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**Research article**

# Ethno-botanical survey of plant species used in traditional medicine in Kinshasa city (Democratic Republic of the Congo)

**Koto-te-Nyiwa Ngbolua[1], Shetonde O. Mihigo[2], Clément Inkoto Liyongo[1], Masengo C. Ashande[3], Damien S.T. Tshibangu[2], Ben Gbolo Zoawe[1], Robijaona Baholy[2], Pierre Ruphin Fatiany[4,5] and Pius T. Mpiana[2,*]**

[1]Département de Biologie, Faculté des Sciences, Université de Kinshasa, B.P. 190, Kinshasa XI, RD Congo
[2]Département de Chimie, Faculté des Sciences, Université de Kinshasa, B.P. 190, Kinshasa XI, RD Congo
[3]Comité scientifique pour la recherche, le développement et la conservation de la biodiversité (CSB), Faculté des Sciences, Université de Kinshasa, B.P. 190, Kinshasa XI, RD Congo
[4]Département de Génie chimique, Ecole supérieure Polytechnique, B.P. 1500, Université d'Antananarivo, 101 Antananarivo, Madagascar
[5]Institut Malgache de Recherches Appliquées, Avarabohitra Itaosy lot AVB 77, B.P. 3833, 102 Antananarivo, Madagascar

*Corresponding Author: ptmpiana@yahoo.fr
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**Abstract:** An ethno-botanical survey was conducted among traditional healers and medicinal plant vendors in Kinshasa city (DR Congo) in order to identify plant species used in traditional medicine to treat common diseases, with the aim of documenting, preserving, and sustaining this valuable traditional knowledge. Surveys were conducted from February to April 2014 among 50 medicinal plant vendors, in five markets (Limete, Makala, Matete, Mont-Ngafula, and Ngaba). The education level of the majority of informants was secondary school. The age of the informants ranged between 20 and 68 years. Cited plant species were collected and identified at the herbarium of the Faculty of Science, University of Kinshasa. Their ecological status was also determined. The 50 informants used 32 plant species (belonging to 22 families and 30 genera) in traditional medicine in Kinshasa. Their herbal remedies were administered as aqueous decoctions against 38 different diseases. It was found that ligneous, savanna, phanerophyte, and pantropical-type plant species were predominant both in numbers of species as well as in citations. Roots were the most used plant part, and malaria and haemorrhoids were the most treated diseases.
**Keywords:** Traditional healers - Medicinal plant vendors - Sustainable management.

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## INTRODUCTION

In Africa, over 80% of the population relies on medicinal plants for their primary healthcare (WHO 2002, Ngbolua *et al.* 2011a,b, Fatiany *et al.* 2013, Fatiany *et al.* 2014a). There is limited access to modern medicine and the facilities are poor (Kabena *et al*. 2015, Ngbolua *et al*., 2014b,c,d). The Democratic Republic of the Congo (DRC) is one of the most plant diversity rich countries in Africa, and contains 47% plant diversity of the African rain forests (Debroux *et al*. 2007). Although traditional medicines are used throughout the country and across all cultures, only a small percentage of its flora has been subject to detailed phytochemical and toxicological evaluations (Mihigo 2005, Mpiana *et al*. 2007, Ngbolua 2012).

Thus, and in order to document, preserve, and sustain this traditional and valuable knowledge; several studies on the uses of traditional medicines in the country have been undertaken; in such provinces, tribes and cities as Kisangani city (Wome 1985, Katemo *et al*. 2012), Bobangi city (Ilumbe 2006) and Bikoro city (Ilumbe 2010). Likewise, some studies have also been conducted in Kinshasa city on plant species used to treat infectious and pathologies (like malaria and amibiasis) and for intimate female hygiene in selected markets


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(Ngbolua *et al*. 2014d, Kabena *et al*. 2015). In addition, recent rural population displacement due to war has caused important changes in the demographic profile of Kinshasa city (by rural migration, the number of Kinshasa inhabitant passed from 8 million to about 12 million people these fifteen last years), making it a necessity to update the knowledge and uses of medicinal plants in this city by surveying markets no previously included. It should be noted that in Kinshasa city as in other central Africa capitals, people occupy the municipalities according to their ethnic origin. Thus, the present study would make it possible to identify plant species not previously included in the former studies or to know the new use of the existing plant species. Indeed, a same plant can be used for different uses in different parts of the country by others ethnic groups (Ngbolua *et al*. 2011a, b).

The main objective of the present study was to make an updated inventory of plant species used in traditional medicine in Kinshasa city, particularly in Limete, Makala, Matete, Mont-Ngafula, and Ngaba municipalities. The specific objectives consisted of a botanical survey and identification of medicinal plants, their ecological study, and a preliminary phytochemical screening of those plant species for which a higher informant consensus factor was obtained.

## MATERIALS AND METHODS

### Study Area

*Geographic location:* Kinshasa is located between 4˚18' and 4˚25' S latitude, and between 15˚15' and 15˚22' E longitude. The city's boundaries are the Bandundu province that covers the North and East parts, the Bas-Congo province in South, and the Republic of Congo in the West. Its average altitude is 360 m above sea level**.**

*Soils:* According to Sys (1961), Kinshasa soils belong to the following classification. Order: Kaolisoils, Sub-order: Hydro-xerokaolisoils, and the group of Arenoferrals.

*Hydrography:* Kinshasa is located along the Congo River, and its hydrology network comprises local and allogenic rivers of which the most important are Ndjili, Nsele, and Mai-Ndombe.

*Climate:* In Kinshasa, the climate is warm, tropical humid, of the Aw4-type following Köppen classification (Bultot 1954). Two seasons alternate in Kinshasa, the dry season (June to September) and the rainyseason (October to May).

*Vegetation:* The original vegetation in Kinshasa consisted of forests, savannas, and the aquatic and semi-aquatic valleys of the Congo River and Pool Malebo. Studies on the African vegetation by White (1979) and Troupin (1966) have successively placed the DR Congo in the following sub-divisions: Guineo-Congolese region, Congo-basin domain and the Congo-Zambezian transition Sector.

*Ethnography:* Kinshasa city is a town with a heterogeneous population; inhabitants originate from many different ethnic groups. The 450 tribes present can be grouped into four predominant linguistic groups: Lingala, Tshiluba, Swahili and Kikongo. However, the indigenous population of this city consists of Teke and Humbu (Mokengo 2011).

### Ethno-Botanical survey

Ethno-botanical information about the plant species reported in this study was obtained by interviewing traditional healers and medicinal plant vendors in Kinshasa city (Bajpai *et al.* 2016). Surveys were conducted from February to April 2014, in five markets (*viz*. Limete, Makala, Matete, Mont-Ngafula, and Ngaba). A total of 50 traditional healers and medicinal plant vendors were interviewed,on a voluntary basis. Local language Lingala was used during anthropological interviews.

The study followed principles laid out in the Declaration of Helsinki (Ngbolua *et al*. 2013, Ngbolua *et al*. 2014d, Fatiany *et al*. 2014b, Fatiany *et al.* 2015). The research was performed according to the principles laid out in the Nagoya protocol (Coomb 2005, Buck 2011, Soares 2011). Required permission was obtained from the Ministry of Environment of the DRC in order to collect plant samples and conduct non-commercial research on Congolese medicinal plants.

The questionnaires were divided into three sections: (i) personal information (including name, age, sex, marital status, studies level and profession) and reason of the recourse to the traditional medicine; (ii) vegetable material (including plant vernacular and scientific names); (iii) traditional medicine practice (including knowledge of diseases and symptoms, diagnosis of disease, plant used parts, state of the plant materials, modes of preparation and conservation of recipes, route of the administration and dose of recipes, results of the treatments of diseases, knowledge about toxic plants). Collected plants were identified using taxonomic keys and by comparison of

voucher specimens with specimens deposited at the herbarium of the "Institut National d'Etudes et Recherches Agronomiques" (INERA), located at the Faculty of Science of the University of Kinshasa.


**Figure 1. A,** One of the authors (Clément Inkoto Liyongo) interviewing a medicinal plant vendor in a local market; **B,** Some medicinal plant species in the local marked.

**Data analyses**

The reported medicinal plants species were classified on the basis of their ecological characteristics, including morphological type, biological type, habitat type, and phytogeographic distribution. The following parameters were used for additional data analyses: number of plant species, number of recipes, number of citations, and number of informants, the informant consensus factor, usage value, confirmation indices and the usage value agreement. The usage value agreement (UVAs) which is an index of evaluating the medicinal and cultural value of plants was calculated using the following formula:

$$UVAs = UVs * CIs \quad (1) \qquad [\text{with } UVs = \frac{\sum_{i=1}^{n} Uis}{Ns} \quad (2) \qquad \text{and } CIs = \frac{Ni}{Nt} (3)].$$

Where, UVs : usage value, Where, CIs : confirmation indices, Uis : number of usage of the species s quoted by informant i, Ns : number of species, Ni : number of informants having cited this species, Nt : total number of informants.

The usage value agreement is defined as the relative importance of each plant type known to be used as herbal medicine. This index is useful in identifying plants with the highest use (most frequently mentioned) in the treatment of a disease with a given informant consensus factor value (ICF) (Ilumbe *et al.* 2014). ICF (ranging from 0 to 1) is used to deduce the homogeneity in the information on the use of a specific plant to treat a certain disease. The informant consensus factor value was calculated using the following formula:

$$ICF = \frac{Nc - Nps}{Nc - 1} (4)$$

Where, Nc is the number of plant use reports (citation number) per each category (disease) and Nps, number of plant species (taxa used).

A high value of ICF (close to 1) shows that a reduced number of plant species are quoted by a large number of informants for a specific type of treatment; indicating the consistence of the use of this medicine (Alsarhan et *al*. 2012).

**RESULTS AND DISCUSSION**

The 50 informants in the ethno-botanical survey used 32 plant species (belonging to 22 families and 30 genera) in traditional medicine in Kinshasa city/DRC.

**Floristic Study**

Medicinal plants reported during the course of this investigation were characterized for their morphological type, biological type, habitat type and phytogeographic distribution (Fig. 2–5).

*Morphological type*

The morphological classification (Fig. 2) of medicinal plant species was carried out as previously reported (Katemo *et al*. 2012, Ngbolua *et al*. 2013, Ngbolua *et al*. 2014d); they were classified as follows: trees, shrubs, lianas, annual herbs, perennial herbs and under-shrubs.

The 32 reported medicinal plant species consist of mainly shrubs that account for 31% of the total. The next important morphological type was made of perennial herbs (22%), followed by lianas and trees: 16% each, under-shrubs (9%) and annual herbs (6%).

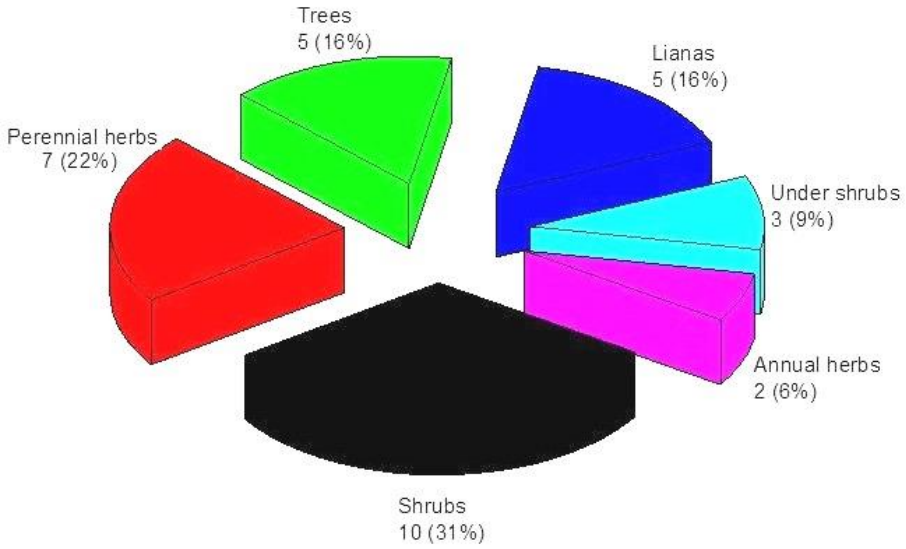


**Figure 2.** Morphological types of the inventoried medicinal plant species.

The high number of shrubs in traditional medicine practices in Kinshasa can be justified by the fact that the city is located in a savanna-type ecosystem. In addition, it has been argued that the increased use of savanna plant species in traditional recipes may be due to them having a relatively higher content of potentially bioactive metabolites (Bitsindou 1996).

*Biological type*

The biological types have been classified as follows: mesophanerophytes, microphanerophytes, nanophanerophytes, lianescent phanerophytes, dressed therophytes, climbing herbs, bulbous geophytes or climbing therophytes. Theinventoried plantspecies were found to belong to various biological types (Fig. 3), including the microphanerophytes (28%), nanophanerophytes (22%), lianescentphanerophytes (16%), mesophanerophytes (13%), climbing herbs (13%), dressed therophytes(3%), climbing therophytes (3%) and bulbous geophytes (3%).

The predominance of phanerophytes among the reported plantspecies is a characteristic of tropical regions and may also correlate to the ease with which their tissues have been claimed to synthesise bioactive secondary metabolites (Betti et *al*. 2013, Ngbolua et *al*. 2014d). In addition, the perennial character of the reported species supports their high availability and usage by the communities (Ilumbe et *al*. 2014).

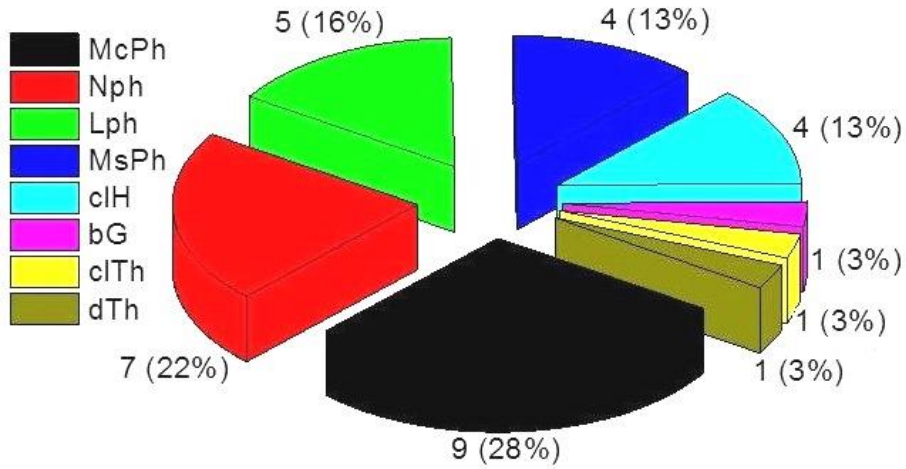


**Figure 3.** Biological types of the inventoried medicinal plants. [**McPh,** microphanerophytes; **Nph,** nanophanerophytes; **Lph,** lianescent phanerophytes; **MsPh,** mesophanerophytes; **clH,** climbing herbs; **bG,** bulbous geophytes; **clTh,** climbing therophytes; **dTh,** dressed therophytes]

*Habitat type*

The biotopes of the inventoried plant species were classified as follows: forest, savanna (including wooded grassland), ruderal habitat, farmland (including fallow land) and cultivated plants. About 47% of the reported

plant species were found to be of forest type, while the cultivated plants-type, the savanna-type, the ruderal type and the farmland type plants accounted for 31, 13, 6 and 3%, respectively (Fig. 4).

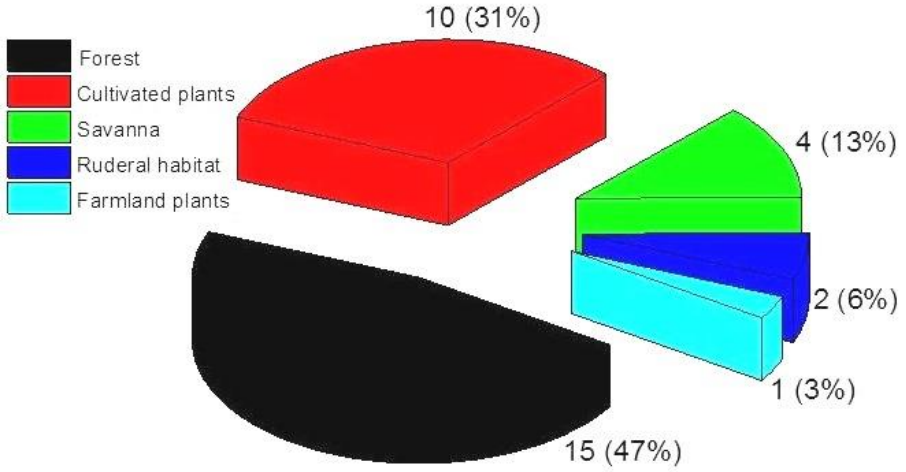


**Figure 4.** Biotope types of the inventoried medicinal plants.

*Phytogeographic distribution*

The phytogeographic distribution (Fig. 5) of species was recorded according to Central Africa's chorographic subdivisions (White 1979, Denys 1980, White 1983) as follows: Guinea-Congolese, Afro-tropical, pan-tropical, Guinean, paleo-tropical and Afro-Malagasyplant species.

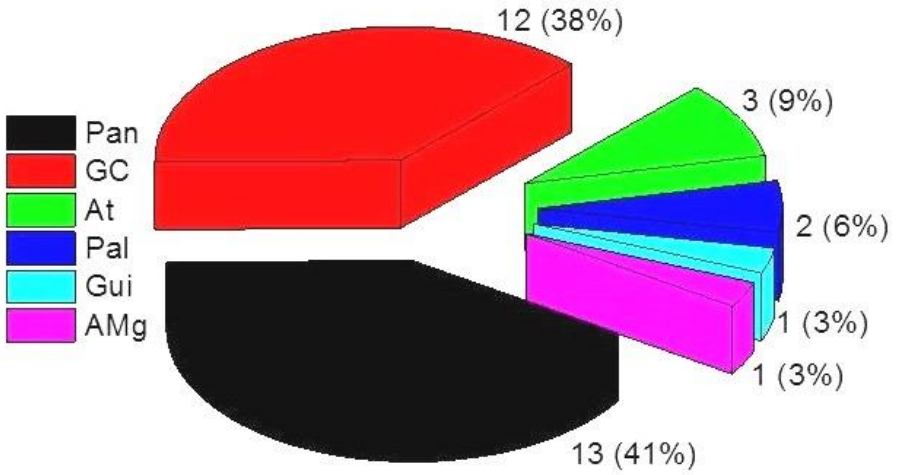


**Figure 5.** Phytogeographic distribution of the inventoried medicinal plants**.** [**GC,** Guinea-Congolese; **At,** Afro-tropical; **Pan,** pan-tropical; **Guin,** Guinean; **Pal,** paleo-tropical; **AMg,** Afro-Malagasy plant species]

It was found that the reported medicinal plant species are widely distributed and belong to the following distribution classes: pantropical (41%), Guinea-Congolese (37%), Afrotropical (9%), Paleo-tropical (6%), Guinean and Afro-Malagasy: 3% each. The reported 32 medicinal plant species are presented in Appendix with their scientific names, ecological characteristics, vernacular names, treated diseases, used plant parts, and the dosage.

**Plant species usage and other considerations**

The number of plant species per treated disease, the number of citations, and the informant consensus factor are given in table 1.

**Table 1.** Treated diseases and Informant consensus factors.

| Treated diseases | Number of plant species | Number of citations | Informant consensus factor |
|---|---|---|---|
| Anemia | 1 | 1 | 0 |
| Backache | 7 | 9 | 0.25 |
| Buruli ulcer | 1 | 1 | 0 |
| Cough | 1 | 1 | 0 |

| | | | |
|---|---|---|---|
| Cyst | 1 | 1 | 0 |
| Demons | 1 | 1 | 0 |
| Diabetes | 2 | 4 | 0.67 |
| Diarrhorea | 1 | 1 | 0 |
| Fever | 1 | 1 | 0 |
| Fibroma/Fibroid | 1 | 1 | 0 |
| Gastritis | 2 | 4 | 0.67 |
| Gonorrhea | 1 | 1 | 0 |
| Guts | 2 | 2 | 0 |
| Haemorroids | 10 | 12 | 0.81 |
| Headache | 2 | 4 | 0.67 |
| Hepatitis | 1 | 1 | 0 |
| Hernia | 2 | 2 | 0 |
| High blood pressure | 2 | 3 | 0.5 |
| Infections | 1 | 2 | 1 |
| Kidney | 1 | 2 | 1 |
| Lack of appetite | 1 | 1 | 0 |
| Madness | 1 | 1 | 0 |
| Malaria | 8 | 13 | 0.42 |
| Myoma | 2 | 2 | 0 |
| Pain | 1 | 1 | 0 |
| Poison | 1 | 1 | 0 |
| Pruritus | 1 | 1 | 0 |
| Rheumatism | 1 | 1 | 0 |
| Sexualimpairment | 2 | 3 | 0.5 |
| Shock | 1 | 1 | 0 |
| Sinusitis | 1 | 1 | 0 |
| Skin diseases | 1 | 1 | 0 |
| Sore throat | 1 | 2 | 1 |
| Sterility | 1 | 1 | 0 |
| Tinea | 2 | 2 | 0 |
| Toothache | 1 | 1 | 0 |
| Typhoidfever | 3 | 3 | 0 |
| Yellow fever | 3 | 3 | 0 |

**Note:** Informant consensus factor: 1 = 100% Consensus; 0.5-0.9 = High Consensus; 0.1-0.4: Weak Consensus; 0: Absence of consensus (Disagreement).

Out of 38 recorded diseases, malaria was the most cited as having been treated, and it was followed by haemorrhoids and backache. These three diseases are treated using 33% of the reported/inventoried medicinal plant species. Infection, sore throat and kidney complicationsare treated by all the informants (maximum consensus). On the other hand, *Annona senegalensis, Aframomum alboviolaceum* and *Mondia whitei*, were cited by every informant (high usage value agreement).This can indicate that these plants are probably the most active. So, these three plant species were submitted to a preliminary phytochemical screening in order to have an idea on their secondary metabolites profile. Qualitative analysis showed that the three plants species contain saponins and leuco-anthocyanins but lack flavonoids. In addition, anthocyanins and quinones were absent in *Aframomum alboviolaceum* and *Annona senegalensis*, respectively; but were present in *Mondia whitei*. These secondary metabolites are known for their bioactivity. Indeed, saponins are well known for their haemolytic inducing properties (Bruneton 1999). Anthocyanins were reported to possess antisickling activity while quinones were reported to have antiplasmodial and cytotoxic activities *in vitro* (Fatiany et *al*. 2013, Mpiana et *al*. 2008).

Diabetes, gastritis and headache also recorded a high (67%) consensus among the informants. *Morinda morindoides, Annona senegalensis, Garcinia kola, Aframomum alboviolaceum, Nicotiana tabacum, Mondia whitei,* and *Sida rhombifolia* were the reported plant species used in the treatment of these diseases. The treatment of high blood pressure and sexual impairment recorded a moderate (50%) consensus; high blood pressure was treated using *Aframomum alboviolaceum* and *Sida rhombifolia,* while sexual impairment was treated by *Oldenlandia herbacea* and *Heinsia crinita*. Haemorroids, backache and malaria haven't recorded a maximum (100%) consensus between informants despite the fact that they were claimed to being treated with a high number of medicinal plant species (10, 7 and 8 plant species respectively).

Moreover, the recorded medicinal plant species were studied for their confirmation indices, the usage values and the usage value agreements. Eighteen plant species were found to have higher (≥ 1.5) usage values, and these are *Morinda morindoides, Mondia whitei, Aframomum alboviolaceum, Alchornea cordifolia, Cogniauxia podolaena, Crossopteryx febrifuga, Cymbopogon citratus, Nicotiana tabacum, Hyptis suaveolens, Capsicum annuum, Harungana madagascariensis, Sarcocephalus latifolius, Gladiolus gregarius, Gongronema latifolium, Annona senegalensis, Senna alata, Sida rhombifolia, Selaginella myosurus* (Table 2). Indeed, il was reported that medicinal plant species having an UV ≥ 1.5 has great cultural and medicinal values (Ilumbe *et al*. 2014).

**Table 2.** Reported plant species and their usage value agreements (UVAs).

| N° | Plant species (Family) | NR | NI | NC | UV | CI | UVA |
|---|---|---|---|---|---|---|---|
| **1** | *Aframomum alboviolaceum* (Ridl.) K.Schum. (Zingiberaceae) | 10 | 4 | 6 | 1.5 | 0.08 | 0.12 |
| **2** | *Aframomum melegueta* (Roscoe) K.Schum. (Zingiberaceae) | 5 | 3 | 2 | 0.67 | 0.06 | 0.04 |
| **3** | *Alchornea cordifolia* (Schumach. &Thonn.) Müll. Arg.(Euphorbiaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.02 |
| **4** | *Aloe buettneri*A.Berger (Xanthorrhoeaceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **5** | *Ananas comosus* (L.) Merr. (Bromeliaceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **6** | *Annona senegalensis* Pers. (Annonaceae) | 11 | 3 | 7 | 2.3 | 0.06 | 0.14 |
| **7** | *Capsicum annuum* L.(Solanaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.02 |
| **8** | *Citrus limon* (L.) Burm.f. (Rutaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **9** | *Cogniauxia podolaena*Baill. (Cucurbitaceae) | 3 | 1 | 3 | 3.0 | 0.02 | 0.06 |
| **10** | *Crossopteryx febrifuga* (Afzel.) Benth. (Rubiaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **11** | *Cymbopogon citrates* (DC.) Stapf(Poaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **12** | *Erythrina abyssinica* Lam. ex DC. (Leguminosae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **13** | *Garcinia kola* Heckel (Clusiaceae) | 6 | 3 | 3 | 1.0 | 0.06 | 0.06 |
| **14** | *Gladiolus gregarius*Welw. ex Baker (Iridaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **15** | *Gongronema latifolium* Benth. (Apocynaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **16** | *Harungana madagascariensis* Lam. ex. Poir (Hypericaceae) | 2 | 1 | 2 | 1.0 | 0.02 | 0.04 |
| **17** | *Heinsia crinita* (Afzel.) G.Taylor (Rubiaceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **18** | *Hyptis suaveolens* (L.) Poit. (Lamiaceae) | 3 | 1 | 3 | 3.0 | 0.02 | 0.06 |
| **19** | *Millettia eetveldeana* (Micheli) Hauman (Leguminosae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **20** | *Mondia whitei* (Hook.f.) Skeels (Apocynaceae) | 9 | 4 | 7 | 0.8 | 0.08 | 0.14 |
| **21** | *Morinda morindoides* (Baker) Milne-Redh. (Rubiaceae) | 3 | 1 | 3 | 3.0 | 0.02 | 0.06 |
| **22** | *Nicotiana tabacum* L.(Solanaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **23** | *Oldenlandia affinis* (Roem. &Schult.) DC.(Rubiaceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **24** | *Oryza sativa* L. (Poaceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **25** | *Persea americana* Mill. (Lauraceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **26** | *Piper nigrum* L.(Piperaceae) | 2 | 2 | 1 | 0.5 | 0.04 | 0.02 |
| **27** | *Quassia Africana* (Baill.) Baill. (Simaroubaceae) | 6 | 4 | 3 | 0.8 | 0.08 | 0.06 |
| **28** | *Sarcocephalus latifolius* (Sm.) E.A. Bruce (Rubiaceae) | 2 | 2 | 2 | 1.0 | 0.04 | 0.04 |
| **29** | *Securidaca longipedunculata* Fresen. (Polygalaceae) | 1 | 1 | 1 | 1.0 | 0.02 | 0.02 |
| **30** | *Selaginella myosurus* (Sw.) Alston (Selaginellaceae) | 2 | 1 | 2 | 2.0 | 0.02 | 0.04 |
| **31** | *Senna alata* (L.) Roxb. (Leguminosae) | 3 | 2 | 3 | 1.5 | 0.04 | 0.06 |
| **32** | *Sida rhombifolia*L. (Malvaceae) | 4 | 1 | 4 | 4.0 | 0.02 | 0.08 |

**Note:** NR = Number of recipes, NI = Number of informants, NC = Number of citations, UV = Usage value, CI = Confirmation indices, UVA = Usage value agreement.

Considering the confirmation indices, six plantspecies (*Mondia whitei, Aframomum alboviolaceum, Quassia africana, Aframomum melegueta, Garcinia kola* and *Annona senegalensis*) seemed to be the most used, their confirmation indices values being higher than 0.5. However, combining the usage values and the confirmation indices, only three plant species (*Aframomum alboviolaceum, Annona senegalensis* and *Mondia whitei*) had the highest usage value agreements (>0.1) and are the most used to treat/cure diseases.

As for the informants, they were studied for their age, sex, marital status, profession, and education level. It was found that they ranged between 20–68 years (Fig. 6). Among the informants, females were the most abundant (68%), while the majority (82%) of informants attended secondary school.

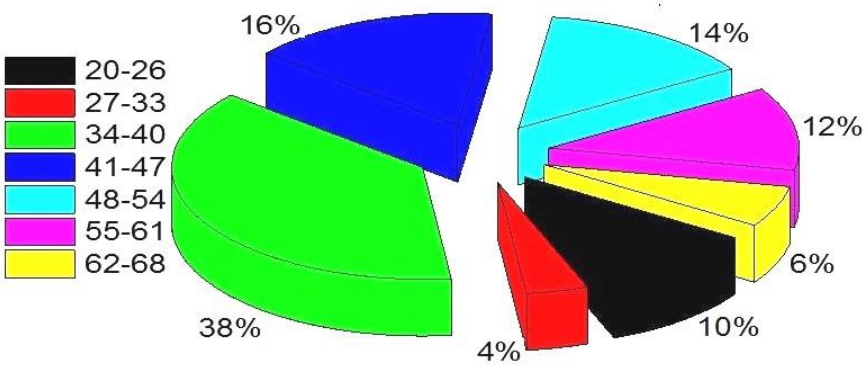


**Figure 6.** Age-based distribution of informants.

Informants having 34–40 years of age were the most abundant; 38% of the informants were in this age class. Other informant's ages ranged between 41–47 (16%), 48–54 (14%), 55–61 (12%), 20–26 (10%), 62–68 (6%) and 27–33 years (4%). It was also found that younger (20–34 years: 14%) people used medicinal plants more than the elders (62–68 years: 6%). t-Student test confirmed that this difference was statistically different at a probability threshold of 0.05 ($p < 0.05$). Of the informants, 90% were married and 10% were single.

Regarding the professional activities of the informants, medicinal plant vendors (44%) and traditional healers (44%) were the most common informants, followed by electricians (4%), house wives (4%), students (2%), and aestheticians (4%) (Fig. 7).

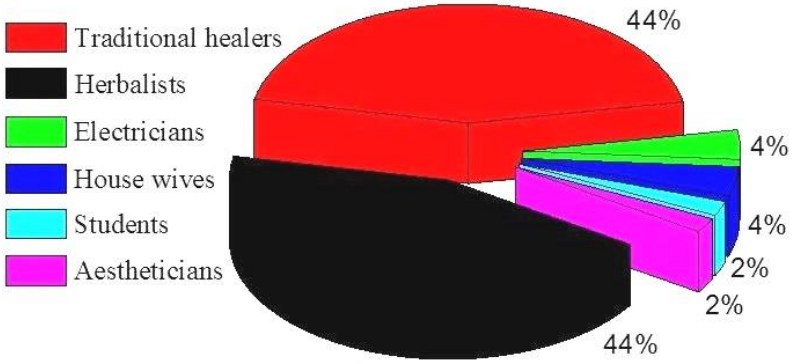


**Figure 7.** Professional activities-based distribution of informants.

Moreover, 50% of the informants turned to traditional medicine exclusively, while 4% used the modern medicine and 46% of them used both traditional and modern medicines. As for the composition of recipes, 64% of the informants used a single plant while the remaining used a combination of at least two plant species for the preparation of their recipes.

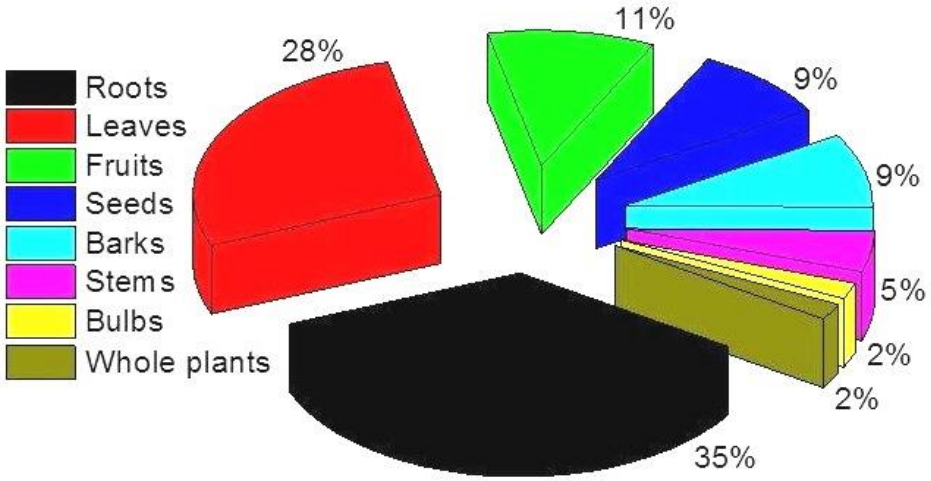


**Figure 8.** Used plant parts for the inventoried medicinal plant species.

Various plant parts are used in recipes in traditional medicine practices in Kinshasa. Roots are the most used plant part, accounting for 35%, followed by leaves (28%), fruits (10%), seeds (9%), barks (9%), stems (5%), and bulbs (2%); while the whole plant was used in 2% of recipes (Fig. 8). It should be noted that any extensive use of roots presents a serious threat to the sustainable preservation of biodiversity. The use of leaves may be justified by the abundance of chemical groups they contain, and the fact that they have been claimed to be the main synthesis site of secondary metabolites in plants (Dibong *et al*. 2011, Ngbolua *et al*. 2013).

Fifty-two percent of the informants use freshly collected plant materials while 16% use dried materials and 32% use both fresh and dried plant materials. For those informants who dry their plant material, 23% exposes their samples to direct sun but over 75% of them dry their materials under shade.

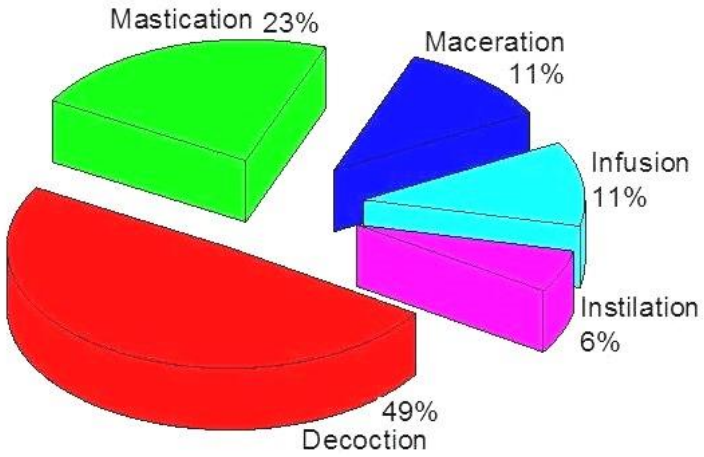


**Figure 9.** Modes of preparation of recipes.

In addition, and as reported by several other investigators (Saoud *et al.* 2010, Katemo *et al*. 2012), water is the used solvent; and decoction was found to be the preferred mode of preparation of recipes, accounting for 49%. This may be due to the fact that it has been reported that traditional healers believe that heat and steam remove toxic substances from plant materials (Ngbolua 2012). Other modes of preparation of recipes include maceration (23%), infusion (11%), mastication (11%) and instillation (6%) (Fig. 9).

Prior to and during the sales, the prepared recipes are packed through different means including bottles, bags and other packaging tools. The conservation methods (some being also the packaging tools) were reported to be shade (46%), sun light (4%), plastic bottles (34%), plastic bags (7%), glass bottles (5%), paper (3%) and other unspecified means that account for about 1% (Fig. 10).

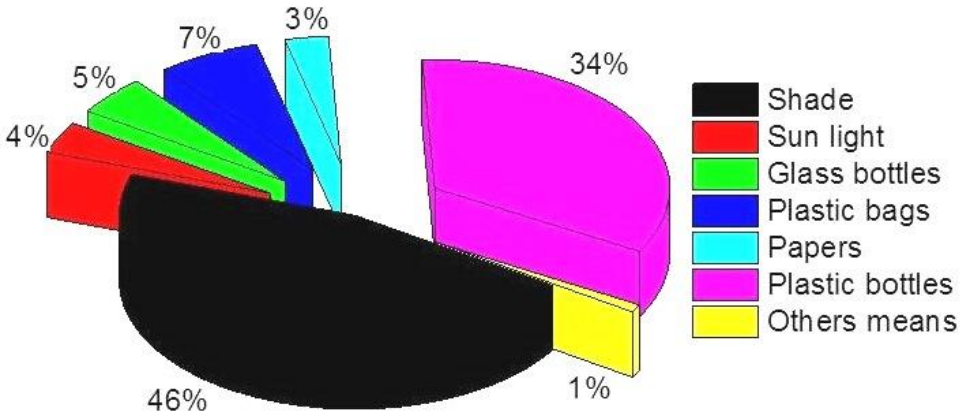


**Figure 10.** Modes of conservation of recipes.

The informants were also interviewed for their knowledge about the diagnosis of diseases and the results of the treatments. They revealed that 74% of the diseases are diagnosed by the patients themselves, while medical staff and patients' family members were responsible for the diagnoses of 24% and 2%, respectively.

Concerning the results on the treatments of diseases (Fig. 11), the informants indicated that 44% of their patients were healed, while 17% got improvement, 32% of the treatments failed and that side effects were observed in about 7% of the cases.

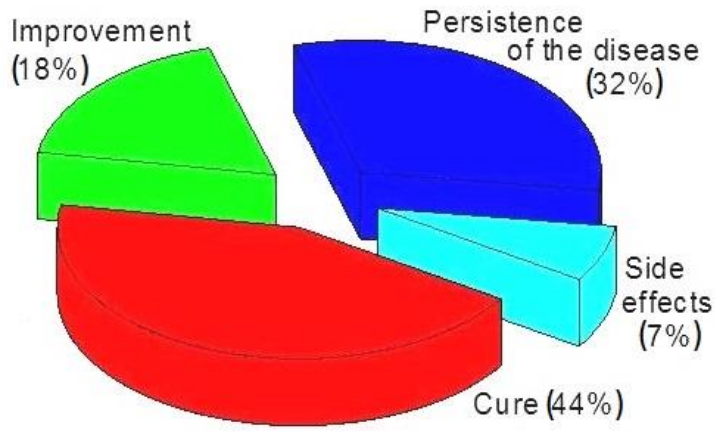


**Figure 11.** Results of the treatments of diseases.

Another important part of the investigation was the awareness of the existence of toxic plants among the prescribers of traditional medicine. In this regard, 52% of the informants indicated that some of their plant species were toxic and these consisted of *Cogniauxia podolaena*, *Hyptis suaveolens* and *Quassia africana*. These plant species are being used in the management of such diseases as malaria, hernia, typhoid fever, fibroma, myoma, cysts, haemorrhoids, rheumatism and shock. It is therefore important that people relying on the above-mentioned plant species be made aware of the possible toxicity dangers associated with those plants. Indeed, it was reported that the stem and root barks of *Quassia africana* were cytotoxic for MRC-5 cells with a $CC_{50}$< 10 µg.ml$^{-1}$ (Musuyu *et al*. 2012).

**Similarity of plant species usage**

The convergence of the remedies used and the medicinal practices in different countries is a very significant criterion in ethno-pharmacology. The frequency of citations by both traditional healers and literature is an indication of the probable biological activity of the plant. If a plant species is employed as remedy by local communities in different countries, this may be considered as a strong indication that the biological activity could be effective (Ngbolua *et al*. 2011b).

Some of the 32 plant species have been reported by other authors to treat various ailments (Neuwinger 2000, Karou *et al*. 2011, Betti *et al*. 2013). For example, seven of the 32 plant species were repeatedly cited by the traditional healers in other central African countries, while others (eight plant species) have been scientifically validated as anti-parasitic or antisickle cell disease in previous studies (Mpiana *et al.* 2007, Betti *et al*. 2013).

In addition, compared to former work (Ngbolua 2015), 17 out of 32 plant species in the present study were not quoted in our previous study. A possible reason for this could be that the recent rural migration following the war in the RDC influenced ethno-medical knowledge of Kinshasa city, whose population currently amounts to approximately 12 million inhabitants. Another reason could be the possibly that the informants were not the same in the two studies. To this end, the great interest of the population in traditional medicine for their primary health care in the context of the demographic explosion in Kinshasa city and the fact that the roots are the most used parts, conducting to the destruction of the plants, can represent an environmental risk for the forest resources surrounding the city, because of the increasing demand for medicinal plants. Thus, the creation of community based agro-forest plantations could constitute the solution for a sustainable management of the ecosystems surrounding the city.

## CONCLUSION

The aim of this ethno-botanical study was to determine plant species used in traditional medicine in Kinshasa city (DRC). Results from this study have shown that herbal remedies are widely used in the city and administered as aqueous decoctions against as many as 38 different diseases. It was found that ligneous, savanna, phanerophytes, and pantropical-type plant species predominate both in numbers of species as well as in citations. The education level of the majority of traditional healers and medicinal plant vendors was secondary school. Their age ranged between 20 and 68 years. Roots were the most used plant parts and malaria and haemorrhoids were the most treated diseases.

This report may be used as data base and information source for researchers who follow the ethno-pharmacology approach for their investigation of natural sources for bioactive secondary metabolites. Within this context, it is recommended that detailed phytochemical and pharmacological studies be performed on the most interesting species determined by the present study as these could lead to the development of active substances against the cited diseases.

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**Appendix:** Ethno-botanical and ecological data of reported plant species.

| Plant species (Ecological characters and voucher no.) | Vernacular names | Treated diseases | Used plant parts | Dosage |
|---|---|---|---|---|
| *Aframomum alboviolaceum* (Ridl.)K.Schum. (Perennial herb; clH; GC; Savanna; Dumont 149) | Tondolo | High blood pressure, malaria, headache, myoma, gastritis, pruritis | Leaves, fruits, roots | ½ glass 2x/day (Maceration filtrate); 4 drops/day (instillation) (5 days) |
| *Aframomum melegueta* (Roscoe) K.Schum (Perennial herb; clH; AMg; Savanna; Denis 4) | Mondongo | Cough, sore throat, backache | Fruits | 1 fruit/day; 1 glass 2x/day (maceration) filtrate |
| *Alchornea cordifolia* (Schumach. & Thonn.) Müll. Arg. (Shrub; McPh; At; Forest; Devred 265) | Mbunzi Mbunzi | Haemorroids, fever, | Leaves, roots | 2 glasses/day (5 days) |
| *Aloe buettneri* A. Berger (Shrub; Nph; GC; Savanna; -) | Badinseke | Tinea | Leaves | 3-4glasses/day Maceration filtrate (7 days) |
| *Ananas comosus* (L.) Merr. (Perennial herb; Nph; Pan; Cultivated; -) | Langa (Ananas) | Lack of appetite | Fruits | 1 fruit/day |
| *Annona senegalensis* Pers (Shrub; McPh; GC; Savanna; A. Léonard 5635) | Lolo | Haemorroids, infections, malaria, diabetes | Roots | 2 glasses/day (7 days) |
| *Capsicum annuum* L. (Undershrub; Nph; Pan; Cultivated; Breyne 2161) | Tuenga | Madness, toothache | Leaves | 2 drops 2x/day (5 days) |
| *Citrus limon* (L.) Burm.f. (Shrub; McPh; Pan; Cultivated; -) | Kpepke (Citron) | Fever, cough | Fruits, leaves | 2 glasses/day; 4 fruits/day |
| *Cogniauxia podolaena* Baill. (Liana; Lph; GC; Forest; Devred 144) | Kisakamba | Fibroma,myoma, cyst | Roots | ½ glass 2x/day (5 days) |
| *Crossopteryx febrifuga* (Afzel.) Benth. (Shrub; McPh; At; Savanna; Donis 1577) | Mapela ya zamba | Haemorroids | Leaves, roots | 2 pumps/day, 1x/week |
| *Cymbopogon citrates* (DC.) Stapf (Perennial herb; clH; Pan; Cultivated; -) | Sinda | Malaria, pain | Leaves | Tea-like drink (5 days) |
| *Erythrina abyssinica* Lam. ex DC (Shrub; McPh; GC; Forest; Eleanor Phillips 4222) | Mukadi pembe | Haepatitis, | Roots | Small portion |
| *Garcinia kola* Heckel (Tree; MsPh; GC; Forest; A. Léonard 1848) | Ngadiadia | Malaria, guts, diabetes | Seeds | 2-5 grams/day (3 days) |
| *Gladiolus gregarious* Welw. ex Baker (Perennial herb; bG; Pan; Cultivated; Schmitz 6013) | Litungulu ya zamba | Haemorroids, backache | Bulbs | 1 Pump 2x/day (3 days) |
| *Gongronema latifolium*Benth (Liana; Lph; Pan; Forest; Compere 1162) | Lolango | Haemorroids, poison | Roots | 1 Pump/day (3 days) |
| *Harungana madagascariensis* Lam. ex Poir (Tree; McPh; GC; Forest; Davio 37) | Ntunu | Hernia, yellow fever | Roots | 2 glasses/day (7 days) |
| *Heinsia crinita* (Afzel.) G.Taylor (Shrub; McPh; Gui; Forest; Breyne 3264) | Kitamata | Sexual impairment | Roots | 2 glasses/day (14 days) |
| *Hyptis suaveolens* (L.) Poit. (Shrub; Nph; Pan; Cultivated; Breyne 3655 ) | Musunda | Haemorroids, rheumatism, shock | Roots | ½ glass 2x/day (Maceration filtrate) (5 days) |
| *Millettia eetveldeana* (Micheli) Hauman (Tree; MsPh; GC; Forest; Devred 364) | Mbuengi | Haemorroids | Roots | 2 glasses/day (5 days) |
| *Mondia whitei* (Hook.f.) Skeels (Liana; Lph; GC; Forest; Compere 773) | Kimbiolongo | Kidney, gastritis, backache, guts | Stem, roots | 1 glass/day (decoction) (3 days) |
| *Morinda morindoides* (Baker) Milne-Redh. (Liana; Lph; GC; Forest; Breyne 3384) | Kongo bololo | Malaria, diabetes, typhoid fever | Leaves | ½ glass 2x/day |
| *Nicotiana tabacum* L. (Annual herb; Nph; Pan; Cultivated; -) | Bulu ( Fumu) | Headache, sinusitis | Leaves | 2 bowls/day |

| | | | | |
|---|---|---|---|---|
| *Oldenlandia affinis* (Roem. & Schult.) DC. (Annual herb; clTh; Pan; Ruderal; Diankenda 156) | Ankoro | Sexual impairment | Roots | Small portion |
| *Oryza sativa* L. (Perennial herb; dTh; Pan; cultivated; -) | (Loso) Riz | Diarrhoea | Seeds | 1 glasses/day |
| *Persea americana* Mill. (Tree; MsPh; Pan; Cultivated; Devred 1366) | Avocatier | Anemia | Leaves | 1 cup/goblet, 2x/day |
| *Piper nigrum* L. (Liana; Lph; Paleo; Forest; Breyne 830) | Ketshu | Haemorroids | Seeds, stem | 2 glasses/day (3 days) |
| *Quassia Africana* (Baill.) Baill. (Shrub; MsPh; GC; Forest; Dechamps 8080) | Mumpesepesi | Malaria, hernia, typhoid fever | Leaves, roots | 2 glasses/day (5 days) |
| *Sarcocephalus latifolius*(Sm.) E.A. Bruce (Shrub; McPh; At; Savanna. Devred 389) | Kilolo,Kiloloki Kwango | Haemorroids, backache, diabetes, infections | Roots | 2 glasses/day |
| *Securidaca longipedunculata* Fresen. (Tree; McPh; Paleo; Forest; Collens 60) | Nsunda | Exteralhaemorroids | Roots | 2 glasses/day |
| *Selaginella myosurus* (Sw.) Alston (Perennial herb; clH; GC; Forest; -) | Tosangango | Demons, Buruli ulcer | Leaves, stem | ½ glass, 2x/day |
| *Senna alata*(L.) Roxb. (Undershrub; Nph; Pan; Ruderal; Breyne 2418) | Jokote | Tinea, (gonorrhea) | Leaves | 2 drops (½ glass), 2x day (7 days) |
| *Sida rhombifolia*L. (Undershrub; Nph; Pan; Cultivated; Devred 531) | Lukuliande | Gastritis, high blood pressure, lack of appetite, backache | Leaves | 2 glasses/day |