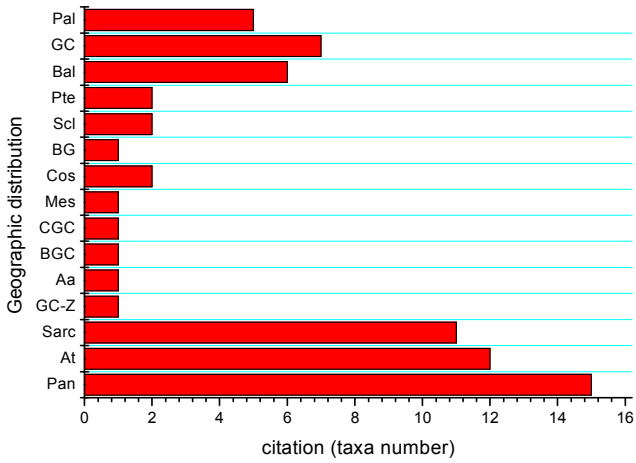

Figure 5. *Phytogeographical distribution of plants.*

Figure 5 shows that the listed species are widely distributed throughout the world. We observe a predominance of panetropical species (Pan: 23%), followed by afro-tropical species (At: 19%), Sarcochores (Sarc: 17%), guinea-congolian (GC: 10%), Balochores (Bal: 9%), Paliotropical (Pal: 7%), pterochores (Pte), cosmopolitans (HC) and sclerochores (Scl) 3% each. While Lower Guinea (BG), Central Guinea-Congolian (CGC), African Americans (Aa), Lower Guinea-Congolian (BGC), Guinea-Congolian and Zambezians (GS-Z) each represent only 1%. These results show that these plant taxa are widely distributed in Africa. Thus, their protection should be a concerted effort at the national, sub-regional and regional levels, based on a certain political will.

The biological types of plants are presented in the figure below.

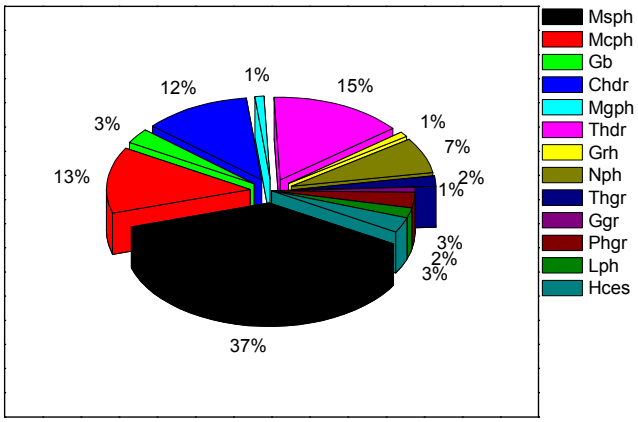

Figure 6. *Biological types of plants.*

It appears that the antidiabetic plants listed belong to 13 biological types, the most common of which are mesophanerophytes (Msph: 37%), followed by therophytes (Thdr: 15), microphanerophytes (Mcph: 13%), erect camphytes (Chdr: 12%), nanophanerophyte (Nph: 7%), bulbous geophytes (Gb), climbing phanerophytes (Phgr) and cespiteux grasses (Hces) each account for 3%. While megaphanerophytes (Mgph), rhizomatous geophytes (Grh), climbing geophytes (Ggr) and vine phanerophytes are almost at the trace state (1% each).

The predominance of phanerophytes among listed taxa is a characteristic of tropical regions and may also correlate with the fact that their tissues have been claimed to synthesize secondary bioactive metabolites [10, 23-24].

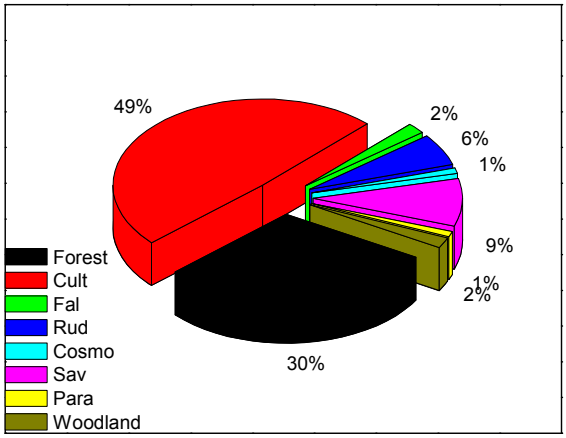

Figure 7. *Types of biotopes of listed plants.*

The biotope type of the inventoried plant species has been classified as follows: forest, savannah, ruderal habitat, fallow, woodland, parasitic plants, cultivated plants and cosmopolitan plants. About 49.3% are cultivated plants followed by forest (30.4%), savannah (8.7%) and ruderal (5.8%) plants. While fallow, cosmopolitan, parasitic and undergrowth plants represent 1.45% each. This predominance of the cultivated type can be justified by the fact that the population seeks to cultivate various useful plants close to their habitations.

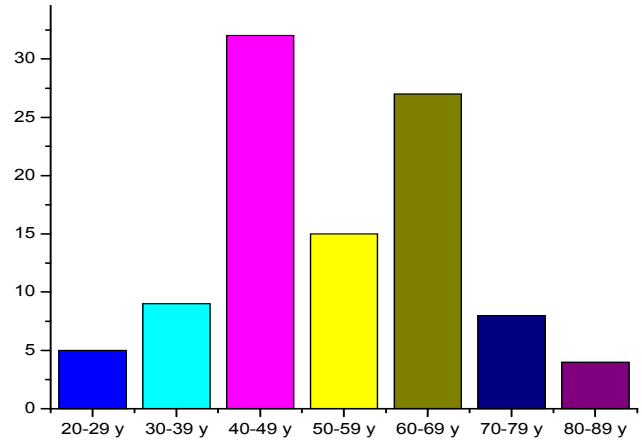

Figure 8. *Distribution of respondents according to age.*

This figure shows that the use of medicinal plants is almost universal but concentrated between 40-49 years (32%), followed by the age group 60-69 years. Intakes for the elderly (20-39 years) are the least common.

The elderly are mostly heads of households and represent family authority. Mulwele et al. [25], who inventoried medicinal plants marketed in the various markets of Kwango, reported that 60 out of the 75 respondents were over 40 years of age. These elderly people are also expected to provide more reliable information, as they hold much of the ancestral knowledge that is part of the oral tradition [26]. Anyinam [27] shows that knowledge of the properties and uses of medicinal plants is acquired through a long experience accumulated and transmitted from one generation to the next. Benkhnigue *et al.* [28] support this view by showing that experience with age is the main source of information at the local level about the use of plants in traditional medicine.

The distribution of respondents according to sex (gender) is presented in the figure below.

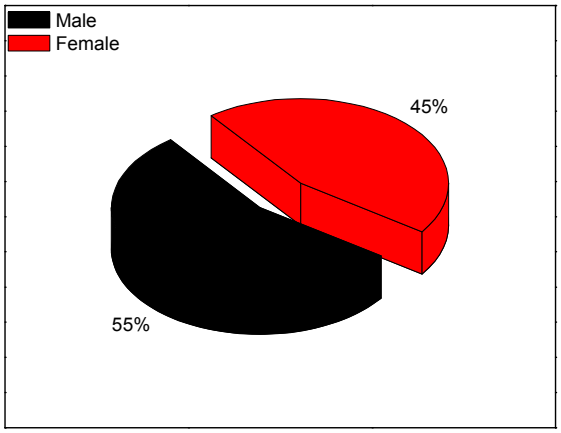

Figure 9. *Distribution of respondents according to gender.*

From the above figure, it was observed that 545% were male and 45% were female. Mulwele *et al.* [25] reported that female use medicinal plants much more in Douala, Cameroon.

The figure below presents the distribution of respondents according to their education level.

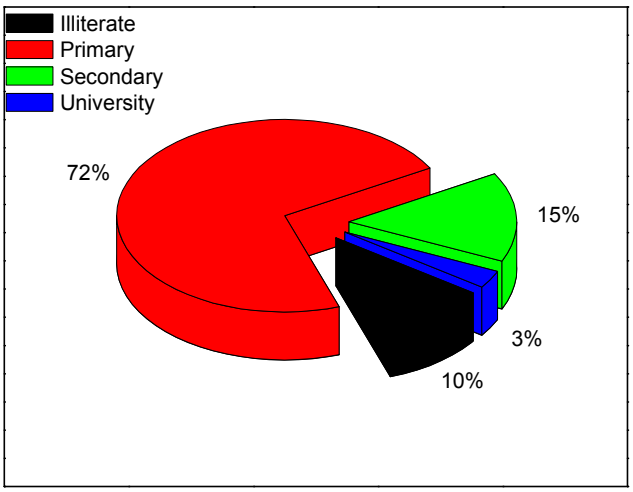

Figure 10. *Distribution of respondents according education level.*

The above figure showed that 72% of medicinal plant users have been enrolled in primary school, 15% have reached secondary school and 3% have reached university level. There were about 10% of people with no education at the school level. These results corroborate with the work of Mulwele *et al.* [25] and Kahouadji [29] showed that riparian surveyed in Douala have a level of education at least equivalent to that of primary school.

5. Conclusion

The purpose of this study was to identify the anti-diabetic medicinal plants used in Kinshasa, Kongo Central and Kwango provinces.

The results obtained in this study show that: The inventoried medicinal flora is made up of 68 species which are divided into 34 families of 58 genera; the leaf is the most commonly used part in the treatment of diabetes (65.3%) and maceration is the most commonly used method of preparation; the use of medicinal plants is reported in almost all age groups from 20-89 years of age but with a predominance among people aged 40-49 years; Trees and phanerophyte species predominate in the flora studied; the majority of users of these medicinal plants have a primary level of education.

It would be desirable that in-depth phytochemical and pharmacological studies be carried out on these plants with a view to their scientific validation.

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