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Assessment of the Diversity of Antidiabetic Plants and Local Practices Used in the Traditional Treatment of Diabetes in Benin

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ABSTRACT

Traditional medicine was, and still is, used by people who rely on the popular use of medicinal and aromatic plants and who are unable to bear the burdens of modern medicine. It is in this context that this study was initiated. The aim is to assess the biological diversity of anti-diabetic plants and local practices used in the traditional treatment of diabetes in Benin. An ethnobotanical survey was carried out among diabetic patients in Benin, using a questionnaire. A total of twenty-three anti-diabetic plants in North Benin and twenty-two in South Benin, thought to be effective and used by diabetics, were identified. These included *Phyllanthus amarus*, *Moringa oleifera*, *Bridelia ferruginea*, *Khaya senegalensis*, and *Momordica charantia*. Phyllanthaceae, Moringaceae, Euphorbiaceae, Meliaceae, and Cucurbitaceae are the dominant botanical families. However, it should be noted that these plants are geographically distributed (North and South Benin). In addition, there is a low diversity and equipartition of individuals between the different species used in the treatment of diabetes in the two regions of Benin. It is important to note, however, that there is no specific local practice adapted to a supposedly effective anti-diabetic plant. The leaves of *Bridelia ferruginea*, *Phyllanthus amarus*, and *Moringa oleifera* are more commonly used and prepared by infusion or maceration in the traditional treatment of diabetes in North Benin. On the other hand, the fruits, barks, roots, and sometimes the seeds of *Catharanthus roseus*, *Momordica charantia*, *Sarcocephalus latifolius*, and *Khaya senegalensis* are the plant organs prepared by decoction or directly eaten in the traditional treatment of diabetes in southern Benin. This study also reveals that knowledge of local practices in the traditional treatment of diabetes is not identical according to ethnic group and the patient's religion. Indeed, the Bariba, Dendi, Idatcha, Lokpa, Warma, and Wèmin, who practice the Muslim religion, have identical knowledge in North Benin, unlike the Gourmantché, Adja, Fon, Goun, Mahi, Minan, Peul, and Yoruba, who are either Christian or of the traditional religion in South Benin.

Keywords: Antidiabetic plants, Local practices assessment, Traditional medicine, Benin

INTRODUCTION

Natural resources are not only necessary for mankind's material well-being but also for its cultural and spiritual aspirations. Among the benefits to human well-being is the manufacture of medicines whose active ingredients are mostly derived from resources such as plants, used in traditional and modern medicine for the treatment of various diseases and bodily disorders (Palomo Nadja, 2010), including diabetes. This traditional pharmacopoeia, discovered by the first explorers of Africa, has already been introduced into many medicines in Europe. It has also given rise to major discoveries such as reserpine from Rauwolfia vomitoria, the starting point for neurosedatives.

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Diabetes is one of the world's most widespread non-communicable diseases (Jayakumar et al., 2010). According to the WHO, more than 176 million people worldwide are affected (WHO, 2004). It is estimated that prevalence, from 2.8% in 2000, will reach 4.4% of the world's population by 2030 (Sarah et al., 2004; Etuk et al., 2010). Of all the continents, Africa is the one most affected by this disease (Erasto et al., 2005). Moreover, in developing African countries, the medical management of diabetes is limited by the inaccessibility of certain populations to health centers and the high cost of conventional medicines. Modern medicine is often geographically, culturally, or financially inaccessible to most of the population in poor countries like Benin (Dresse et al., 2013).

According to the WHO (2000), nearly 80% of Benin's population uses traditional medicine (Dougnon et al., 2016), and there are over 7,500 traditional healers in Benin, compared with just 600 doctors for a population of nearly 10 million (Ministry of Health, Republic of Benin, 2010). In such conditions, people often turn to medicinal plants for treatment. These plants are readily available and can be found in abundance, often within the vicinity of dispensaries and hospitals. It is also disheartening to hear people say, "Such and such a medicine is missing," when most of the time, the remedy whose absence is deplored is in the courtyard of the dispensary or hospital.

Various ethnobotanical research projects have been undertaken in Benin to document and perpetuate traditional medical knowledge. These include the work of Akouedegni et al. (2012), Fah et al. (2013), Dassou et al. (2014), Koudokpon et al. (2015), Lougbégnon et al. (2015), Kouchadé et al. (2016), Dougnon et al. (2016), and Ouachinou et al. (2017). However, few studies have focused on the evaluation of the local medicinal plants and practices most frequently cited and used for the traditional treatment of diabetes in Benin.

Hence, the present study aims to assess the biological diversity of anti-diabetic plants and local practices used in the traditional treatment of diabetes in Benin. We test the hypothesis that the anti-diabetic plants and practices used by diabetics in the traditional treatment of diabetes in Benin change according to the local geographical area and the socioeconomic profile of the patient.

STUDY METHODOLOGY

Study Area

The study was carried out in four communes (Gogounou, Parakou, Abomey-Calavi, and Pobè) across four agro-ecological zones of Benin.

The North Benin cotton zone includes Ségbana, Gogounou, Banikoara, and Kandi. It covers 20,930 km² and has 44,251 inhabitants with 29,227 farming households. Production systems in this area are based on sorghum and maize, supplemented by yams. The low population density explains the availability of land.

The cotton zone of central Benin includes Bassila, Parakou, Tchaourou, Ouessé, Bantè, Savè, Savalou, Glazoué, Kétou, Djidja, Dassa, and Aplahoué. This zone covers 32,163 km² and has 1,166,182 inhabitants with 9,153 farming households. The production system is based on cereals, tubers, and legumes produced twice a year, thanks to the two rainy seasons that characterize the area.

The Terres de Barre zone comprises the communes of Abomey-Calavi, Allada, Kpomassé, Tori-Bosso, Zè, Djakotomé, Dogbo, Kouékanmey, Houéyogbé, Toviklin, Adjarra, Ifangni, Missérété, Porto-Novo, Abomey, and Bohicon. It covers an area of 6,391 km² with 1,960,136 inhabitants and 144,715 farming households. The production system is based on the cultivation of maize, cassava, and groundnuts. In this zone, rainfall is often disrupted, leading to changes in annual production cycles.

The Depression zone includes Pobè and Toffo. It covers an area of 2,564 km², with a population of 3,914,147. Maize combined with cassava, tomatoes, chilies, and other crops form the basis of the zone's production system, which holds great potential for the population.

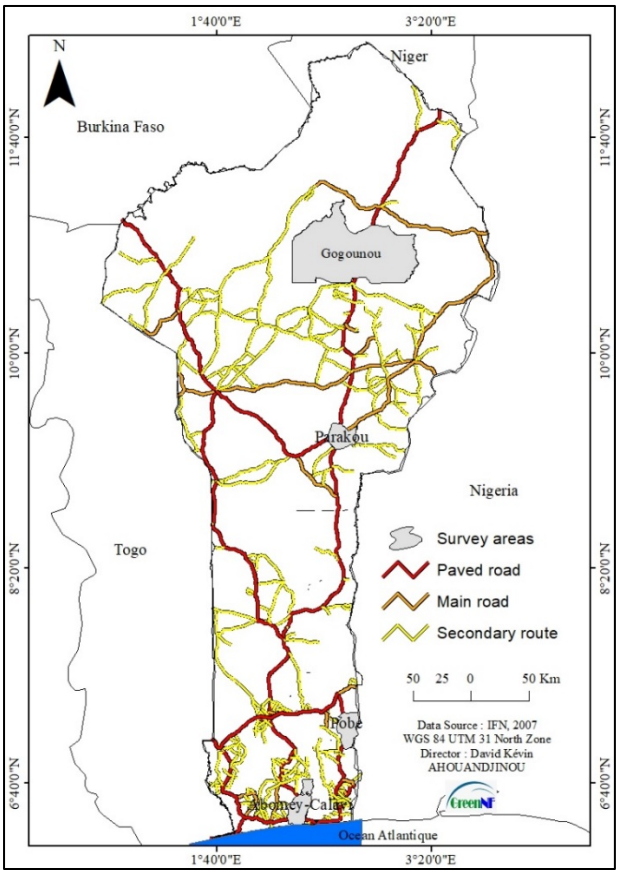

Figure 1: Location of study area

Data Collection and Analysis Methods

To carry out this study, we conducted surveys in four communes in North Benin (Parakou and Gogounou) and South Benin (Abomey-Calavi and Pobè). We used a combination of non-random Snowball (Houehanou et al., 2015) and accidental sampling methods to sample 120 diabetics (30 per commune). Data were collected using a survey questionnaire based on semi-structured and individual interviews (Saadou, 2008; Dansi et al., 2008; Dassou, 2015). The approach to the patients interviewed was based on dialogue in local languages (Bariba, Dendi, Peulh, Fon-Gbé, Mahi, Yoruba, Goun, and Nago) and in French for some.The information gathered from patients covered geographical data (place of residence of the respondent); socio-economic data (age, sex, ethnic group, marital status, religion, level of education, and profession); and local practices in the use of anti-diabetic plants (plants thought to be effective and used, forms of administration, parts used, method of preparation, dosage, etc.). For the analysis of these data, the Flore Analytique du Bénin, Arbres, Arbustes et Lianes des zones sèches de l'Afrique de l'Ouest, and other documents were used to identify the medicinal plant species identified.The data recorded on the survey forms were manually processed and encoded in a database designed and processed using Excel 2013, followed by frequency analysis. To assess the biological diversity of anti-diabetic plants, the local importance of each plant in the treatment of diabetes was calculated using the relative frequency of citation (FRC = Fc/N, with Fc being the number of respondents mentioning the species and N being the total number of

respondents) (Tardio et al., 2008). Shannon diversity indices $\mathbf{H'} = -\sum_{n=1}^{S}\left(\frac{ni}{N}\log(\frac{ni}{N})\right)$ and Pielou's equitability index (E = H'/log(S), where S is the total number of plants cited) were calculated to assess the diversity of anti-diabetic plants in North and South Benin and also tested by the chi-square test of independence. In addition, the plants assumed to be effective and most cited were subjected to a simple factorial correspondence analysis (SFCA) followed by a numerical hierarchical classification to group these plants by zone. As for the evaluation of local practices, we have drawn up a typology of the anti-diabetic plants supposedly effective and most cited by patients, and the associated local practices, according to the zones surveyed on the one hand, and the patient's ethnic group and religion on the other. This was made possible by multiple correspondence factorial analysis (MFCA) followed by numerical hierarchical clustering. All statistical analyses were performed using R statistical software (Version 4.0.1) at a significance level of 5%.

RESULTS

Diversity of Anti-Diabetic Plants

The relative citation frequencies of plants considered effective by diabetics in North and South Benin and used in the traditional treatment of Diabetes are shown in figure 2. In North Benin, 23 plants were identified, three of which have a relative frequency of citation greater than or equal to 10%, respectively *Phyllantus amarus, Moringa oleifera and Bridelia ferriginea*; with a Shannon index of 1.02 and a Pielou equitability of 0.76. There is low diversity and equipartition of individuals between the different species used in the treatment of diabetes. In southern Benin, 22 plants were inventoried, three of which have a relative frequency of citation greater than or equal to 10%, respectively Khaya senegalensis, *Momordica charantia* and *Phyllantus amarus*; with a Shannon index of 0.98 and Pielou equitability of 0.74. There is low diversity and equipartition of individuals between the different species used in the treatment of diabetes.

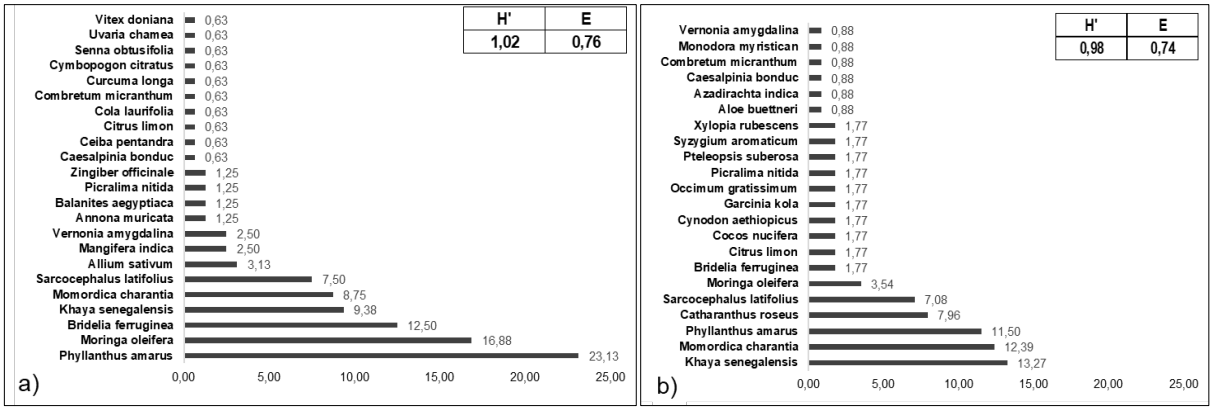

Figure 2: List of effective anti-diabetic plants by zone according to diabetics surveyed

Biological Diversity of Anti-Diabetic Botanical Families

Figures 3 shows the botanical families of species recorded in North Benin (a) and South Benin (b). The latter shows that the plant species recorded in North Benin are grouped into twenty-one (21) botanical families, the most represented of which are Phyllanthaceae (23.13%), Moringaceae (16.88%) and Euphorrbiaceae (12.5%) respectively. In southern Benin, however, the plant species recorded are grouped into eighteen (18) botanical families, the most represented of which are Meliaceae (14.16%), Cucurbitaceae (12.39%) and

Phyllanthaceae (11.5%). The botanical families of anti-diabetic plants are thus distributed according to geographical area.

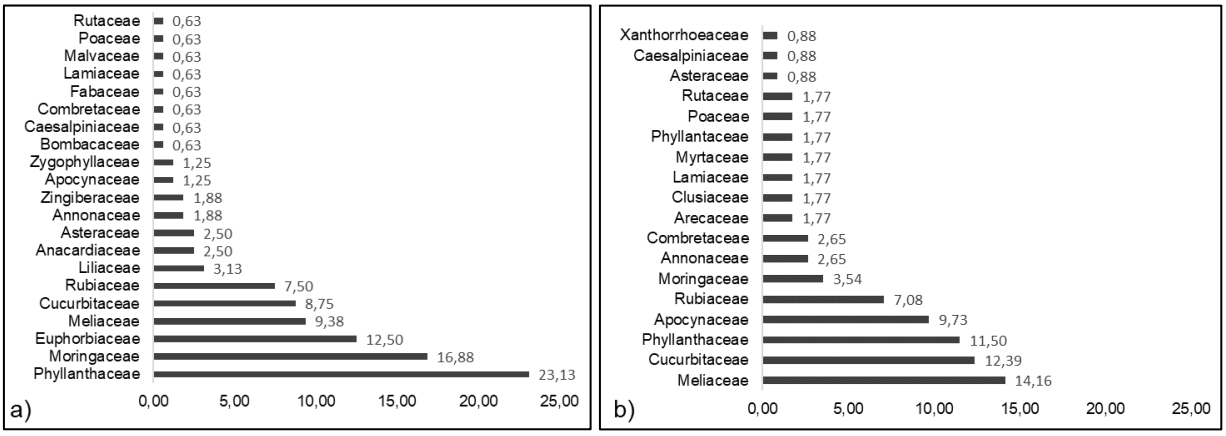

Figure 3: List of anti-diabetic botanical families identified by zone

Assessing the Diversity of Plants with Anti-Diabetic Properties

Figures 4 and 5 show, respectively, the factorial correspondence analysis and the groupings of supposedly effective and most cited anti-diabetic plants by zone. These two maps explain 97.91% with a highly significant probability (P=0.000008) of the distribution of plants by zone. Analysis of these figures shows that the anti-diabetic plants deemed to be effective are not the same in all zones, and are categorized into three (03) groups. The first group comprises the *Bridelia ferruginea*, *Phyllantus amarus* and *Moringa oleifera* plants identified in northern Benin. The second and third groups include *Momordica charantia, Khaya senegalensis* and *Sarcocephalus latifolius* in Abomey-Calavi and *Catharanthus roseus* in Pobè. The anti-diabetic plants most cited as being effective are distributed geographically.

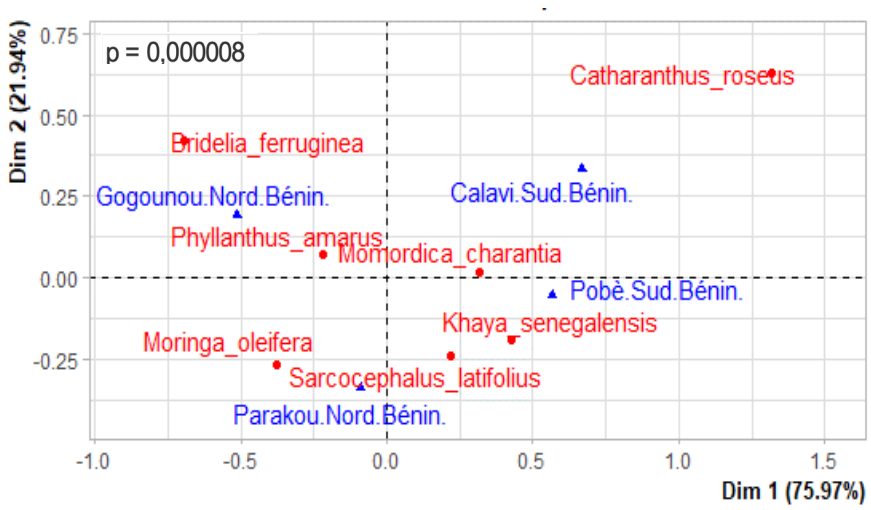

Figure 4: Distribution of the most frequently cited anti-diabetic plants, by zone

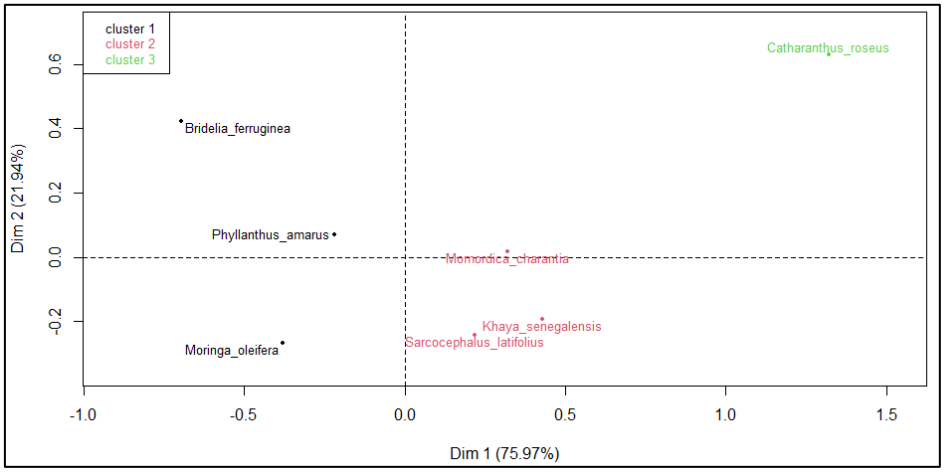

Figure 5: Group of effective anti-diabetic plants cited by zone

Type of Medicine Used

Figure 6 shows the types of medicine used by patients to treat diabetes. The results show that patients use three different types of medicine. Analysis of this figure reveals that 84.25% of patients use a combination of modern and traditional medicine to treat their diabetes. Next come those using only modern medicine and only traditional medicine, with proportions of 11.72% and 4.03% respectively.

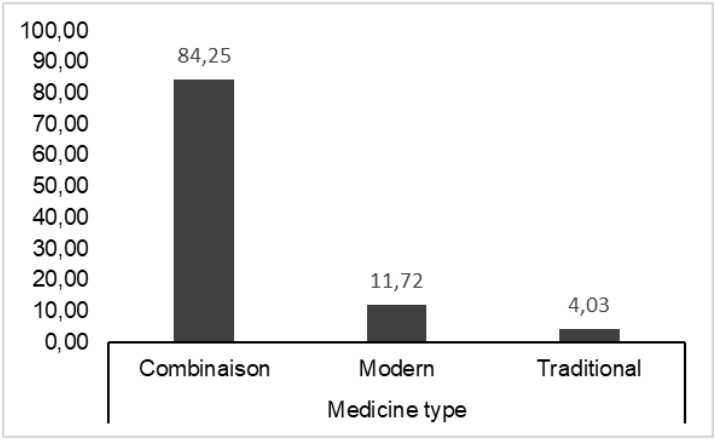

Figure 6: Type of medicine used to treat diabetes

Local Practices Used to Treat Diabetes

From the analysis of the following figure 7, it appears that the plant organs used by diabetics are leaves, roots, bark, seeds and fruits. Leaves (64.90%) are the most commonly used organs. Roots (14.69%) and barks (13.06%) follow. In addition, decoction (58.78%) is the preparation mode most used by the sick, followed by infusion and maceration with proportions of 34.29% and 6.12% respectively.

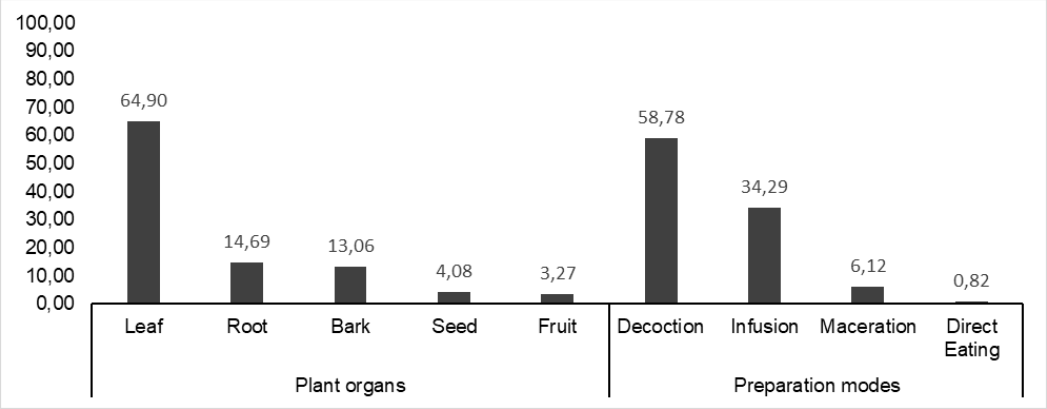

Figure 7: Plant organs and preparation methods used to treat diabetes in Benin

Assessment of Local Practices Used to Treat Diabetes

Figure 8 shows a factorial analysis of the groupings of plants thought to be effective, those most cited by patients and associated local practices, according to the areas surveyed. The latter explains 92.54% of our information. This map reveals the formation of two clusters. Each group is made up of plant species, plant organs and preparation methods. Leaves are the plant organs used by infusion or maceration to prepare *Bridelia ferruginea, Phyllantus amarus* and *Moringa oleifer*a in the traditional treatment of diabetes in North Benin. In southern Benin, on the other hand, fruits, barks, roots and sometimes seeds are the plant organs used by decoction or direct consumption to prepare *Catharanthus roseus, Momordica charantia, Sarcocephalus latifolius* and *Khaya senegalensis* for the traditional treatment of diabetes.

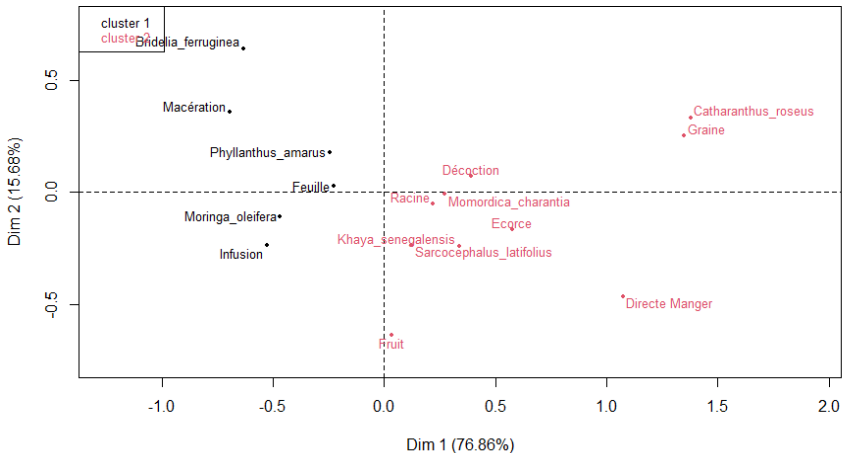

Figure 8: Grouping of anti-diabetic plants thought to be effective, most cited by patients and associated local practices, by survey area

Figure 9 shows the distribution of ethnic and religious groups of diabetic patients according to the local practices used. This explains 67.9% of our information, with two possible groupings according to factorial analysis. We can see that ethnic groups such as the Bariba, Dendi, Idatcha, Lokpa, Warma and Wèmin, who are mostly Muslims, have the same knowledge of local practices in the traditional treatment of diabetes in North Benin. Whereas in southern Benin, Gourmantché, Adja, Fon, Goun, Mahi, Minan, Peul and Yoruba, who are either Christian or of the traditional religion, have similar knowledge of local practices.

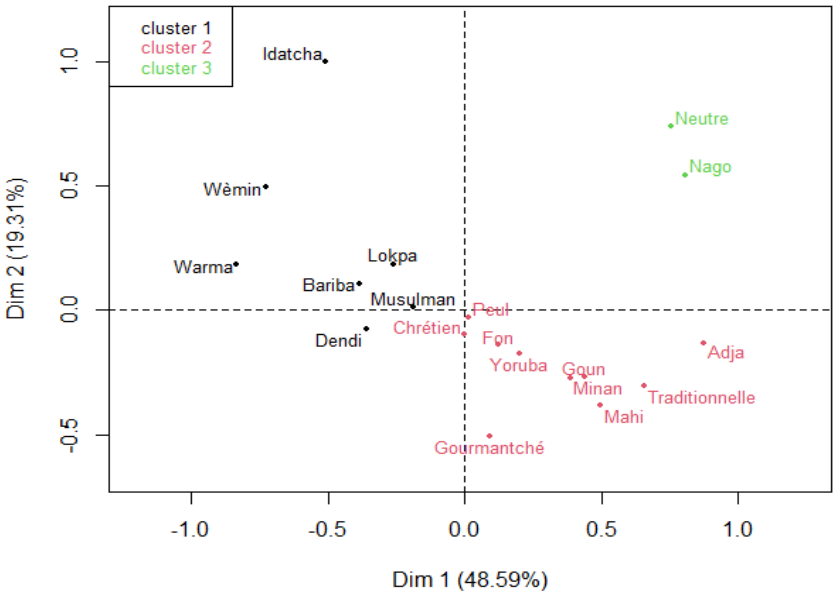

Figure 9: Distribution of ethnic and religious groups of diabetic patients according to local practices used

DISCUSSION

The data collected enabled us to identify twenty-three anti-diabetic plants in northern Benin and twenty-two in southern Benin, all of which are thought to be effective and used by diabetics. These species include *Phyllantus amarus, Moringa oleifera* and *Bridelia ferriginea* (in North Benin); *Khaya senegalensis, Momordica charantia* and *Phyllantus amarus* (in South Benin). They belong to the botanical families Phyllanthaceae, Moringaceae and Euphorrbiaceae in northern Benin, and Meliaceae, Cucurbitaceae and Phyllanthaceae in southern Benin, in order of dominance. It can therefore be said that the anti-diabetic plants most cited as effective are distributed geographically. This diversity of plants observed corroborates with other ethnobotanical studies carried out in the communes of Glazoué and Savè in Centre-Bénin, where 144 plants used in the traditional treatment of diabetes were recorded, the most dominant of which are those found in this study (Lawin et al., 2016). There are also some similarities with the results of Fah et al, (2013) where 61 anti-diabetic plants were recorded among pregnant women in Abomey-Calavi and Cotonou, the most cited being *Catharanthus roseus, Lippia multiflora* and *Phyllantus amarus*. This state of affairs is understandable, as the geographical area of the studies differs. Moreover, the present study concerns anti-diabetic plants assumed to be effective in general, whereas that of Fah et al. (2013) strictly considered plants used against diabetes in pregnant women. The appearance of *Phyllantus amarus* as the most cited species in both study areas testifies to its importance in the treatment of diabetes. In addition, there was low diversity and equipartition of individuals between the different species used to treat diabetes in the two Benin poles. This low diversity of plants may be the probable reason why we were particularly interested in plants thought to be effective and used by diabetics. On the other hand, for the traditional treatment of diabetes, the combination of modern and traditional medicine is more widely used by patients. On the other hand, 21% of cases of plant use in the Fellaoucene region, Wilaya de Tlemcen, were noted in Zahira's 2017 ethnobotanical study of anti-diabetic plants. This difference with our study may be due to the difference in social class of the countries in which the study is conducted. Also, the use of medicinal plants remains the prerogative of poor people (Gnagne et al., 2017). Local practices differ according to geographical area. Indeed, the results of this study show that leaves, roots and barks, as well as decoction and infusion, are the plant organs

and methods of preparation of anti-diabetic plants most cited by patients. These results are in line with those of Azzi et al. (2012), who showed that the plant parts cited were the leaves. These results are contrary to those of Thirumalai et al, (2012) for whom leafy stems are the most used. Other ethno-pharmacological studies report that leaves are the most commonly used part of the plant (Gedif & Hahn, 2003; Giday et al., 2003; Macia et al., 2005; Neves et al., 2009). As the leafy stem is made up of stem and leaf, these results are not significantly different. This frequent use of leaves in traditional medicine has already been reported by several authors, including Mehdioui et al. (2007), Upadhya et al. (2012), Gbekley et al. (2015), Béné et al. (2016) and Nzuki (2016). But, it is very important to note that there is no specific local practice adapted to a supposedly effective anti-diabetic plant most cited by diabetics. Indeed, the leaves of *Bridelia ferruginea*, *Phyllantus amarus* and *Moringa oleifera* are more commonly used and prepared by infusion or maceration in the traditional treatment of diabetes in North Benin. On the other hand, the fruits, barks, roots and sometimes the seeds of *Catharanthus roseus, Momordica charantia, Sarcocephalus latifolius* and *Khaya senegalensis* are the plant organs prepared by decoction or directly eaten in the traditional treatment of diabetes in southern Benin. The study also revealed that local knowledge and practices in the traditional treatment of diabetes are not identical according to ethnic group and the patient's religion. Indeed, the Bariba, Dendi, Idatcha, Lokpa, Warma, Wèmin and Muslim religions have identical knowledge in North Benin, unlike the Gourmantché, Adja, Fon, Goun, Mahi, Minan, Peul, Yoruba who are either Christian or of the traditional religion in South Benin.

CONCLUSION

The aim of this study is to assess the biological diversity of anti-diabetic plants and local practices used in the traditional treatment of diabetes in Benin. A diverse array of plants considered effective and utilized by diabetics were identified from north to south Benin, including *Phyllanthus amarus*, Moringa oleifera*, Bridelia ferruginea*, *Khaya senegalensis*, and *Momordica charantia*. These species exhibit a distinct geographical distribution. The predominant botanical families involved are Phyllanthaceae, Moringaceae, Euphorbiaceae, Meliaceae, and Cucurbitaceae. Local practices vary significantly depending on the plant species used, the ethnic group, and the patient's religious affiliation. This variability in practices indicates that many plants are not fully understood in terms of their preparation methods, preservation techniques, consumption patterns, and other aspects. Addressing these parameters through controlled studies and developing strategies for conserving and valorizing anti-diabetic plants and associated traditional knowledge would be beneficial.

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