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Ethnopharmacological survey of plants used against diabetes in Bukavu city (D.R. Congo)

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Abstract
Diabetes mellitus is a public health problem in many countries. It is a poorly understood disease and costly for the individual, family and community. Plants are used in most of developing countries to remedy to this disease. An ethnopharmacological survey was conducted in Bukavu city (Democratic Republic of Congo) in order to identify the plant species used in traditional medicine for the treatment of diabetes mellitus and their mode of preparation. Forty-seven healers belonging to several different ethnic groups were interviewed concerning the plant species used in traditional treatment of diabetes mellitus in Bukavu city. Thirty plant species belonging to nineteen botanical families were identified. The decoction has been the main mode of preparation (80%); oral ingestion was the major route of administration (approximately 97% of cases). More than 35% of plant used parts for the preparation of recipes were the leaves. Other ingredients were added to the recipes, usually either to improve taste to increase shelf life and to potentiate the action. Most of the recipes listed, approximately 73,3% (22 out of 30 species) are reported in the literature and for most of them, the evidence of their effectiveness is demonstrated. Phytochemical, pharmacological and toxicological studies are in progress.

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1. Introduction

Diabetes mellitus is a public health problem in many countries and is a major cause of premature morbidity. It is a poorly understood disease and costly for the individual, family and community. Diabetes mellitus is a complex disease as well as by pathophysiological mechanisms or by its genetic determinism and the genesis of its complications. This is a heterogeneous group of metabolic diseases whose major characteristic is chronic hyperglycemia resulting from a defect in the secretion or action of insulin, or both abnormalities (Bouxid, 2012; Grimaldi, 2009). So, diabetes is a metabolic disease characterized by a disorder in the regulation of carbohydrate metabolism leading to hyperglycemia. It is widely distributed in the world, 5-7% of the world population are affected (Weaber, 2007).

According to Boyle et al. (2001), people with diabetes worldwide will reach 300 million by 2025 and more. WHO predicts global increase of the prevalence of diabetes, mostly type 2, one hundred thirty-five million in 1995 to 300 million in 2025 (Gning et al., 2007). The International Diabetes Federation (IDF) estimated that the prevalence rate currently ranges between 0.5% and 0.3%, could grow to 9.5% with a total of fifteen million diabetic patients in Africa in 2025 (IDF, 2009)

Despite the use of oral hypoglycemic as anti-diabetic drugs, diabetes and its complications remains the major problem in the therapeutic management of patients. The success in the search of bioactive molecules would be of great interest, since conventional drugs, including insulin and oral hypoglycemic agents such as sulfonylurea produce adverse effects after regular administration (Nissenand and Wolski, 2007).

The use of herbal medicine to treat diabetes is an indigenous practice in Africa (Mbodj, 2003). In fact, according to the World Health Organization (WHO) estimation, more than 80% of the African populations use medicine and traditional pharmacopoeia for their health care. The African continent boasts a large number of medicinal plant species. Indeed, on the 300,000 identified plant species on the planet, more than 200,000 live in the African tropical forest and have medicinal properties (Sofowora, 1993). The DR Congo harbors half of the continent rainforest. Thus, medicinal plants are the key product for Congolese population. Both urban and rural populations depend on medicinal plants for their health care need, so the search for anti-diabetic herbal drugs from traditional pharmacopeia is a new challenge.

The aim of this study was to perform the survey of plants used against diabetes mellitus in D.R Congo in order to preserve the cultural heritage of Congolese ethnomedicine by documenting information on anti-diabetic plants.

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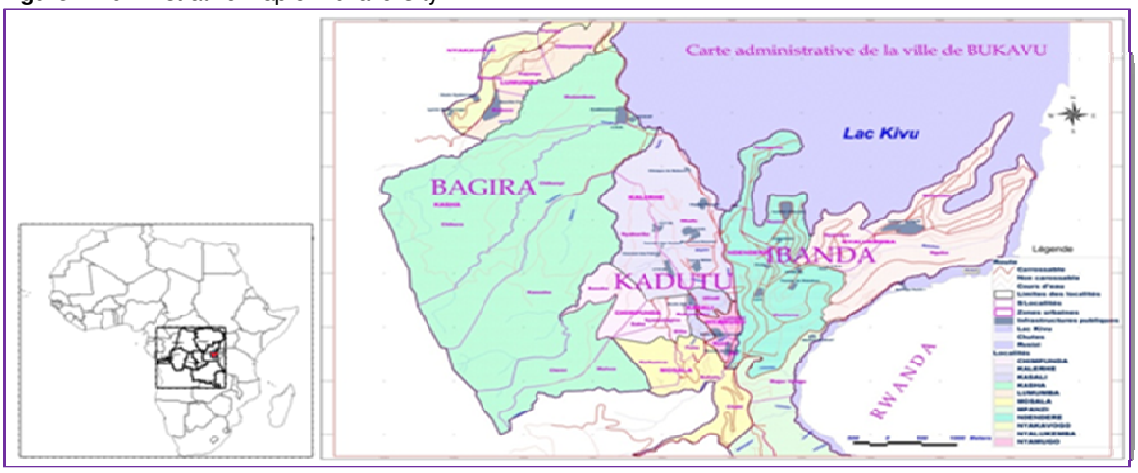
2. Experimental

*2.1 S*tudy area.

The ethnopharmacological investigations were conducted in Bukavu, the capital of the province of South Kivu in the eastern part of DR Congo (Fig. 1)

Figure1: Administrative map of Bukavu City



Bukavu is located between 2° 3'S latitude and 28° 50'E longitude. Its average altitude is 1600 m. This city is located in a humid tropical climate with short dry season (3-4 months) and the temperature is weighted by the presence of Kivu Lake (Chamaa et al., 1981). The climate of Bukavu city is regulated geographically by the equator line and altitude. According to its humid climate, the city of Bukavu would have forest vegetation. The presence of relict species of deciduous seasonal forests in some places is bio indicator vegetation.

In 2009, the population of Bukavu was estimated to 619,161 inhabitants.

2.2 Ethnopharmacological survey

Ethno-botanical surveys were conducted for 9 months, from June 2009 to March 2010.

The method used is essentially based on asking questions directly to respondents, using a questionnaire previously established. A total of forty-seven traditional healers of various ethnic groups were interviewed.

The data checklist for Ethnobotanical field work focuses on the following elements (Adjanohou et al.1983):

- Identification of the traditional healer(name, age, address, quality)
- Plant data (scientific and vernacular names, village survey, parts used, method of harvesting stage or degree and organ development)
- Plant therapy data : methods of preparation and administration (transaction and pharmaceutical form, concentration of the organ dose, frequency of taking, instructions and any other associated plants)
- Other indications (diseases and symptoms, physiological effects, against indications and side effects).

Collected plants were indentified at the Laboratory of Ecology and Plant Resources Management, Faculty of Science, Official University of Bukavu, D.R Congo. Vouchers specimens are on deposit at the same laboratory.

3. Results and Discussion

The present study has inventoried thirty plants species belonging to nineteen botanical families used in the treatment of diabetes in Bukavu. All belong to the branch Magnoliophyta, they were listed in alphabetical order of their families and species followed by other information. These plants are presented in Table1. The following details were recorded: morphological types, biological types, habitat types and phytogeographic distribution. The following morphological types were inventoried: Trees (T), shrubs (Sh), sub-shrubs (Ssh), Liana (L), annual herb (Ah), Vicace herb (Vh) and perennial herb (Ph).

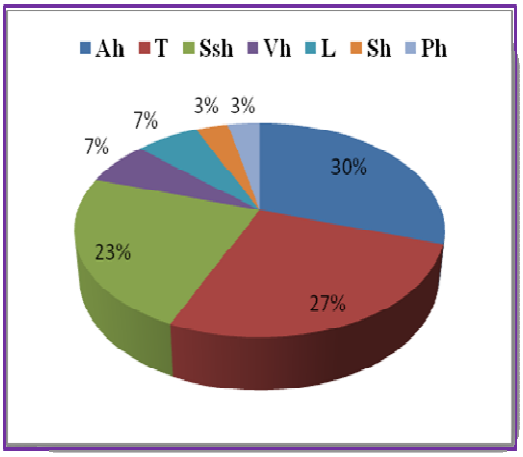
Biological types below have been selected: Mesophanerophytes (MsPh), Microphanerophytes (McPh), Nanophanerophytes (NPh), Chamephytes (Ch), Therophytes (Th) and Geophytes (G). Habitat types are distributed as following: Forest (For), Cultured (Cult), Ruderal (Rud) and Fallow (Fal).

Phytogeographic distribution has been recorded as following: Cosmopolitan (Cosm.), Pantropical (Pan), Paleotropical (Pal), Afro-tropical (Af tr), Guinean (Guin), Centroguinean (C-Guin), Afro-american (Af am), American tropical (Am tr), and Afro-madagascar (Af ma) (Nyakabua, 1982; Katemo et al, 2012).

3.1 Morphological types

The Ethnopharmacological survey of plants used against diabetes in Bukavu city shows that ligneous plants represent about 50% of species (T=27% and Ssh 23%) while herbaceous and liana represent 50% (fig. 2).

Figure 2: Weighted morphologic types



3.2 Biological types

The inventory of 30 species of plants used in Bukavu, management of diabetes has led us to identify biological types as follows (Fig.3): NPh, MCPH, Th, Ch, G and MSPH. It is clear that the MCPH are dominant, representing 30% of this species inventoried all followed NPh (27%). MSPH are the minority (3%).

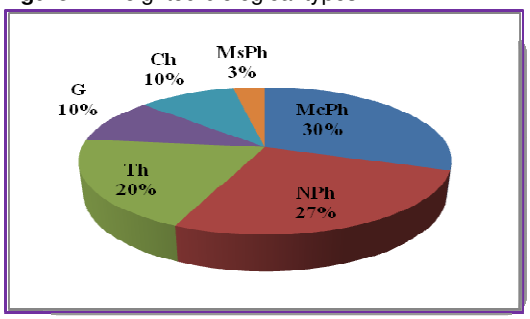
Table 1: Plants used against diabetes in Bukavu city (D.R. Congo)

Families	Plants species	Used parts	Treated diseases (symptoms)	Vernacular name (language)	Preparation mode	Frequency (%)
Alliaceae	*Allium cepa* L. Vh, G, Cult Cosm.	Bulbs	Hypertension, skin infections rheumatism, bronchitis and arthritis	Itunguru (Mashi) Litunguru (Swahili)	Decoction (Oral ingestion)	25^{a} 35^{b}
	Allium sativum L. Vh, G, Cult Cosm.	Bulbs	Hypertension, hypotension intestinal parasites, infection and stimulating immunity	Itunguru sumu (Mashi) Litunguru Sumo (Swahili)	Decoction Pounding (Oral ingestion)	45^{a} 23^{b}
Anacardiaceae	*Mangifera indica* L. T, McPh, Cult, Pan.	Bark	Urinary tract infections, amibiasis Tooth decay and constipation	Mwembe (Mashi) Hembe (Swahili)	Decoction (Oral ingestion)	$27^{a}19^{b}$
Apocyanaceae	*Catharanthus roseus* (L.) G. Don. Ssh, NPh, Cult,Pan (Am tr)	Leaves	Headache, insomnia and asthma	Vinka (Swahili)	Decoction (Oral ingestion)	52^{a} 42^{b}
	Vinca minor L. Ssh, NPh,Cult., Pan (Am tr).	Leaves and roots	Cancer, diarrhea, Vomiting, malaria, Amibiasis, dizziness, gonorrhea, migraine, headache hemorrhage, gastro-enteritis and Colitis	Vinka nyeupe (Swahili)	Decoction (Oral ingestion)	24^{a} 8^{b}
Asteraceae	*Artemisia absinthium* L. Ah,NPh, Cult, Pal.	Leafy stem	Disorders of gallbladder dyspepsia, painful and irregular rules	Kanyambuba Kalume (Mashi)	Decoction (Oral ingestion)	5^{a} 16^{b}
	Artemisia annua L. Ah,NPh, Cult., Pal.	Leafy stem	Malaria, cough, headache, menstrual pain and hypo andacidity		Decoction (Oral ingestion)	2^{a} 0^{b}
	Bidens pilosa L. Ah, Th, Rud.Pan.	Leafy stem	Cough	Kashisha (Swahili) Nyassa (Kilega) Igishokoro (Kinyarwanda)	Decoction (Oral ingestion)	11^{a} 4^{b}
	Tithonia diversifolia (Hem)A.Cray. Ssh, NPh, Rud, Pan (Am tr)	Leaves	Amibiasis	Cilula (Mashi)	Decoction (Oral ingestion)	13^{a} 0^{b}
	Vernonia amygdalina Del Sh, McPh, Fal, Af tr.	Leaves	Malaria	Mubirizi (Mashi)	Decoction (Oral ingestion)	22^{a} 8^{b}
Basellaceae	*Basella alba* L. Ah, Th, Cult Pan.	Leaves	Stomachhache	Nderema (Mashi), ndelama (Kilega)	Decoction (Oral ingestion)	15^{a} 0^{b}
Bignoniaceae	*Spathodea campanulata* Beauv. T, McPh, Cult, Af tr (Guin)	Bark	Urinary tract infections and Gonorrhea	Cifulula, Langalanga (Mashi), Mbalimbali (Swahili)	Decoction (Oral and parenteral feeding)	32^{a} 8^{b}
Caricaceae	*Carica papaya* L. T, McPh, Cult., Pan (Am tr).	Leaves and fruits	Constipation, amibiasis, other intestinal worms, painful colitis and irritable bowel and menstruals pain	Ipapayi (Mashi), papayi (Swahili)	Decoction (Oral ingestion)	13^{a} 0^{b}
Fabaceae	*Albizia grandibracteata* (Taub.) T, McPh, For, Guin.	Bark	Filariasis, skin and urinary tract infections	Mushebeye (M), kahunda (Kibembe), mushebele(Kinyarwanda)	Decoction (Oral ingestion)	8^{a} 4b*
	Caesalpinia decapetala Alston T, NPh, Cult, Pan.	Leaves	Amibiasis, hypo acidity and Enuresis	Lurhé (Mashi)	Infusion (Oral ingestion)	15^{a} 4b*
	Cassia occidentalis L. Ssh, NPh, Cult, Pan.	Leaves	Spleen, liver and menstrual Spain	Mushegamanjoka, Kashegema (Mashi)	Decoction (Oral ingestion)	$25^{a}16^{b}$

	Indigofera arrecta Hochst. ex A. Rich Ah, McPh, Fal, Pan.	Roots	Malaria and fractures	Kasholoza, Kavunanfuka (Mashi), abwebwe (Kibembe) musholotsi (Kihavu), umwikokori (N) and umusoro (Kinyarwanda.)	A chew (Chewing)	10^a 0^b
Hypericaceae	*Harungana madagascariensis* Lama. ex Poir. T, McPh, For, Af ma.	Leaves	-	Kadwamuko (Mashi), Ndura (Swahili) Ndimu (Mashi), Chunghwa	Decoction (Oral ingestion) Extraction	9^a 16^b
Lamiaceae	*Salvia officinalis* L. Ssh, Ch, Cul, Pan (Am tr).	Leaves	Menstrual disorders, vaginal irritation, excessive sweating, oropharyngeal disorders and digestive		Infusion (Oral ingestion)	13^a 12^b
	Phaseolus vulgaris L. Ah, Th, Cult, Cosm (Am tr).	Green pods	Arthritis, kidney stones, gout and rheumatism	Cishimbo, mukenji (Mashi) maharagwe (Swahili)	Decoction (Oral ingestion)	25^a 12^b
Lauraceae	*Persea americana* Mill. T, MsPh, Cult, Pan (Am tr).	Leaves and fruit Wines	Constipation, kidney and various pains	Ivoka (Mashi), avocati (Swahili)	Decoction (Oral ingestion)	30^a 19^b
Malvaceae	*Sida acuta* Burm. f. Ssh, Ch, Rud, Pan.	Bark	Prostate	Mudundu (Mashi)	Decoction (Rectal)	15^a 0^b
Piperaceae	*Piper guineense* Schum. and Thonn. L, McPh, For, Guin.	Bark	Cough, sore throat, spasms gastro intestinal disorders, diarrhea and vomiting	Njilulu (Mashi)	Decoction (Oral ingestion)	10^a 4^b
Poaceae	*Zea mays* L. Ah, Th, Cult. Cosm (Am tr).	Filaments of Stamens	Hypertension, edema, arthritis, nephritis, diarrhea and kidneystones	Muhindi (Swahili), Cigonji (Mashi)	Decoction (Oral ingestion)	25^a 0^b
Rutaceae	*Citrus limon* (L.) Burm. f. T,McPh, Cult, Pan.	Fruits	Cough, sore throat and stomach pain	Ndimu (Mashi), Chunghwa kali (Swahili).	Extraction (Oral ingestion)	9^a 16^b
Solanaceae	*Solanum americanum* Miller Ah, Th, Rud, Cosm.	Fresh leaves	Stomach, itching and rashes and various	Mulunda (Mashi)	Decoction (Oral ingestion)	6^a 12^b
	Physalis peruviana L. Ah, Th, Rud, Pan.	Aerial part	Colic in children, spleen, malaria and inflammation.	Mbuma (Mashi), mbupuru (Kinande), Umuhire (Kinyarwada)	Decoction (Oral ingestion)	13^a 0^b
Urticacaea	*Urtica dioica* L. Ah, Ch, Fal. C-Guin.	Leaves	Hepatitis, rheumatism, edema, uterine bleeding	Chachingi (Mashi)	Tincture (Alcohol 70 °) and infusion (Oral ingestion)	18^a 12^b
Verbenaceae	*Stachytarpheta indica* (L.) Vahl Ssh, NPh, Cult, Pan.	Leafy stem	-	"Insulin"(Swahili)	Decoction (Oral ingestion)	35^a 4^b
Xanthror-rhoeaceae	*Aloe* sp.Ph, G, Cult, Pan.	Aerial part	Burns and abscesses	Kizimia Muliro (Mashi)	Expression	26^a 16^b

a. Frequency of citation by traditional healers
b. Frequency of citation in the literature
* Name of specie not precise.

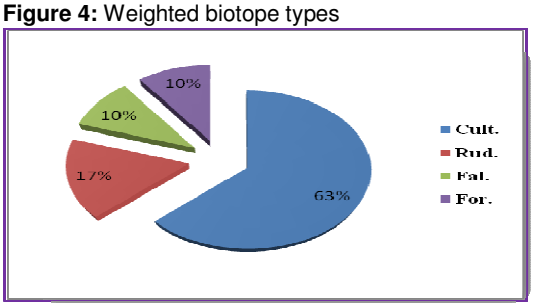
Figure 2: Weighted biological types



3.3 Biotope types

The species used in folk medicine against diabetes in Bukavu city (Fig. 4) is found in different biotopes. Crop is the main habitat type with 63% of used species followed by ruderals (17%)> Forest and fallow species represent each 10%.

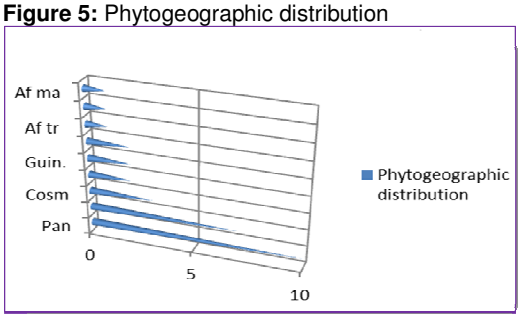
Figure 4: Weighted biotope types



3.4 Phytogeographic distribution

The analysis of the phytogeographic distribution of the inventoried flora against diabetes in Bukavu city (Fig. 5) indicates the predominance of Pan (33.3%) followed respectively by Pan (Am tr) (23.3%), Cosm (10%), Guin (6.6%), Cosm (6.6%), and Pal (6.6%). Af tr, C-Guin, Af tr (Guin) and Af ma represent only 3.3% for each phytogeographic distribution.

Figure 5: Phytogeographic distribution



3.5 Floristic analysis

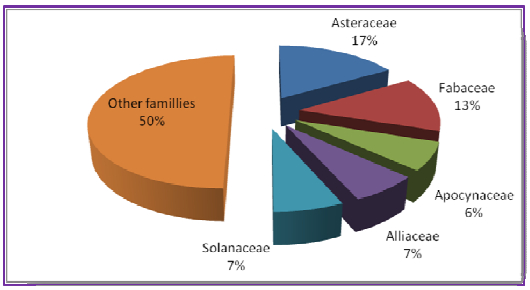
From a biological point of view, there exists among the inventoried medicinal plants: 9 annual herb (30%), the 30 collected species are woody plants (18 phanerophytes), most of them (19 species) being cultivated species while the pan tropical distribution was predominant (10 species).¶

3.6 Characteristic of plant material

3.6.1 Botanical families involved in the study

Figure 6 shows the distribution of inventoried species according to their botanical families

Figure 6: Distribution of species according to their botanical families



This figure shows that on thirty plant species collected, five species (17%) belong to the Asteraceae family; followed by Fabaceae family (12%), Solanaceae and Alliaceae families (7%) each, Apocynaceae family (6%) and others grouped families (50%).

3.6.2 Modality and harvest stage or degree of development of the plant organs

The harvest terms depend on one traditional healer to another. In general, for the most of the traditional healers, the harvest is time independent (53.33%). However, some of them prefer to collect in the morning and in the evening, the others prefer only amorning harvest. Concerning the stage or degree of development of the plant organ, the case of organ harvested at maturity was the most frequent (66.66%). This does not exclude the possibility of harvesting young organs (23.33%), the organs outside the flowering period, etc.

3.6.3 The parts used

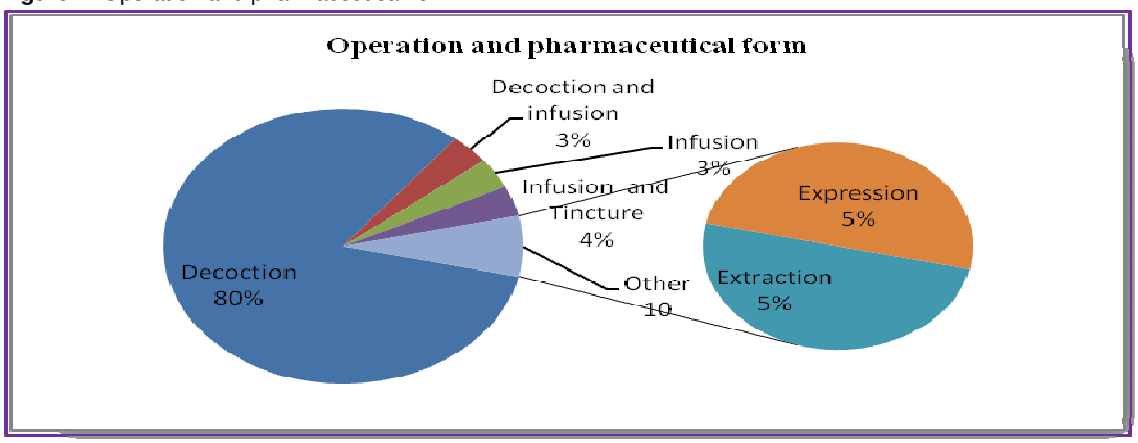
The leaves were the most parts (organs) cited during the survey (over 35%). Sometimes apart from the leaves, leafy stems and fruits were also cited. The use of leaves could be justified by the abundance of chemical groups that they contain. In fact, the main site of synthesis of plant secondary metabolites is leaf, leaves are than, the most used organs in traditional medicine (Katemo et al, 2012; Mpiana et al, 2010).

3.7 Methods of preparation and administration

3.7.1 Operation and pharmaceutical form.

Operation and pharmaceutical form of recipes are summarized in the figure 7.

Figure 7: Operation and pharmaceutical form



The decoction is the main mode of preparation of remedies. This was reported for 24 of 30 plants species (80%). Water is the solvent used for the preparation of drugs. These results are in arguments with previous reported works. In fact, main secondary metabolites responsible of biological activities are soluble in water that is the cheapest solvent that can be used by traditional healers (Mpiana et al, 2010; Mpiana et al, 2012; Katemo et al, 2012).

3.7.2 Concentration of the organ and dose frequency per dose

Careful observation and discussions with traditional healers during exploratory surveys can demonstrate that the concept of dose and dosage exists in the traditional therapeutic system. Somme imperfections seen seem to be no more injurious to health than those likely to occur in other forms of medicine. Thus, a good level of judicious use of poisonous plants is observed. It was also noticed a frequent use of utensils of modern life for the administration of medications. So, the simple fact of not finding the same frequency in regimens of traditional medicine is not sufficient to incorrectly conclude to the non-existence of African medicine dosages (Adjanohou et al. 1983).

In general, the organ concentration, the dose, the frequency or period of consuming the product are dependent on prescriber to another. In most cases, the drug is prescribed in 2 or 3 doses; usually the dosage is a standard glass of about 150 ml.

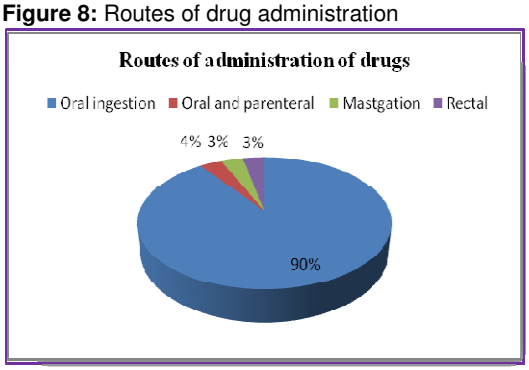
3.7.3 Instructions and other related drugs

Figure 8 gives routes of drugs administration.

As it can be found in this figure, oral ingestion is the most mode of administration (90%).

In order to improve the taste, to increase shelf life, make better absorption of active ingredients and to potentiate the action, one or more plant products were associated during preparation. Thus, a given recipe could include a range of products from different plants. Alpha

Figure 8: Routes of drug administration



3.7.4 Other indications

The same plant species may be prescribed for many diseases. This is the case for *Urtica dioica, Catharanthus roseus, Artemisia annua, Vinca minor, Piper guineense and Physalis peruviana*, etc. In fact, some of these plants were also found to possess therapeutic value for fighting against sickle cell disease and malaria (Mpiana et al., 2007; Mpiana et al., 2010; Mpiana et al., 2012; Ngbolua et al., 2011).

3.8 Similarities of Use

According to the results of the Table 1, several species listed have already proved their effectiveness in the treatment of diabetes as well as in the Democratic Republic of Congo, in Africa and in other continents.

Moswa et al., (2005), reported that 37 plant species belonging to 23 different families are used as antidiabetic in Congolese traditional

medicine. Among them, 9 cited (24.32%) were also identified among the 30 plant species reported in the present study. It is in particular the case of: *Catharanthus roseus, Vernonia amygdalina, Cassia occidentalis, Harungana madagascariensis, Allium cepa, Allium sativum, Mangifera indica, Piper guineense and Albizia sp*., Pamplona (2001) reported the antihyperglycaemic effects respectively the leaves of *Urtica dioica, Salvia officinalis* and *Vinca minor* and the pods *Phaseolus vulgaris*, bulbs of *Allium cepa* and *Allium sativum*. The glucose lowering effects were attributed to glucoquine and to the arginine for which, the blood glucose lowering effects were found to be similar to that of the glucoquine (insulin plant). Plant species such as *Allium cepa, Allium sativum, Catharanthus roseus* and *Caesalpinia sp*. (Pousset, 1989; Tossou et al,1995), were also reported to have hypoglycemic properties. However, *Allium cepa*, *Catharanthus roseus* and *Solanum* sp. were also found on the list of twenty species used in Nigeria traditional medicine in the treatment of diabetes mellitus (Iwu, 1993). A laboratory bioassay conducted in Morocco has highlighted the hypoglycemic activity of *Artemisia herba-alba* (Hmamouche et al., 1995). The study conducted in South Kivu on medicinal plants and veterinary Bushi by Defour (1995) confirms the use of *Persea americana, Phaseolus vulgaris, Allium cepa, Urtica dioica, Solanum americanum* and *Catharanthus roseus* in the treatment of diabetes among Bushi people.

Catharanthus roseus, Allium cepa, Persea americana, Allium sativum, Phaseolus vulgaris, Vinca minor, Vernonia amygdalina, Cassia occidentalis, Solanum americanum, Aloe ssp. Caesalpinia ssp., Vernonia spp., Bidens pilosa, Mangifera indica, Artemissia absinthium, *Spathodea campanulata* and Stachytarpheta indica (L.) Valil were cited by several others authors (Katemo et al., 2012 ; Kasali et al., 2012 ; Bavurhe et al., 2012 ; Apeme et al., 2011; Marhegeko, 2010; Benkhnigue, 2010-2011 and Fézan et al.,2008). This indicates that such plants can effectively possess an antidiabetic effect and their phytochemical and pharmacological effect must be studied.

Conclusion

The contribution of medicinal plants in the resolution of health problems became undeniable. Scarcity or absence of health centers in the villages, the slow service in hospitals, unavailability and high cost of pharmaceuticals, are some factors that can increase awareness of the importance of traditional medicine.

Diabetes is a disease in which the old classic symptoms are well known by the majority of healers or healers interviewed. The main part of plants recorded 73.3% (22 out of 30 species) are listed in the literature and for most, the evidence of their effectiveness is demonstrated.

The present study was undertaken in the prospects of implementation of initiatives that could lead, in the future, to the manufacture of improved traditional medicines for the treatment of diabetes. Phytochemical, pharmacological and toxicological studies of some of these plants are in progress.

Author's Contribution and Competing Interests

The authors declare that this work is original and there are no competing interests.

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