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An ethnobotanical survey of antidiabetic plants used by Hausa–Fulani tribes in Sokoto, Northwest Nigeria

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ABSTRACT

Ethnopharmacological relevance: Sokoto is known for its diverse traditional medicinal wealth and international market of traditional medicines in Africa. However, information of the folk knowledge, especially for the treatment of diabetes, is not documented.
Aim of the study: This survey identified and documented the information on traditional medicinal plants used by Hausa–Fulani community of Sokoto for the treatment of diabetes.
Materials and method: Demographic data and information about the medicinal plants were collected via administration of semi-structured oral questionnaires. Willing herbal medical practitioners/traditional healers were interviewed. The medicinal plants mentioned by herbalists were collected and authenticated by a taxonomist and the voucher specimens were preserved.
Results: Fifty one informants across the state divulged information on traditional medicinal plants and practices used in diabetes and revealed 54 species, belonging to 33 families, with *Cassia sieberiana* being cited the most (19 times) and ranked first (39%). *Azadirachta indica*, *Ficus exasperata* and *Schwenckia americana* ranked second (15%), each cited 8 times.
Conclusion: The survey documented the rich wealth of knowledge and usage of plants for the treatment of diabetes in Sokoto. The paper will not only serve as a source of information but will also help to make the knowledge accessible for further drug screening and development, and at the same time underlines the need for biodiversity conservation of this traditional wealth.

1. Introduction

Diabetes is a major life threatening disease all over the world. It is seen as a complex and rapidly growing problem that results in shortage or lack of insulin secretion and/or reduced sensitivity of tissue to insulin (WHO, 2006). The World Health Organization (WHO) has defined diabetes as primarily a condition associated with hyperglycemia that gives rise to microvascular damage including retinopathy, neuropathy and nephropathy (WHO, 2006). According to the WHO projections, diabetes will be the 7th leading cause of death by the year 2030 (Mathers and Loncar, 2006). Its prevalence has been increasing over the past few decades, which may be attributed to a number of factors such as obesity, change due to urbanization, and sedentary lifestyle (Ginter and Simko, 2010; Hu, 2011; Wu et al., 2014; Gutch et al., 2014). According to an estimate, there were about 382 million peoples with diabetes in 2013, in addition to 316 million with impaired glucose tolerance that were at a high risk from the disease. The number of people with diabetes by the year 2035 is alarmingly expected to reach 471 million (IDF, 2013). Also, the global prevalence for adults between 18 years and above who suffered from diabetes during the year 2014 was 9% (IDF, 2013). In Africa, where diabetes was once rare, 19.8 million peoples suffered from diabetes in 2013, and the figure is expected to rise to 41.5 million by 2035 (Peer et al., 2014). This is undoubtedly an alarming figure that shows close to 5% of the African people are suffering from diabetes. Epidemiological data from International Diabetes Federation (IDF, 2013) on the prevalence of diabetes ranked Nigeria first in African region with about 4 million people suffering from the disease and the figure is expected to double by the year 2035. Several reports indicate that the disease is on increasing trend with more than 80% cases of death mostly coming from low and middle income countries (WHO, 2014a, 2014b).

In Africa, patients rely mostly on complementary and alternative medicine (CAM) as well as other beliefs and methods to cure diabetes since most of the conventional drugs are either

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costly or not available (Matheka and Demaio, 2013). African traditional system of medicine is considered to be the oldest and diversified of all the known therapeutic systems (Mahomoodally, 2013). WHO has mentioned that up to 80% of African population relies on traditional medicine in meeting some of their health care needs (WHO, 2008). Historically, plants have been traditionally used for ages to cure ailments. Today, over 70% proportion of patients and healthcare providers in the world rely on herbal medicines directly or indirectly for meeting their health care needs (Wills et al., 2000; Sofowora et al., 2013). A large number of active ingredients in medicinal plants, phytochemicals, have been isolated and proved to be responsible for their pharmacological actions and efficacy (Mukherjee et al., 2010). Some of these are reported for several therapeutic effects, including antidiabetic (Andreu et al., 2005), antiplasmodial (Talontsi et al., 2013), antiviral (Zhang et al., 2014) and many other effects. Knowledge of medicinal plants/herbs in the developing world and their usage in the management of diseases is popular especially among the traditional medical practitioners (TMPs) and is usually retained and transferred among the family members generation upon generation. The efficacy claims of these medicinal plants, however, remain to be elucidated and scientifically validated due to the lack of information and suitable screening/bioassays, thus compromising the acceptability of these herbs being traditionally used for centuries by TMPs.

Nigeria, the most populous country in the African continent with a population of over 160 million, is divided into six geo-political regions (North Central, North East, North West, South South, South East and South West) with 36 states and a total of 774 local government areas (Millar et al., 2014). The country has more than 250 different ethnic groups living together. Among the ethnic groups, Hausa and Fulani are the two major tribes which are most commonly found in the northwest of the country (Adekunle and Otolorin, 2000; Abubakar et al., 2007). Hausa–Fulani people live together sharing common norms and values, having many cultural and social resemblances. They are known to be mostly farmers and cattle rearer (Obi, 1978; Cadmus et al., 2008). The country is endowed with biodiversity of medicinal plants which are used in the African traditional system of medicine for the management of different diseases (Gbile and Adesina, 1987; Ajose, 2007). In a recent review (Lifongo et al., 2014), the economic/traditional uses of some of these medicinal plants of Nigeria have been found to be correlated with their biological activities. But much less attention has been paid to this area when compared with the plethora of information available in traditional Chinese and Indian systems of medicine. Culturally, Sokoto has a good history of herbal trade owing to the fact that the state is on the borderline of the country to the west. The state has a centralized market which attracts people from within and outside the country; thus promoting herbal trade activities in the area. There are reports indicating that the ethnic groups of Sokoto, who are mostly nomadic farmers with widespread use of traditional medicines, have low prevalence of diabetes (Sabir et al., 2013a). This ethnobotanical survey was intended to document medicinal plants which are traditionally used by the Hausa–Fulani peoples for the treatment of diabetes in Sokoto.

2. Materials and methods

In this study, five local government areas (LGAs) of Sokoto, comprising both rural and urban localities, were selected (Fig. 1). The urban localities included Sokoto North and South, and rural localities included Wamako, Kware and Rabah local government areas. Sokoto, which has a total of 23 LGAs, is located in the northwestern Nigeria with mainly Hausa and Fulani as the dominant tribes (Ebenso et al., 2001). It approximately covers 25,973 km^2 and lie between latitude 13°3′5N and longitude 5°13′ 53E, with 3,696,999 population (NPC, 2006). The state borders with Niger republic to the north, and shares boundary with Zamfara state to the south and east and Kebbi state to the west and south (Muhammad et al., 2011).

2.1. Survey design/questionnaire

The semi-structured questionnaire method (Gbolade, 2009) was used with some modifications for interviews. The targeted groups for this study were mainly herbalists and herb sellers, and traditional medical practitioners in selected local government areas. The questionnaire was divided into three sections. The first section contained personal information of the respondents such as the age, sex, religion, contact number, local tribe and nationality.

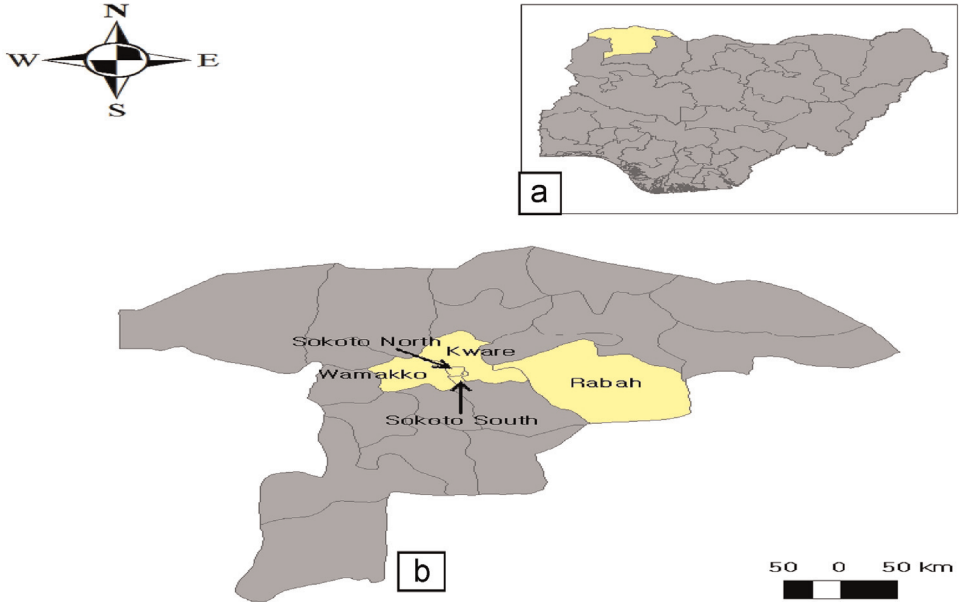

Fig. 1. The map of the study area; (a) Nigeria. (b) Study area in Sokoto showing five local government areas (shaded).

Section two dealt with traditional medical practice which provided information on specialty, practice duration and method of diagnosis, clerking of diabetic patients, admissions and referrals as well as dietary recommendations. Lastly, the third section dealt with plants and recipes, mode of preparation and other treatment methods and information used by the respondents in the treatment of diabetes.

2.2. Ethnobotanical data collection

This study was conducted in two phases: phase 1, the administration of the questionnaire, and phase 2, the specimen/sample collection phase. In phase 1, first the chairman of TMPs in Sokoto state was contacted to obtain the names of knowledgeable herbalists, TMPs or herb sellers in the area of diabetes cure. Secondly, consent of each respondent was taken prior to the administration of the questionnaire. Those who refused to divulge the information were not considered. Only 2% of the informants were able to read and fill in the questionnaire by themselves. The administration of the questionnaire was more of an oral interview. The names of the medicinal plants divulged by the informants were recorded in the local language used by these informants. At the time of collection of samples for identification (phase 2), the same informants who provided information about the herbs in phase 1 were contacted and the specimens, as identified by the informants, were collected. Names of medicinal plants recorded at the time of administration of the questionnaire were used during sample collection with the help of the informants who provided information earlier in phase 1. In fact, informants were visited multiple times as per their convenience and also to collect right specimen at the right time (season). Monetary incentives were given to these experts (informants) to motivate them. Paying incentives to informants to motivate them to divulge information is an acceptable practice in Africa and other poor and developing economies. Sometime, even if the intention is not to offer the money, these peoples ask for money after the help for the time and information they provided, and also for the warm welcome upon revisit. Studies in Africa have resorted to rewarding the informants for their time and information (Gbolade, 2009).

2.3. Data analysis

Data obtained from ethnobotanical survey of antidiabetic medicinal plants used in the study area for the treatment of diabetes was analyzed and the medicinal plants were ranked on the basis of how often a particular plant was cited by the informants and frequency of citation (FC) was determined for each of the plants as follows: $FC = NC/TI \times 100$, where NC indicated the number of citation, and TI, the total number of informants.

3. Results

3.1. Collection, identification and preservation of plants

After the questionnaire administration, identification of medicinal plants as well as data analysis, all medicinal plants mentioned by the informants were ranked based on frequency of citation. A total of 51 informants across the state divulged information on traditional medicinal plants and practices used by the TMPs for the treatment of diabetes. The survey revealed 54 species, belonging to 33 families, with *Cassia sieberiana* being cited the most (19 times) and ranked first (39%). *Azadirachta indica*, *Ficus exasperata* and *Schwenckia americana,* which belong to families *Meliaceae, Moraceae* and *Solanaceae,* respectively, ranked second (15%), each cited 8 times (Fig. 2). For the preservation, the plant

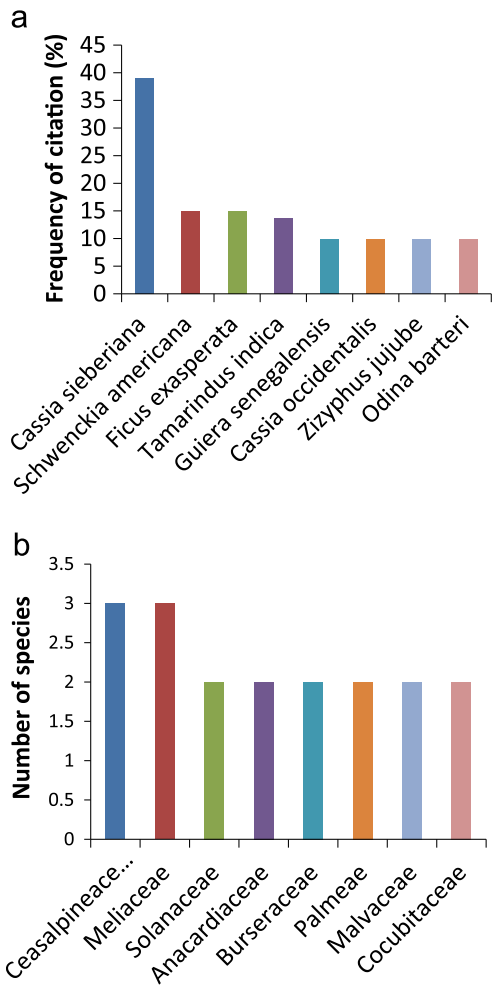

Fig. 2. The most cited (a) Species of antidiabetic plants and (b) families in the study area.

part was dried and pressed in a standard sheet. The plant part was identified by a taxonomist in the herbarium of Usmanu Danfodiyo University Sokoto. Botanical names of all medicinal plants authenticated by the taxonomist were further checked from www.theplantlist.org. The list of the medicinal plants reported in this study is provided in Table 1. When compared, ethnobotanical information obtained from Hausa and Fulani tribes revealed that the number of antidiabetic medicinal plants mentioned by Fulani informants (20) was more than what Hausa informants (16) mentioned in the survey.

3.2. Demographic characteristics

The survey was conducted between July and September 2013 at various districts of the five selected local government areas. A semi-structured questionnaire was administered to 51 (99% male and 1% female) respondents in the study area comprising mostly of Hausa–Fulani tribes. The age of the informants was between 30 and 88 years and their years of experience were between 9 and 48 years (Fig. 3).

3.3. Admission and referral

We found only 2% informants who claim to admit patients during treatment. On the aspect of referral, they said if it warrants, they refer a patient to a senior colleague in the same field but not

Table 1
List of traditional medicinal plants used by the traditional medical practitioners for the treatment of diabetes in Sokoto.

Local name	Common name	Botanical name	Family	Voucher no	LGA	EG	PU	MP	NC	FC	R
Aduwa	Soapberry tree	*Balanites aegyptiaca* (L.) Del	*Zygophyllaceae*	UDUH/ANS/0024	K	F	LRB	MD	1	1.9	8
Ararrabii	Sand paper tree	*Commiphora kerstingii* Engl	*Burseraceae*		K	F	L	M	1	1.9	8
Bagaruwa	Egyptian mimosa	*Acasia nilotica* (L.) Wild	*Mimosaceae*	UDUH/ANS/0020	SN	H	R	D	1	1.9	8
Baushe	Black afara	*Terminalia macroptera* Guill & Perr	*Combretaceae*		W	H	R	D	1	1.9	8
Borai	Sand paper tree	*Ficus exasperata* Vahl	*Moraceae*		W\K	B	LRB	MD	8	15	2
Cini dazugu	Barbados nut	*Jatropha curcas* L	*Euphobiaceae*	UDUH/ANS/0042	R/K	B	LRB	MD	3	5.8	6
Dandana	–	*Schwenckia americana* L.	*Solanaceae*	–	W/R	F	LRB	MD	8	15	2
Dogon yaro	Neem	*Azadarachta indica* A. Juss	*Meliaceae*	UDUH/ANS/004	R/K	B	LRB	ID	8	15	2
Dorawa	Africa locust bean tree	*Parkia fillicoidea* Oliv	*Leguminoseae*	UDUH/ANS/0028	SN	F	R	D	1	1.9	8
Dunya	Black plum	*Vitex doniana* Sweet	*Verbenaceae*	UDUH/ANS/0051	R	F	B	D	1	1.9	8
Faru	Olive	*Odina barteri* Oliv	*Anacardiaceae*	UDUH/ANS/0026	K/R	B	LB	MD	5	9.8	4
Gamji	Red robber tree	*Ficus platyphylla* Del	*Uritricaceae*	UDUH/ANS/0044	K	F	B	D	1	1.9	8
Garahuni	African cucumber	*Momordica balsamina* L.	*Curcubitaceae*	UDUH/ANS/0058	R/K	H	L	M	4	7.8	5
Gardaye	–	*Acacia albida* Del	*Leguminoseae*	UDUH/ANS/0062	K	F	R	D	1	1.9	8
Gaudi	Waterleaf	*Talinum triangulare* (Jacq) Wild	*Portulacaceae*	UDUH/ANS/0053	SN	F	RB	D	3	5.8	6
Gawo	Winter thorn	*Acacia macrostachya* DC	*Leguminoseae*	UDUH/ANS/0052	R	H	R	D	1	1.9	8
Geza	–	*Combretum altum* Guill & Perr	*Combretaceae*	UDUH/ANS/0046	SS/K	H	R	D	2	3.9	7
Giginya	African fan palm	*Borassus flabellifer aethiopum*	*Palmeae*	UDUH/ANS/0047	R	F	B	D	1	1.9	8
Goriba	Doum palm	*Hyphaene thebaica* (L.) Mart	*Palmeae*	UDUH/ANS/0048	SS	F	R	D	1	1.9	8
Gwadda	Pawpaw	*Carica papaya* L	*Papayaceae*	UDUH/ANS/0012	K	B	LSF	M	3	5.8	6
Gwadda-daji	African custard-apple	*Annona senegalensis* Pers	*Anonaceae*	UDUH/ANS/0037	R	F	LS	M	2	3.9	7
Hano	Frankincense tree	*Boswellia dalzielii Hutch*	*Burseraceae*	–	SS/W	B	R	D	4	7.8	5
Hilisko	Neutral henna	*Cassia obovata* Collad.	*Leguminoseae*	UDUH/ANS/0014	K	F	L	M	2	3.9	7
Idon zakara	Rosary pea	*Abrus precatorius* L	*Leguminoseae*		R/K	B	L	M	4	7.8	5
Kai-kai mashekiya	Hairy indigo	*Indigofera hirsute* L.	*Fabaceae*	UDUH/ANS/0049	SS	H	L	M	1	1.9	8
Kainuwa	American waterlily	*Nymphaea odorata* Aiton	*Nymphaeaceae*	UDUH/ANS/0057	K	F	L	M	2	3.9	7
Kalgo	Camel's foot	*Piliostigma reticulatum* (DC.)	*Caesalpineacea*	UDUH/ANS/0021	K/W	B	RB	D	4	7.8	5
Kamumuwa	The air potato	*Dioscorea bulbifera* L.	*Dioscoreaceae*		SN	B	R	D	2	3.9	7
Kankana	Water melon	*Citrullus lanatus* (Thunb)	*Cucurbitaceae*	UDUH/ANS/0055	R	F	FS	M	1	1.9	8
Katala	King tuber mushroom	*Pleurotus tuber-regium*	*Pleurotaceae*		SS	H	R	D	1	1.9	8
Kasheshe	–	*Heeria insignis* Delile Kuntze	*Anacardiaceae*		R	F	R	D	1	1.9	8
Kizni	–	*Bridelia ferruginea* Benth.	*Euphobiaceae*		SS	F	B	D	1	1.9	8
Kuka	Baobab	*Adansonia digitata* L.	*Malvaceae*	UDUH/ANS/0016	SN/K	H	RB	D	4	7.8	5
Kwarya	Calabash	*Crescentia cujete* L.	*Bignoniaceae*	UDUH/ANS/0018	*K*	F	BSc	I	2	3.9	7
Kyasuwa	Nigeria grass	*Pennisetum pedicellatum* Trin.	*Gramineae*	UDUH/ANS/0025	SS	H	L	M	1	1.9	8
Madacci	African mahogany	*Khaya senegalensis* (Desv) A Juss	*Meliaceae*	UDUH/ANS/0056	R	H	B	D	1	1.9	8
Magarya	Jujube fruit	*Zizyphus jujube* Linn	*Rhamnaceae*	UDUH/ANS/0017	W/R	F	R	D	5	9.8	4
Majee	African copaiba balsam	*Daniellia oliveri* Hutch & Dalziel	*Leguminoseae*		SS	B	B	D	2	3.9	7
Malga	West African laburnum	*Cassia sieberiana* DC	*Caesalpinaceae*	UDUH/ANS/0051	K/R/W	B	LR	MD	19	9	1
Mangwaro	Mango	*Mangifera indica* L	*Anacardiaceae*	UDUH/ANS/0003	R	F	LB	MD	2	3.9	7
Marke	Axlewood tree	*Anogeissus leiocarpus* DC	*Combretaceae*	–	SN	H	LB	MD	2	3.9	7
Sabara	Moshi medicine	*Guiera senegalensis* J.F Gmel	*Combretaceae*	UDUH/ANS/0013	K/R	B	LR	MD	5	9.8	4
Sanya	Coffee senna	*Securidaca longipedunculata* F	*Polygalaceae*	UDUH/ANS/0054	SN	H	L	M	1	1.1	8
Sanga-sanga	Violet tree	*Cassia occidentalis* L	*Caesalpinaceae*	UDUH/ANS/0023	R/W/K	B	LR	ID	5	9.8	4
Tafarnuwa	Garlic	*Allium sativum* L.	*Aliaceae*		K	F	S	E	1	1.9	8
Tafashiya	African peach	*Sarcocephalus russeggeri K. ex Sch*	Rubiaceae		SN	B	R	D	2	3.9	7
Taura	Boire	*Detarium senegalense* Sensu Auct	*Leguminseae*	UDUH/ANS/0045	R/K	B	RB	D	2	3.9	7
Taro	–	*Combretum sericeum* G. Don.	*Combretaceae*	–	SN	H	B	D	2	3.9	7
Tsamiya	Tamarind	*Tamarindus indica* L	*Leguminoseae*	UDUH/ANS/0027	W/K/R	B	RBS	D	7	13.7	3

Tumatur	Tomato	*Solanum lycopersicum* L.	*Solanaceae*	UDUH/ANS/0060	K	H	S	E	1	1.9	8
Tuna	Savanna woodland tree	*Pseudocedrela kotschyi* (Sch) H	*Meliaceae*	–	SS/K	B	R	D	3	5.8	6
Yadiya	Butterfly weed	*Asclepias tuberosa* L	*Asclepiadaceae*	UDUH/ANS/0019	K	H	LR	I	2	3.9	7
Yankufa	Sleepy morning	*Waltheria indica* L	*Malvaceae*	UDUH/ANS/0061	K	H	L	M	1	1.9	8
Zogale	Miracle tree	*Moringa oleifera* Lam	*Moringaceae*	UDUH/ANS/0022	K/R	B	LBR	ID	4	7.8	5
Zuma[a]	Honey[a]	–	–	–	K	H	–	–	–	–	–

Local name - Hausa language; LGA - Local Government Area (SS - Sokoto South, SN - Sokoto North, W - Wamako, R - Rabah, and K - Kware); EG – Ethnic Group (H – Hausa, F – Fulani and B - Both); PU – Parts Used, (L – Leaf, B – Bark, R – Roots, Sc – Sculp, F – Fruit); MP – Modes of Preparation (M – Maceration, D – Decoction, I – Infusion, E – Eat fruit); NC, Number of Citation; FC, Frequency of Citation; R, Ranking.

[a] Though not a plant, also mentioned by the herbalists.

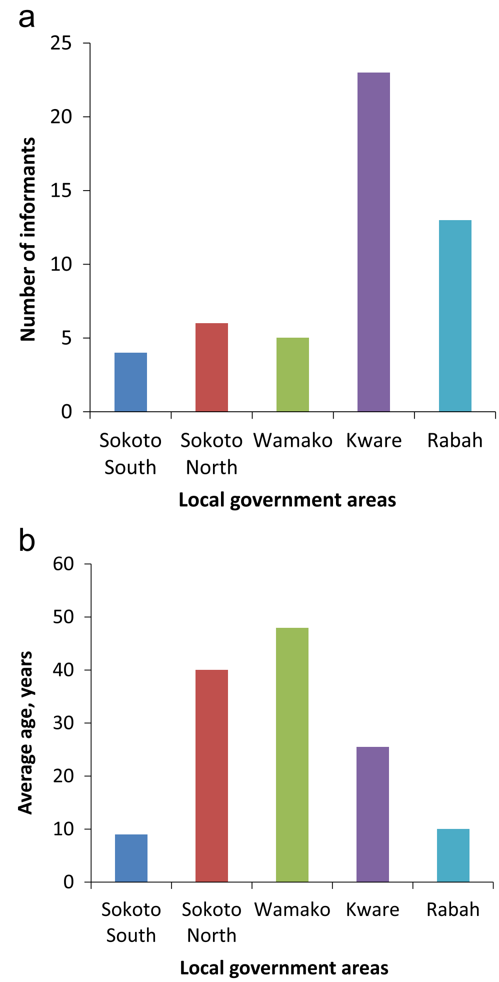

Fig. 3. (a) The number of informants interviewed in the study area, and (b) duration of practice of informants.

to a hospital. They also said that they often ask themselves for suggestions in case they tried a failed procedure.

3.4. Diagnosis, treatment and dietary recommendation

Most of the informants did not use modern methods for the diagnosis of the disease and their speculations about the disease were totally different from the scientific view. Some of them mentioned the disease related to the small intestine, while others said it was related to the liver. Only 5% of the informants said they send the patient to the laboratory prior to the treatment while the rest claimed to have diagnosed the disease either from the taste of urine or if flies are attracted to urine. Herbal practitioners hold a strong view that the disease was curable. Equally during the study, 9% claimed to have treated diabetic patients completely. On the aspect of recommendation, the informants said that after the treatment they did not recommend anything or restrict the patient to a particular type of food.

3.5. Modes of preparation and administration of herbal drug

As mentioned by the respondents, the herbal preparation of bark, root or leaves (Fig. 4, Table 1) was made by first shade-drying and then grinding the plant part to powder. One teaspoonful of the powder was then added to one cup of water or cow's milk or a locally prepared paste made from millet, either *koko* (pap) or *fura*, mixed and orally taken once or twice daily. Sometimes, the root or

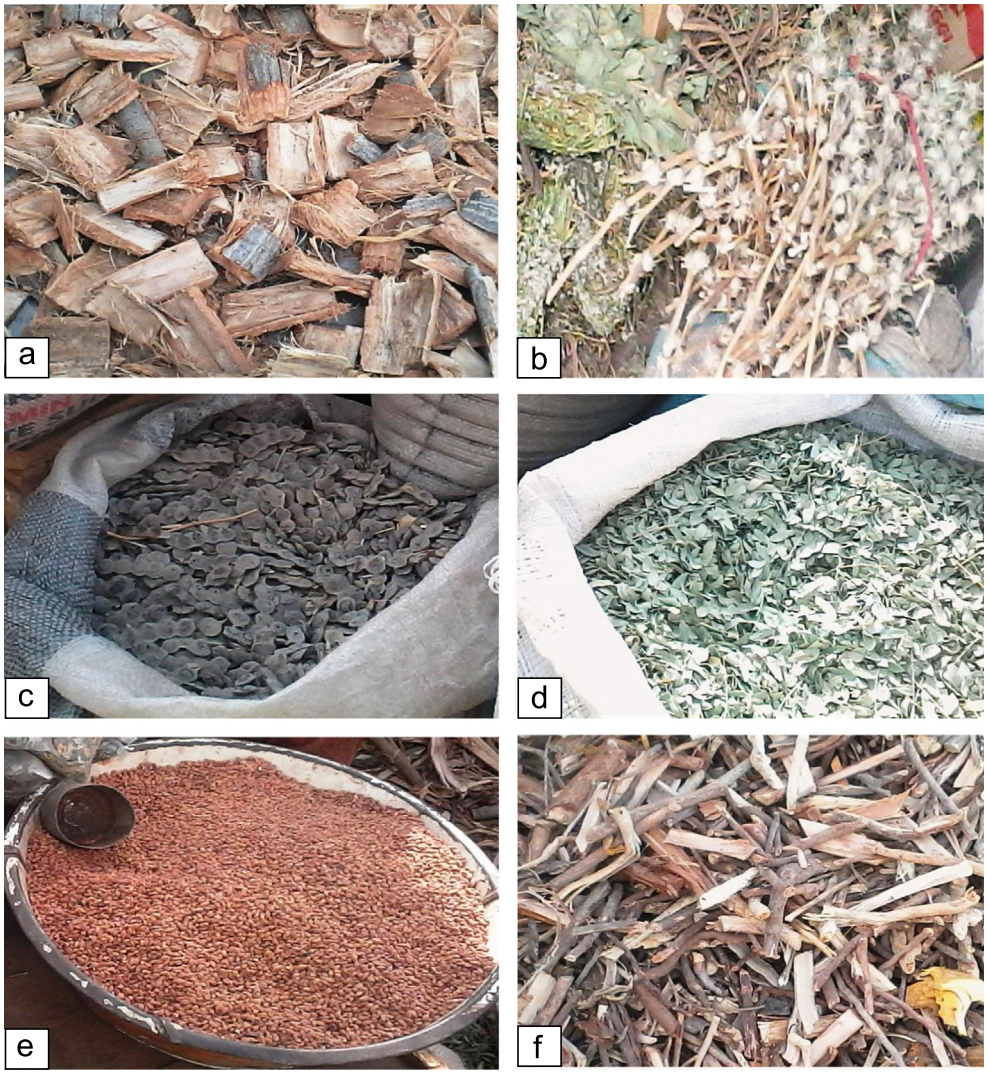

Fig. 4. Different ways in which medicinal plants are displayed in the market by herbalists in Sokoto; (a) bark, (b) whole plant, (c) whole seed, (d) leaves, (e) seeds and (f) roots.

bark, after drying, was reduced to appreciable size and then boiled overnight; a small piece of potassium carbonate (trona), *jar kanwa* was usually added during the preparation of decoction. After cooling, a medium size cup was advised daily. Maceration was also sometimes prepared from leaves of one or more plants and a medium size cup was advised daily, while fruits were eaten directly. Except for the honey, one teaspoonful was advised alone or in *fura* or *kunu* daily.

4. Discussion

The traditional system of medicine in a community is an integral part of the native population that continue to exist generation upon generation. As defined by WHO, traditional medicine is the total knowledge, skills and practices that are based on theories, beliefs and experiences indigenous to different cultures that are used to maintain health as well as to prevent, diagnose, improve, or treat physical and mental illness (WHO, 2008). It is considered to be an important part of culture, tradition and religion of peoples (Steenkamp, 2003; Mafimisebi and Oguntade, 2010). In northern Nigeria, Hausa and Fulani tribes are regarded as peoples with good knowledge of traditional medicine that involve the use of plants and other methods to cure diseases (Abubakar et al., 2007; Smith-Hall et al., 2012). Hausa and Fulani peoples are mostly farmers and hunters with wide knowledge of the preparation and use of plants and other methods to treat diseases (Mafimisebi and Oguntade, 2010). In traditional Hausa Fulani society, peoples with traditional knowledge of curing diseases are considered as traditional medical practitioners or healers. Herbalists on the contrary treat patients with herbal substances mostly and herb sellers sell herbs and may not necessarily have knowledge of curing the disease. The knowledge by which all of them practice is inherited and transferred generation upon generation within the family and varies community wise (Fig. 3). In this study, which comprises of 99% male informants (because of the socio-cultural reasons), Kware local government area provided the highest number of both informants and number of plant species listed by herbalists, followed by Rabah local government. In terms of the duration of practice, the mean years of experience in Wamako and Sokoto north was higher than the rest of the local governments in the study area (Table 1). The study also revealed that the Fulani informants (the dominant tribe in Sokoto) mentioned more number of plants (20) than Hausa informants (16); the rest were mentioned by both tribes (Fig. 3). An explanation could be the fact that majority of inhabitants of Sokoto state was largely Fulani. Intermarriages between Fulani and Hausa people are also common in the area, thereby increasing the degree of

resemblances in terms of culture, norms and values, as well as religion and traditions between the two tribes. This also could possibly explain the reason for high number (18) of medicinal plants mentioned by the two tribes together. Also Kware and Rabah LGAs recorded the highest number of plant species, 29 and 30, respectively, with Sokoto North having the least number (8), while Sokoto South and Wamako LGAs reported 9 species each.

In this survey, the inventory has demonstrated the richness in the medicinal plants of Sokoto which were commonly used by the traditional medical practitioners for the treatment of diabetes. Some of these medicinal plants mentioned by the informants included *A. indica*, *Mangifera indica*, *Allium sativum*, *Carica papaya*, *Abrus precatorius* which have been reported in ethnobotanical surveys conducted in Southwestern and Southeastern parts of the country as commonly used medicinal plants to treat diabetes (Abo et al., 2008; Ajibesin et al., 2008; Gbolade, 2009; Fred-Jaiyesimi et al., 2015). In addition to being reported in both the Southwest and Southeast as antidiabetic, *A. sativum* has also been documented in a study conducted in the South-southern region of the country (Ajibesin et al., 2008). Interestingly, some of these plants such as *A. indica*, *M. indica*, *A. sativum*, *C. papaya* with the addition of *Moringa oleifera* and *Anacardium occidentale* have been reported in other studies in Bangladesh (Kadir et al., 2012), India (Manikandan, 2005; Tarak et al., 2011; Tag et al., 2012), Kenya (Keter and Mutiso, 2012), South Africa (Semenya et al., 2012), Brazil (Trojan-Rodrigues et al., 2012) and Mexico (Cruz and Andrade-Cetto, 2015). This indicated conformity of the information provided by local herbalists in this study with what has been reported elsewhere for the treatment of diabetes. In another study, *M. indica*, *A. sativum*, *C. papaya*, *A. precatorius* and *Khaya senegalensis* were reported to be used traditionally for the treatment of hypertension (Gbolade, 2012).

Of the 54 species belonging to 33 families of medicinal plants listed by the herbalists in the questionnaires, *Leguminoseae* were the highest mentioned (8 times), followed by *Combretaceae* (5 times). Species of *Caesalpinaeceae* and *Meliaceae* families were also among the frequently mentioned antidiabetic plants in the study (Fig. 2). The data obtained during the study was analyzed and ranked on the basis of citation factor and frequency of citation (%) for each of the species was determined. Among the species listed, *Casia sieberiana* ranked highest 1 (39%) followed by *S. americana* 8 (15%), *F. exasperata* 8 (15%) and *A. indica* 8 (15%) (Fig. 2). The information was scanty on the antidiabetic potential of *C. sieberiana* which was the topmost ranked plant used for the treatment of diabetes in the study area. Further studies are required to justify the claim. On the other hand, *F. exasperata* was similarly reported in ethnobotanical survey carried out in the Southeastern part of the country and was reported to be used for the treatment of inflammation (Nwosu, 1998). Its hypoglycemic effect has been reported earlier (Adewole et al., 2011; Adewole et al., 2012). Neem tree, *A. indica* was also ranked second on the basis of citation index; the neem has been extensively used in India for its medicinal property which include antidiabetic (Saxena and Vikram, 2004), antibacterial (Thakurta et al., 2007) and insecticidal (Mulla and Su, 1999) activities. The antihyperglycemic effect of *Tamarindus indica*, which was also repeatedly mentioned by the herbalists, has also been reported by Maiti et al. (2004) and Yerima et al. (2014). Phytochemical screening of these plants is required to identify the active constituents for evaluating their mechanism of action in diabetes. Effect of active principles of *Mangifera indica, Dioscorea bulbitera* and *T. indica* in diabetes has been reported (Muruganandan et al., 2005; Gautam et al., 2012; Apontes et al., 2014), and is being evaluated to find out their possible antidiabetic role. Several plant-derived compounds are presently being considered for clinical trials because of their tremendous effects (Furst and Zundorf, 2014; Ghasemi Pirbalouti et al., 2014).

Literature analysis of all the 54 traditional antidiabetic medicinal plants reported in this study reveals that large number of these plants have been found to have good antidiabetic activity experimentally. Some of them like *Balanites aegyptiatica* (Morsy et al., 2010), *Terminalia macroptera* (Pham et al., 2014; Zou et al., 2014), *Hyphaene thebaica* (Salib et al., 2013), *Vitex doniana* (Oche et al., 2014), *Momodica balsamina* (van de Venter et al., 2008), *Pleurotus tuber-regium* (Huang et al., 2014), *Bridelia ferruginea* (Bakoma et al., 2014), *Adansonia digitata* (P et al., 2011), *Casia occidentalis* (Verma et al., 2010a; Verma et al., 2010b), *Pseudocedrela kotschyi* (Bothon et al., 2013), as well as *Citrus lanatus* (Teugwa et al., 2013) have exhibited significant *in vivo* as well as *in vitro* hypoglycemic effect. Antidiabetic principles from some of these medicinal plants have also been identified.

In the north, unlike in the Southern part of the country, although some of the plants mentioned in the study were also mentioned in the study conducted by Gbolade (2009), the modes of preparation were totally different. In the north, for example, most of the herbal drugs (mono or poly-herbal combinations) were sold in dried form (powder) by herb sellers. Mostly the crude drugs in the form of liquid from maceration or decoction were sold in market as herbal recipes (Gbolade, 2009). The powder is usually taken orally either in hot or liquid local preparations such as the hot pap, *fura* (combination of a paste made from cereal and cow's milk) or even cow's milk alone. Among the six parts of antidiabetic plants mentioned by the informants, root, bark and leaves were the most widely used (Fig. 4). The informants also made mention of an addition of red *kanwa* (a hydrated sodium carbonate) during preparation of decoction from roots and bark of the plants. This is usually a common practice in northern Nigeria in cooking hard substances in the form of food (Uzogara et al., 1990). Honey has also been mentioned by the informants as a supplement to herbal remedies. This has been reported as a support to the informants' claim in many studies especially in diabetic complications (Lotfy et al., 2006).

All the informants interviewed in this study were traditional medical practitioners (healers). Treatment methods that they employed were mostly home based methods where a patient visits the TMP which he/she was suggested by a relative or friend or has belief on him. The TMP usually interviews the patient (diagnosis) to understand the problem and then provides the drug (herb) related to the condition in sufficient quantity for the period before the next visit. Treatment continues based on appointment until the TMP is satisfied with the patient's condition. According to the informants, it was only in very rare circumstances when condition of a patient requires admission; then they admit the patient in their homes for a particular period. Most of the informants believed that diabetes can be cured completely so they do not recommend or restrict patient to a particular type of food. Informants also refer patients to most senior colleagues among them when patient's situation is not improving to available treatment methods known to that TMP. Few informants said that they occasionally sent patients to a laboratory for investigations prior to treatment.

Acceptance of herbal drugs shows an increasing trend even in the western world owing to general perception of less side effects and cost (Wilson et al., 2006). Plants have already found their place in the developing nations; they are used as a source for food and medicine, in addition to shelter and other traditional uses (Etkin and Ross, 1982). The major factor for their continued lack of acceptance, even though they are said to be less toxic than conventional drugs, is their lack of standardization. There is no way these herbal substances used by the TMPs could be standardized without knowing the components of crude drug, and then identifying the active chemical ingredient and establishing a proper mechanism of action. TMPs in most cases lack both proper

understanding of the disease and equally the scientific methods on how to justify their claim. They consider the knowledge with which they practice as a valuable asset and an avenue through which they derive their means of living and popularity. Thus, there is a great need to use all the means possible to go closer to these people in order to get the information on the medicinal plants as well as the methods they traditionally use to cure diseases. This will preserve the information and at the same time make it accessible to the scientific community who can then justify their claim.

People of Sokoto have been reported to show low incidence of type-2 diabetes (Sabir et al., 2013a). Coincidentally, most of the plants mentioned in this survey are used as source of food, apart from other economic uses (Etkin and Ross, 1982). This could possibly be one of the explanations for the low incidence of type-2 diabetes in Fulani nomads in the study area. On the contrary, prevalence of type-2 diabetes among urban Fulani in the study area is on the increase (Sabir et al., 2011; Sabir et al., 2013b), which could be due to their changing life style and food habit. High prevalence of diabetes was also reported among urban Fulani of Port-Harcourt in the south part of the country (Nyenwe et al., 2003). Dysglycaemia was higher among male Fulani individuals of northern Nigeria than female (Sabir et al., 2011). Since demography and food habit among native Africans have been associated with diabetes (Isezuo and Ezunu., 2005), we hypothesize that the habit of consumption of these herbs as food by the people of Sokoto might have contributed to the low prevalence of diabetes in rural areas. The study, however, requires further investigations.

5. Conclusion

This study reports 54 medicinal plant species from 33 families commonly used by the Hausa–Fulani tribes in Sokoto, northwestern Nigeria to treat diabetes. *C. sieberiana*, *F. exasperata*, *S. americana* and *T. indica* were among the most cited medicinal plants traditionally used as antidiabetic. Except for *S. americana* mentioned by Fulani informants, all four most cited medicinal plants were mentioned by both Fulani and Hausa informants as medicinal plants commonly used to treat diabetes in the area. Characterization of these medicinal plants will help in the identification of potential compounds that can be useful in the management of diabetes.

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