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Ethnobotanical study of medicinal plants used for the treatment of Diabetes mellitus in Sidi Bel Abbes region (North-west Algeria)

[Estudio etnobotánico de plantas medicinales utilizadas para el tratamiento de la diabetes mellitus en la región de Sidi Bel Abbes (noroeste de Argelia)]

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Abstract: An ethnobotanical study was conducted with the aim to identify the medicinal plants used for the treatment of Diabetes mellitus (DM) in Sidi Bel Abbes region (Northwest Algeria). Sidi Bel Abbes, known for its diverse ecological habitats, such as mountains, steppe, lake, and fertile plains with diverse medicinal plants. The data was collected through questionnaire and interviews with inhabitants and traditional healers. The results obtained revealed that 33 plant species distributed in 20 genera belonging to 21 families for the treatment of DM were used. The most represented families were Lamiaceae, Asteraceae, Myrtaceae, Fabaceae and Lauraceae. Medicinal plants commonly used were *Trigonella foenum-graecum*, *Olea europaea*, *Cinamomum cassia*, *Artemisia herba-alba*, *Lupinus albus*, *Juniperus communis*, *Rosmarinus officinalis*, *Prunus dulcis* and *Berberis vulgaris*. The study revealed that, leaves, followed by seeds and stem bark were mostly used parts. Also, decoction and infusion were the most frequently used method of preparation. This study confirms that most people with Diabetes mellitus in the study areas rely on traditional medicine for their primary health care needs.

Keywords: Ethnobotanical study; North-west Algeria; Diabetes mellitus.

Resumen: Se realizó un estudio etnobotánico con el objetivo de identificar las plantas medicinales utilizadas para el tratamiento de la Diabetes mellitus (DM) en la región de Sidi Bel Abbes (noroeste de Algeria). Sidi Bel Abbes, conocida por sus diversos hábitats ecológicos, como montañas, estepas, lagos y fértiles llanuras con plantas medicinales. Los datos se recopilaron mediante cuestionarios y entrevistas con habitantes y curanderos tradicionales. Los resultados obtenidos revelaron que 33 especies vegetales distribuidas en 20 géneros pertenecientes à 21 familias fueron utilizadas para el tratamiento de DM. Las familias más representadas fueron Lamiaceae, Asteraceae, Myrtaceae, Fabaceae y Lauraceae. Las plantas medicinales comúnmente utilizadas fueron *Trigonella foenum-graecum*, *Olea europaea*, *Cinamomum cassia*, *Artemisia herba-alba*, *Lupinus albus*, *Juniperus communis*, *Rosmarinus officinalis*, *Prunus amygdalus* y *Berberis vulgaris*. El estudio reveló que las hojas, seguidas de las semillas y la corteza de tallo, eran en su mayoría partes usadas. Sin embargo, la infusión y la decocción son el método de preparación más utilizado. El estudio reveló que las hojas, seguidas de las semillas y las partes del área, eran en su mayoría partes utilizadas. Tambien, la decocción y la infusión fueron los métodos de preparación más utilizado. Este estudio confirma que la mayoría de las personas con Diabetes mellitus en las áreas d'estudio dependen de la medicina tradicional para sus necesidades d'atenciónn primaria de la salud.

Palabras clave: Estudio etnobotánico; Noroeste de Algeria; Diabetes mellitus

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INTRODUCTION

Diabetes mellitus (DM) is one of the major causes of morbidity and mortality in the world. Alarmingly, the number of people with Diabetes continues to grow. Diabetes affects more than 100 million people each year (Baharvand-Ahmadi *et al*., 2015a). It has been estimated that the total numbers of patients with diabetes in the world will rise from 150 million in 2003 to 300 million in 2025 (Baharvand-Ahmadi *et al*., 2015b). However, this disease is the greatest public health problem, is considered as the silent epidemic of the 21st century (Larijani & Forozandeh, 2003). Diabetes now is becoming the third "killer" of humans along with cancer, cardiovascular and cerebrovascular disease (Donga *et al*., 2010). The term "Diabetes" referred to various diseases that are characterized by a marked increase in urine excretion, dehydration and excessive thirst (Calop *et al*., 2008). A person has Diabetes when the fasting blood glucose is greater than or equal to 1.26 g/l. Beside, DM is a chronic disorder that affects the metabolism of carbohydrates, fats, protein and electrolytes in the body due to an absolute or relative deficiency of insulin. Generally, DM is a chronic disease that occurs either when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces. It is also described by an abnormal increase in blood sugar level that causes glycation of the body proteins, which leads to complications such as diabetic nephropathy, neuropathy atherosclerosis, coronary heart disease and development of wounds (Rang *et al*., 1991). Other than organ complications, patients with Diabetes also suffer from various infectious diseases, such as foot and skin infection compared to patients without Diabetes. Diabetes is a major cause of blindness, renal failure, amputation, heart attacks and stroke. Over time, hyperglycemia, or raised blood sugar, is a common effect of uncontrolled diabetes and leads to serious damage to many of the body's systems. Diabetes is a treatable disease, however when it is not under control, the risk of some other diseases are very important, especially cardiovascular disorders. It is therefore a syndrome of disordered metabolism, usually due to a combination of hereditary and environmental causes, resulting in hyperglycemia due to defects in either insulin secretion or insulin action in the body (Elavarasi *et al*., 2013).

In this regard, it is estimated that patients with both diabetes and hypertension, the risk of cardiovascular diseases doubles. At the same time, obesity is associated with insulin resistance and is an important risk factor for heart diseases. Laligani *et al*. (2005), noted that exercising and losing weight have been proved to reduce blood pressure, and reduce the risk of cardiovascular diseases. Today, diabetes controlling is not only to keep blood glucose, lipid and pressure levels within a normal range, but also to prevent related complication and improve patient satisfaction and quality of life (Sarrafzadegan *et al*., 2013; Sarrafchi *et al*., 2015).

According to the cause of the disease (etiology), there are four types of DM, the most common type are Diabetes type one and two, type one Diabetes (ex-insulindependent IDDM) accounts for about 10% of all cases of Diabetes, most of them concern children, but it can occur at any age (Who, 2002). The latest WHO publication (global burden of disease) estimates diabetes in adults to be around 173 million, and around two thirds of these live in developing countries (Wild *et al*., 2003).

Generally, DM is a clinical condition characterized by increased blood glucose level (hyperglycemia) due to insufficient or inefficient insulin. On the other hand, Diabetic patients often have hyperlipidemia that is mostly associated with premature coronary heart disease. So, Diabetes has become a very common problem in our society, with human and financial impacts that need to be studied. Africa and Asia are reported as regions with conditions where Diabetics could rise above the predicted level (American Diabetes Association, 1997). Moreover, in Algeria Diabetes has become a major public health problem.

Before the discovery of insulin in 1921, diabetes controlling was referred to the prevention of early death from the disease (Baharvand-Ahmadi *et al*., 2016). Recently, management of Diabetes continues to be a challenge to the medical community. Similarly, numerous studies have shown that due to the inherent side effects of common oral hypoglycemic synthetic drugs, researchers are now intensifying efforts on alternative and complementary medicines to proffer lasting solution or at least control some harmful effects of synthetic drugs (Hoepelman *et al*., 2003), choosing specific antihyperglycemic agent, is predicated on their effectiveness in lowering blood glucose, extra glycemic effects that may reduce long-term

complications, as well as issues on safety, tolerability, and expense (Bahmani *et al*., 2014a). At the same time, various plants have been traditionally used throughout history to reduce blood glucose and improve Diabetes and its complications (Ziyyat *et al*., 1997). For a long time, medicinal plants have played a very important role to treat various disorders and ailments in people's health (Heredia-Diaz *et al*., 2018). Plants have been used as a medicinal agent since ancient times, first only on a folkloric basis and later developed on a scientific way into a single agent drug (Shuvasish *et al*., 2012). The use of plants as medicine is old as the history of mankind (Al-Douri *et al*., 2010; Parvaiz, 2014). Many countries throughout the world, including Algeria, have their own traditional systems of healing and depend on local folk remedies and traditional medicine to meet their needs and treat different diseases. In addition, the herbal remedies frequently, have higher acceptability than synthetic substitutes, due to their relative less side effects, effectiveness, and bio-medical benefits and relatively low cost. Nowadays, the use of herbal remedies as a way of treatment is still very important for human beings (Dolatkhahi *et al*., 2014). There are about 35.000 to 70.000 plant species that have been used for medicinal purposes worldwide (Rajaei & Mohamadi, 2012). The World Health Organization (WHO) has reported that about 80% of the world's population mainly depends on traditional medicine, and the use of plant extracts is mainly involved in the traditional treatment (Beverly & Sudarsanam, 2011). In recent years, plants as medicine play a significant role in the public health sector worldwide, as many cultures share a strong belief in their ability to cure certain diseases (Malviya *et al*., 2010). A large number of pharmacological researches on the antidiabetic effects of medicinal plants resulted in an increase in the number of people who use these natural compounds to control their disease today (Asadbeigi *et al*., 2014; Bahmani *et al*., 2014b). It was noted that before the discovery of insulin and other blood glucose lowering agents, traditional herbal remedies were used to treat diabetes and related complications. Recently, more than 1200 medicinal plants have been shown to possess antidiabetic activities (Asadbeigi *et al*., 2014; Karamati *et al*., 2014). At the same time, the antidiabetic effects of some of these plant species have been investigated in animal and humane models of diabetes. More so, plant derived products with anti-diabetic and other medicinal potential, are reported to be readily available, effective and affordable (Marles & Farnsworth, 1995; Olanipekun & Kayode, 2014). Ethnobotanical studies of traditional herbal remedies used for Diabetes around the world have identified more than 1.200 species of plants with hypoglycemic activity (Babu *et al*., 2006). At the same time, very few studies have investigated about the use of anti-diabetic plants in Northwest Algeria, especially this country has a long history of civilization as such the use of medicinal herbs is a heritage. In addition, Algeria is one of the richest floras in Africa, with several types of floras which were different according to their biogeographic origins: a Mediterranean flora, a Saharian flora and an endemic flora. Therefore, the indigenous communities have a significant knowledge about medicinal plants. The present study focused to identity the medicinal plants used by the local people of Sidi Bel Abbes region to treat DM, and the other hand to preserve the ancestral knowledge about anti-diabetic medicinal plants in this region. Amiri & Joharchi, (2013), noted that in many developing countries traditional medicinal knowledge and practices have not been adequately studied, exploited or documented. However, the documentation of local folk knowledge through ethnobotanical studies is essential for the conservation and utilization of these medical traditions

MATERIALS AND METHODS

Study area

Sidi Bel Abbes is the second big city in the Northwest Algeria with an area of 9150 km² and has a population of 325000 habitants. The study area has diverse ecological habitats, such as mountains, steppe, lake and fertile plains with diverse medicinal plants. It is bound on the Eastern side by Saida and Mascara, western side by Tlemcen, southern side by Naâma and northern side by Oran and Ain Temouchent (Figure No. 1). It has an elevation of around 800 meters above sea level. Sidi Bel Abbe is characterized by a Mediterranean climate and semi-arid bio-climatic, with a rainy season (January-March) and a dry season (May - August). The mean annual temperature is 37°C and the lowest annual mean temperature is 10.5°C. The mean annual rain fall is 367.5 mm, and the mean relative humidity is 85% (National Metrology Office, 2017). The majority of the people of the study area are rural

people with agricultural activity; hence the use of medicinal plants for different diseases, such as Diabetes is very common in Sidi Bel Abbes region.

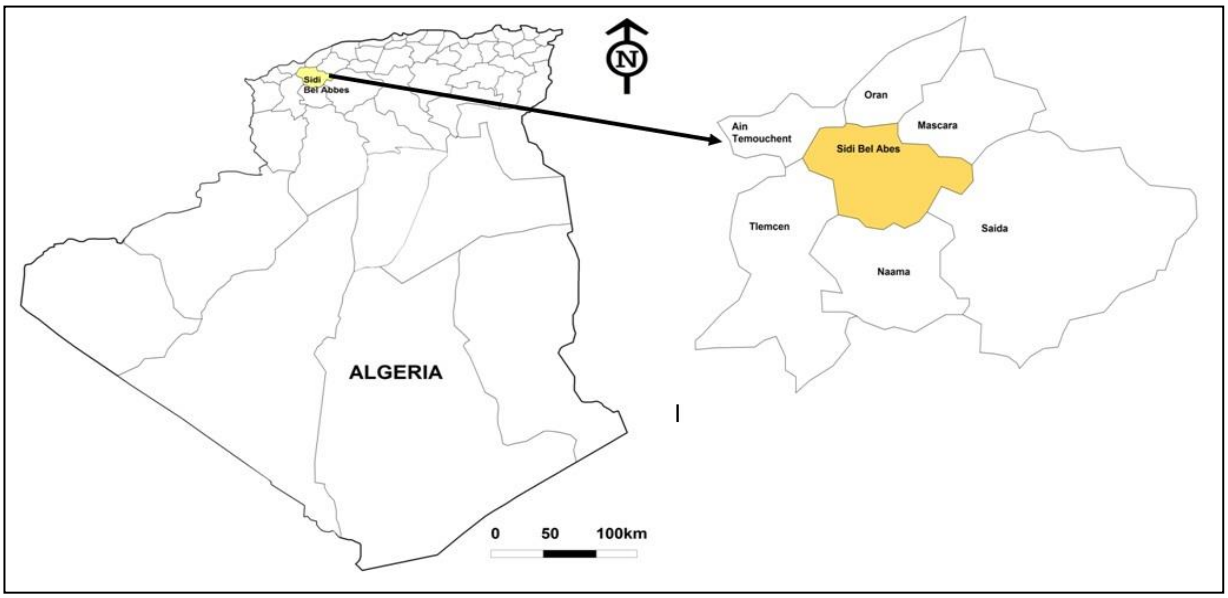

Figure No. 1
Geographical location of Sidi Bel Abbes region (Northwest Algeria) (Lakhdari, 2005)

Ethnobotanical data collection

The ethnobotanical research was carried out from February 2018 to May 2018, in order to obtain data on medicinal plants used to treatment of DM by the local people of Sidi Bel Abbes region. Data of medicinal plants were provided through interviews and questionnaires (face to face in Arabic) with people with DM, who had been diagnosed with a blood test lab and people having knowledge about traditional medicine. We noted, that the survey was performed among diabetic patients of the Diabetes service of the University Hospital of Sidi Bel Abbes city, is a governmental Hospital with different diseases services, among these services Diabetes service. During the survey all the diabetics patients how attend this service to obtain routine analyses such as blood glucose, glycated hemoglobin test and other measurements related to the diabetes, they were interviewed about their hypoglycemic synthetic drugs and if they use antidiabetic medicinal plants. Some patients, come to the hospital with people of different ages living in major cities and around the region, but originally from the study area without Diabetes, but they have more information about medicinal plants, they were interviewed about the antidiabetic medicinal plants used in the study area. On the other hand, we asked the traditional healers called (Achab), five existing in the study area and the old peoples in our family, about the medicinal plants used to treat DM. According to Mahwasane *et al*. (2013) the ethnobotanical surveys, including those conducted with patient interviews, are effective methods in documenting and identifying medicinal plants used in traditional knowledge systems. The questionnaire included questions about patient: age, gender, educational level, type of Diabetes. On the other hand, the plant species used to treat DM with their local names (Arabic name), scientific names, parts or organs plants used, methods of preparation and dosage, and if they collecting or buying. The questionnaire model was examined by the doctors of the Diabetes service of the University Hospital of Sidi Bel Abbes city, and by some doctors of Sidi Bel Abbes University. We noted at the same time, that the questionnaire does not contain the patients identity; in order do not affect patient privacy. However, participation in the survey was voluntary. Next, all the medicinal plants cited in the interviews

were collected and authentically identified with the help of some works on the flora of Algeria (Quezel & Santa, 1962; Quezel & Santa, 1963; Quezel, 2000), and by other works related to the flora of the study area (Lakhdari, 2005, Yousfi & Benbrika, 2008; Bendjeda & Abdelghani, 2009; Coulibaly, 2009). At the same time, a herbarium specimen from each plant was prepared, assigned a code and deposited in the herbarium of Eco- development laboratory, Faculty of Nature and Life Sciences of Sidi Bel Abbes University, Algeria. Finally, all the plants with anti-diabetic potential, they were arranged in the alphabetical order of botanical name followed vernacular name and family. The scientific names were validated in the Faculty of Nature and Life Sciences of Sidi Bel Abbes University.

Demographic characteristics of interviewees

A total of 133 informants including indigenous people with different ages and five traditional healers are participated in this study, and accept to inform about their traditional recipes. It was noted that 85 of informants are women (64%) and 48 are men (36%) (Figure No. 2), with their ages ranging from 20 to 75 years. Moreover, about 70% of the informants were more than 40 years old. At the same time, the people older than 55 years of age, have a frequency uses of medicinal plants (60%), followed by age categories (43 to 50 years), (25 to 40 years), with 25%, 10 %, respectively and finally the age of 20 years with (5%) (Figure No. 3). This finding indicates that the frequency of medicinal plant anti-diabetic use increased with age, similar results were observed in other studies (Jouad *et al*., 2001; Tahraoui *et al*., 2007; Abouri *et al*., 2012; Kpodar *et al*., 2015), how reported that the older people are the more active and experienced in the use of medicinal plants. Also, the old people specially women use and know more about medicinal plants than men and the young generation, at the same time, the ethnobotanical information that people have gained through centuries have been transmitted from generation to another, especially in the same family between women. Women said, that they obtained information's about medicinal plants from their mothers and grandmothers and traditional healers. However, some men obtained their medicinal herbal knowledge from their ancestors and some books about medicinal plants. These results reported that women are more attached than men to traditional medicine, and they have fundamental role in transmission of traditional medicinal herbal knowledge in our society. This finding was in line with the study of Ramdane *et al*., (2015) conducted in Hoggar (South Algeria), Morocco and other parts of the world (Ziyyat *et al*., 1997; El-Hilaly *et al*., 2003; Savo *et al*., 2011; Packer *et al*., 2012). Consequently, the traditional knowledge about medicinal plants and their uses in many regions of Algeria was disappearing recently with the new generations. The young generations in recent years, are not interesting to the medicinal plants. Our results are in accordance with other ethnobotanical studies carried out in Morocco and other Mediterranean areas (Jouad *et al*., 2001; Bousta *et al*., 2014). In was noted in this situation, that the traditional knowledge systems, either lost or transmitted orally from one generation to the next among traditional health practitioners, are in danger due to poor relations between older and younger generations (Al-Douri & Al-Essa, 2010; Ghasemi *et al*., 2013; Shah *et al*., 2013). On the other hand, the results shows, that the frequency of the use of medicinal plants was inversely related to the level of education of the interviewed population; generally illiterate (75%), primary education (15%), secondary education (9%), and finally university education (1%) (Figure 4). Similar findings were also reported in Morocco and other parts of the world, about the level of education of the interviewed population (Ziyyat *et al*., 1997; Eddouks *et al*., 2002; El-Hilaly *et al*., 2003; Savo *et al*., 2011; Packer *et al*., 2012; Tag *et al*., 2012). Finally, it was noted that more 60% of the diabetic patients in the study area, used plants as a complementary treatment to that prescribed by their doctors. This shows the belief and the place occupied by medicinal plants among the diabetic patients in Sidi Bel Abbes region. Generally, people believe that traditional herbal medicines are safer without side effects than synthetic drugs. Moreover, the people in the rural areas of Algeria have more accessibility to herbal products, and they used medicinal plants for many ailments, including diabetes then the urban peoples.

DISCUSSION

Table No. 1, enumerate the data obtained during the ethnobotanical study. In terms of the important number of plant cited with family, Lamiaceae is the most predominant family of ethnomedicinal importance with eight species (*Lavandula*

angustifolia, *Lavandula stoechas*, *Marrubium vulgare*, *Mentha spicata*, *Ocimum basilicum*, *Origanum vulgare*, *Rosmarinus officinalis*, *and Salvia officinalis*). It was followed by Asteraceae with five medicinal plants (*Artemisia absinthium*, *Artemisia herba-alba*, *Dittrichia viscosa*), Fabaceae, Lauraceae and Myrtaceae with two medicinal plants for each family respectively (*Lupinus albus*, *Trigonella foenum-graecum*), (*Cinnamomum cassia*, *Laurus nobilis*), (*Eucalyptus globulus*,*Myrtus communis*), other families; Amaryllidaceae, Amaranthaceae, Berberidaceae, Theaceae, Cucurbitaceae, Apiaceae, Globulariaceae, Cupressaceae, Brassicaceae, Apocynaceae, Ranunculaceae, Oleaceae, Nitrariaceae, and Anacardiaceae are represented with one species. Similar findings were observed in Hoggar (South Algeria) (Bnouham *et al*., 2006; Bahmani *et al*., 2014a), and in other ethnobotanical studies carried out in Morocco, Egypt, Turkey and other Mediterranean areas (Phillips *et al*., 1994; Pieroni *et al*., 2006; Samira *et al*., 2006; Durmuşkahya & Öztürk, 2013); they noted that Lamiaceae and Asteraceae are the most families documented in ethnobotanical studies. Recently, Ramdane *et al*. (2015), found that Lamiaceae followed by Asteraceae were the most predominant families of medicinal species used in extreme South of Algeria.

The results, revealed that 33 plant species are used to treat DM in Sidi Bel Abbes region; according to the results, many plants species with anti diabetic activities are used by the communities of Sidi Bel Abbes region, which represents a good indicator of the profound knowledge on herbal plants held by the local people, they opined that traditional medicines are highly effective for the management of DM, comparatively to the high cost of the synthetic drugs. Although, the modern health care system is easily accessible everywhere in Algeria, but many people believe in alternative medicines. Moreover, in Sidi Bel Abbes region, *Origanum vulgare*, *Lavandula stoechas*, *Dittrichia viscusa*, *Artemisia absinthium*, *Peganum harmala* and *Nerium oleander* are wild species. On the other hand, *Allium sativum*, *Olea europoea*, *Prunus dulcis*, *Mentha spicata*, *Ocimum basilicum* and *Trigonella foenum-graecum* are widely cultivated by the rural peoples of the study area. These results confirm that the flora of the North-west Algeria was very diverse, which was attributed to the geographical characteristic of the study area. Algeria is one of the richest Arab countries with 3164 plant species (Vasisht & Kumar, 2004). Additionally; Algeria is a Mediterranean country with a very rich and diversified potential medicinal flora. Furthermore, the climatic conditions coupled with varied ecological habitats and ecosystems, have contributed positively to the development of important floristic richness. Felidji *et al*. (2010) noted that the Algerian climate (Mediterranean climate) and its soils result in the development of rich medicinal and aromatic flora. However, a few ethnobotanical studies have been carried out Algeria (Benarba *et al*., 2015; Ramdane *et al*., 2015), but it is clear from the results that traditional healers continue to play a significant role in our communities.

In agreement with the present results, several studies have shown the hypoglycaemic activities of some medicinal plants found in our study; *Eucalyptus globulus*, *Salvia officinalis* growing in Algeria, have 96% of alcoholic leaf extracts and they have a significant blood-glucose, lowering potential in glucose loaded rats with minimum toxicity (Houacine *et al*., 2012). *Artemisia absinthium* leaves, have antidiabetic action and can be used as a supplement in the management of diabetes (Busineni Jayasimha & Chikka, 2016). Moreover, *Allium sativum* are used widely to treat diabetes, the hypoglycaemic effect of *Allium sativum*, attributed mainly to allicin-type compound and sulphur compound [di (2-propenyl) disulphide and 2-propenyl propyl disulphide, respectively]. The mechanism of hypoglycaemic action probably involves direct or indirect stimulation of insulin secretion (Carson, 1987). *Artemisia absinthium* produce significant hypoglycaemic activity in both normal and diabetic animals, which could be compared to Metformin (Sabeeha & Nahida, 2013). *Trigonella foenum-graecum*, *Atriplex halimus*, *Olea europaea*, *Allium sativum*, *Nigella sativa*, and *Cinnamomum cassia* were tested for their antidiabetic properties; results indicate that these plants have anti-diabetic properties (Kadan *et al*., 2013). *Salvia officinalis* was commonly used to treat diabetes in Algeria, due to their antidiabetic activities (Sarri *et al*., 2014). On the other hand, *Olea europaea*, *Citrullus colocynthis* and *Allium sativum*, have antidiabetic effects due to various herbal components such as phenolics, tannins, saponins and alkaloids have antidiabetic properties, flavonoids and phenolic components are characterized as the main blood glucose lowering components (Benarba, 2015).

Rashmi & Rahul (2011) confirmed the vital role of *Trigonella foenum-graecum* on diabetes due to the insulinotrophi and antidiabetic properties, which have been associated with the amino acid 4-hydroxyisoleucene that occurs in fenugreek by about 55%. Generally, the extracts, powder and gum of fenugreek seeds and leaves are reported to have shown anti-diabetic and hypocholesterolemic properties during the clinical trials within animals as well as humans (Abdel Barry *et al*., 1997; Al Habori & Raman, 1998; Vats *et al*., 2001). Furthermore, the extract of *Lupinus albus* exhibited a marked antihyperglycemic activity (Knecht *et al*., 2006); the antidiabetic effect of the plant may be attributed to the presence of an active protein: Conglutin-γ. On the hand, De Bock *et al*. (2013), found that the dried leaves of *Olea europaea* contain minimum 5% of Oleuropein, but the olive leaf extract supplementation, is associated with a reduction in the glucose and insulin excursion after oral glucose challenge, suggesting an improvement in both pancreatic b-cell function and insulin sensitivity. At the same time, Kaeidi *et al*. (2011) conclude that olive leaf extract inhibits high glucose-induced neural damage and suppresses diabetes-induced thermal hyperalgesia. Basak & Candan, (2013) have been identified 29 compounds representing 99.18% of the total oil of *Laurus nobilis* 1,8-cineole (68.82%), 1-(*S*)-α-pinene (6.94%), and *R*-(+)- limonene (3.04%), which were determined to be the main components and the essential oil and 1,8-cineole inhibit α-glucosidase by competitive inhibition, but 1-(*S*)-α-pinene and *R*-(+)-limonene are uncompetitive inhibitors. Moreover, the essential oil obtained from Laurel leaves, it's the main components inhibit α-glucosidase, for this it's a main components could be effective in the treatment of diabetes by scavenging reactive oxygen species and inhibiting α-glucosidase. Ziyyat *et al*. (1997) noted that *Citrullus colocynthis* have also an antidiabetic activity, due to their constituents; pectic, colocyntheim, gym, fixed oil albuminoids, colocynthetin and colocynthis fruits, have been prescribed in order to reduce blood glucose in traditional systems of medicine of many countries. The mechanisms by which these plants lower blood are related directly to various herbal components such as phenolics, tannins, saponins and alkaloids, have antidiabetic properties, flavonoids and phenolic components are characterized as the main blood glucose lowering components (Wainstein *et al*., 2012). Furthermore, flavonoids can be effective in improving the blood glucose indexes via their antioxidant activity (Song *et al*., 2005). Regarding hydro alcoholic extraction of nettle could lead to rebuild β-cells in pancreas via its antioxidant characteristics. On the other hand, tannin and carotenoids, as nettle's constituents could be effective in improving blood glucose indexes (Mangels *et al*., 1993). Generally, the biological activities of some of Algeria medicinal plants are known already from other studies that were carried out elsewhere (Atmani *et al*., 2009; Atmani *et al*., 2011; Chelli-Chentouf *et al*., 2012; Bouzabata *et al*., 2013). Finally, it has been shown that various herbal components such as phenolics, tannins, saponins and alkaloids have antidiabetic properties, flavonoids and phenolic components characterized, are the main of blood glucose lowering components (Wainstein *et al*., 2012; Allen *et al*., 2013).

Regarding the mode of preparation of medicinal plants (Figure No. 5), different mode have been adopted in the treatment of Diabetes mellitus in the study area, but overtime the most application is decoction and infusion which is the most frequently used methods of preparation adopted from leaves, seed and aerial parts, followed by maceration method from fruits and bulb. Generally, decoction and infusion methods by using water to extract the active component for later drinking as teas. Our results are similar to those reported in other region of Algeria and Morocco (Ziyyat *et al*., 1997; Eddouks *et al*., 2002; Tahraoui *et al*., 2007; Benarba, 2016). Additionally, decoction and infusion as preparation methods for herbal medicines are very simple, economic, and quickly methods. The aerial parts and the bark are usually air dried and pulverized (Heredia-Diaz *et al*., 2018). However, the dosages and the frequency of treatment are not standardized, but they depend on the decision and folk experience of the herbalist and old women. On the other hand, it was observed that the most plants anti-diabetic were found to be used singly, but in few situations the combination of different plants and parts in the preparation of anti-diabetic herbal remedy is used by the peoples with DM, they believed that some plants enhance the action of other herbs. The use of more than one plant species to prepare a remedy to treatment of DM; is attributed to the additive or synergistic effects that they could have (Bussmann & Sharon, 2006). In the study area; all the preparations

of the ant-diabetic medicinal plants are given orally, because the oral route is the most comfortable for the administration and the most widely used by the population. Similar finding were reported in other region of Algeria and Turkey (Durmuşkahya & Öztürk, 2013; Benarba, 2016).

About the plants parts used in treatment of DM, it was observed that different parts plants are commonly used by the peoples of Sidi Bel Abbes, however, the leaves were the most frequently used parts, followed by seeds and finally stem bark (Figure No. 6). Recently, Benderradji *et al*. (2015) demonstrated that in South-east of Algeria, leaves were the most commonly used parts in the treatment of different ailments. These results are in accordance with what found in studies conducted in other parts of the world (Terruzzi *et al*., 2011; Yabesh *et al*., 2014; Thomford *et al*., 2015), which reported the predominant use of plant leaves followed by flowers, fruits and stems. The predominance of leaves in herbal therapies, may be attributed to their abundance in the nature, and their richness in secondary metabolites produced by photosynthesis. Many researchers noted the predominance of leaves in herbal therapies; De Bock *et al*. (2013), noted that the dried leaves of *Olea europaea*, contain minimum 5% of oleuropein. Leaves and seeds *Trigonella foenum-graecum*, may contain or accumulate the pharmacologically active agents of these plants (Mowla *et al*., 2009; Hamza *et al*., 2012). Leaves of *Olea europaea*, contain several potentially bioactive compounds that may have hypoglycemic properties in both human diabetic subjects (Jemai *et al*., 2009; Wainstein *et al*., 2012). On the other hand, collection of leaves would be much easier and sustainable than roots or flowers (Offiah *et al*., 2011), they collected in larger quantities when compared with other plant parts (Heredia-Diaz *et al*., 2018). Besides, the collection and the mode of preparation of medicine from leaves are much easier than other parts of the plant (Giday *et al.*, 2009). In addition, the presence of high amount of chemicals compounds in leaves, which could be easily extracted and used in different forms (Imran *et al*., 2014). Generally, the leaves and the bark of plants have been reported to accumulate tannins and other alkaloids (Okoegwale & Omefezi, 2001), which may be responsible for their medicinal properties and explain their wide use (Focho *et al*., 2009).

Table No. 1
Medicinal plants used against Diabetes Mellitus in Sidi Bel Abbes region

Scientific name	Family	Vernacular Name	Used parts	Mode of preparation
Allium sativum L.	Amaryllidaceae	Thoum	Bulb	Maceration
Artemisia absinthium L.	Asteraceae	Chhiba	Aerial parts	Decoction and Infusion
Artemisia herba-alba Asso.	Asteraceae	Chih	Aerial parts	Decoction and Infusion
Atriplex halimus L.	Amaranthaceae	Gtaf	Leaves	Infusion and Decoction
Berberis vulgaris L.	Berberidaceae	Ghriss	Bark	Decoction and Infusion
Camellia sinensis (L.) Kuntze	Theaceae	Tay lakhdar	Leaves	Infusion
Cinnamomum cassia (L.) J.Presl	Lauraceae	Korfa	Bark	Decoction
Citrullus colocynthis (L.) Schrad.	Cucurbitaceae	Hantal	Fruits	Maceration
Cuminum cyminum L.	Apiaceae	Kamoun	Seeds	Infusion
Eucalyptus globulus Labill.	Myrtaceae	Kaliptous	Leaves	Infusion
Globularia alypum L.	Globulariaceae	Tasselgha	Leaves	Infusion
Dittrichia viscosa (L.) Greuter.	Asteraceae	Magraman	Bark	Decoction
Juniperus communis L.	Cupressaceae	Araar	Leaves	Infusion and Decoction
Laurus nobilis L.	Lauraceae	Rand	Leaves	Decoction
Lavandula angustifolia Mill.	Lamiaceae	Khozzama	Leaves and Flowers	Infusion and Decoction
Lavandula stoechas L.	Lamiaceae	Halhal	Leaves	Decoction
Lepidium sativum L.	Brassicaceae	Hab el-rchad	Seeds	Decoction
Lupinus albus L.	Fabaceae	Tarmess el lmor	Seeds	Decoction

Marrubium vulgare L.	Lamiaceae	Mariwat	Aerial parts	Infusion and Decoction
Mentha spicata L.	Lamiaceae	Naanaa	Leaves	Infusion
Myrtus communis L.	Myrtaceae	Rayhan	Leaves	Infusion
Nerium oleander L.	Apocynaceae	Dafla	Leaves	Decoction
Nigella sativa L.	Ranunculaceae	Sanouj	Seeds	Decoction
Olea europoea L.	Oleaceae	Zaytoun	Leaves	Decoction
Ocimum basilicum L.	Lamiaceae	Hbak	Leaves and Fruits	Infusion
Origanum vulgare L.	Lamiaceae	Zaater	Leaves	Decoction and Infusion
Peganum harmala L.	Nitrariaceae	Harmal	Seeds	Decoction
Prunus dulcis (Mill.) D.A.Webb.	Rosaceae	Louz el lmor	Fruits	Powder
Pistacia lentiscus Desf.	Anacardiaceae	Dharo	Leaves	Infusion and Decoction
Rosmarinus officinalis L.	Lamiaceae	Iklil el djabel	Leaves	Decoction and infusion
Ruta Montana L.	Rutaceae	Fidjel	Aerial parts	Infusion and Decoction
Salvia officinalis L.	Lamiaceae	Marimia	Leaves	Infusion
Trigonella foenum-graecum L.	Fabaceae	Halba	Seeds	Decoction and Infusion

Table No. 2
The main photochemical compoundd relative to the antidaibetic activity of some antidiabetic medicinal plants

Plant species	Phytochemical compound	References
Allium sp	Quercetin (phenol)	Kumari *et al*., 1995
Artemisia herba-alba (Asso)	Glycosides, coumarins, alkaloids, flavonoids, phenolics, terpenes.	Awad *et al*., 2012
Allium sativum	Allicin (di-(2-propenyl)disulphide, sulphur (2-propenyl propyl disulphide), phenolics, tannins, saponins and alkaloids	Busineni Jayasimha & Chikka, 2016; Benarba, 2015
Cinnamomum sp.	Cinnamaldehyde (phenol)	Al-Dhubiab, 2012
Citrullus colocynthis	phenolics, tannins, saponins, alkaloids, colocyntheim, gym, fixed oil albuminoids, colocynthetin	Benarba, 2015; Ziyyat *et al*., 1997.
Lupinus albus	active protein (Conglutin-γ)	Knecht *et al*., 2006
Laurus nobilis	essential oil: 1,8- cineole 1-(S)-α-pinene, R-(+)- limonene	Basak & Candan, 2013
Olea europoea L.	Oleuropein (polyphenol), phenolics, tannins, saponins, alkaloids	De Bock *et al*., 2013; Benarba, 2015
Trigonella foenum-graecum L.	4-hydroxyisoleucene (amino acid)	Rashmi & Rahul, 2011

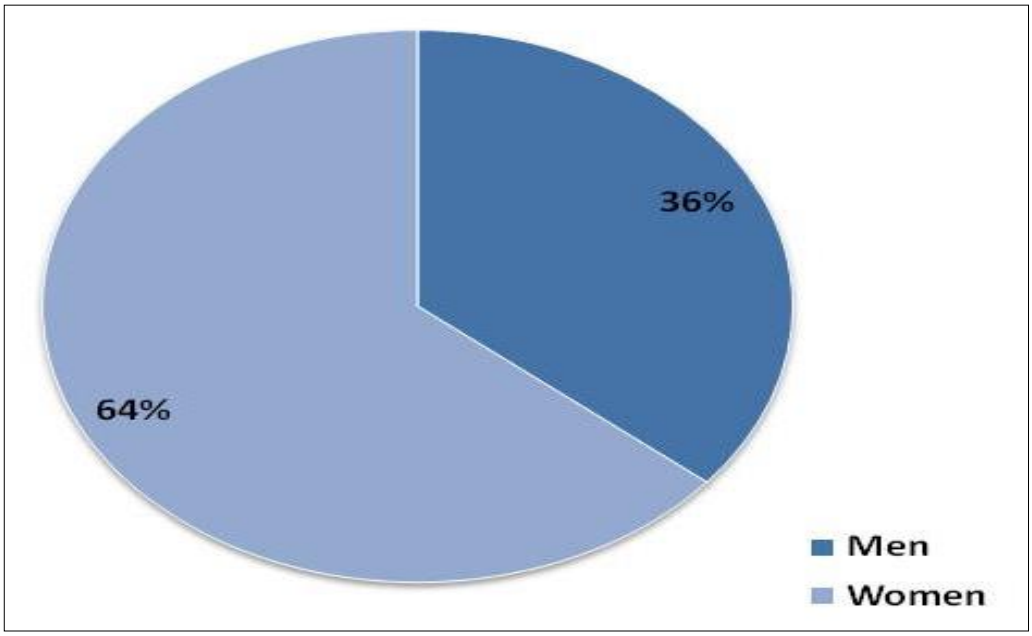

Figure No. 2
Percentage of use of medicinal plant with antidiabetic activity between sexes in Side Bel Abes region

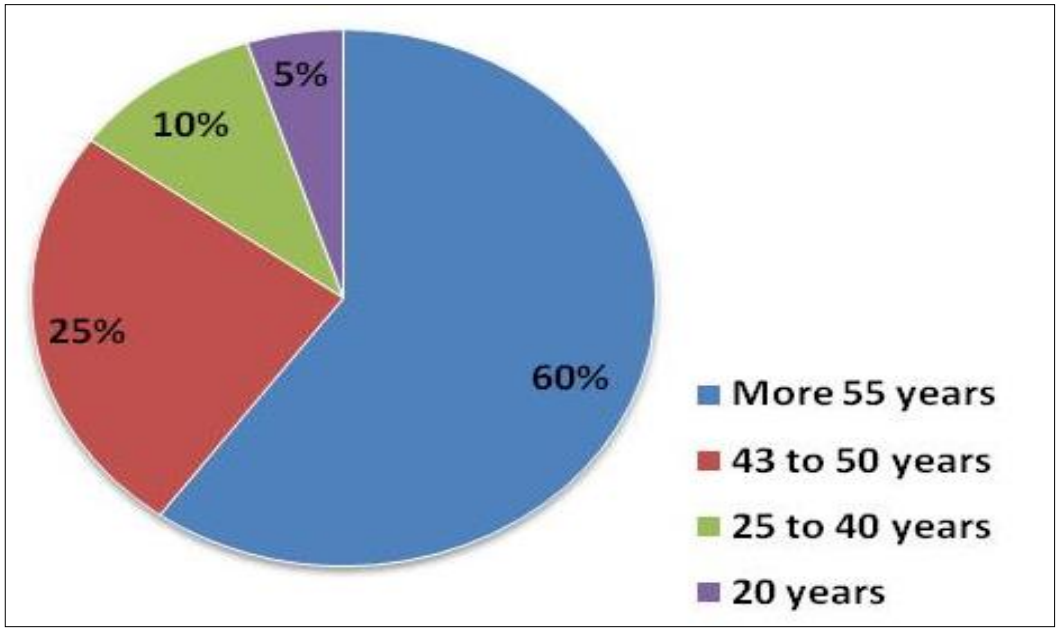

Figure No. 3
Percentage of medicinal plant anti-diabetic use with age category in Side Bel Abes region

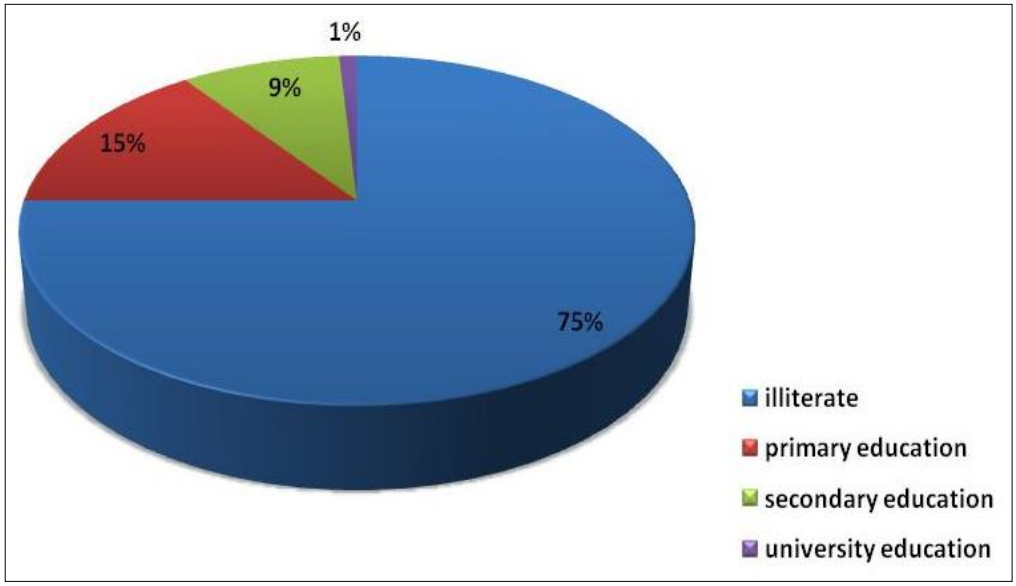

Figure No. 4
Percentage of medicinal plant antidiabetic use with the level of education in Side Bel Abes region

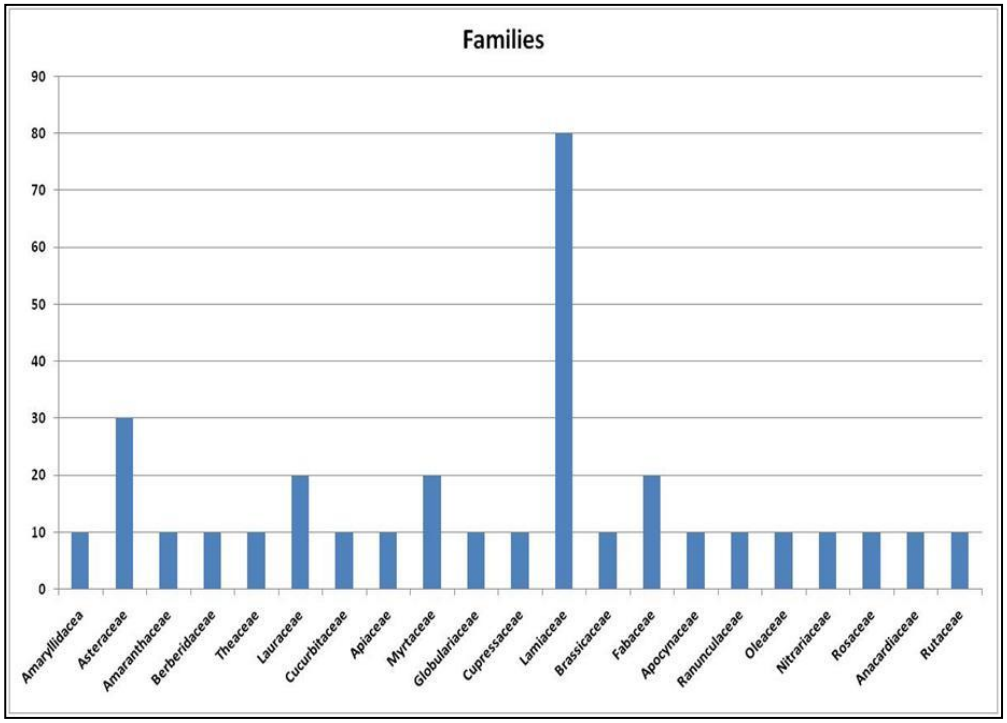

Figure No. 5
Frequency of medicinal species per botanical family.

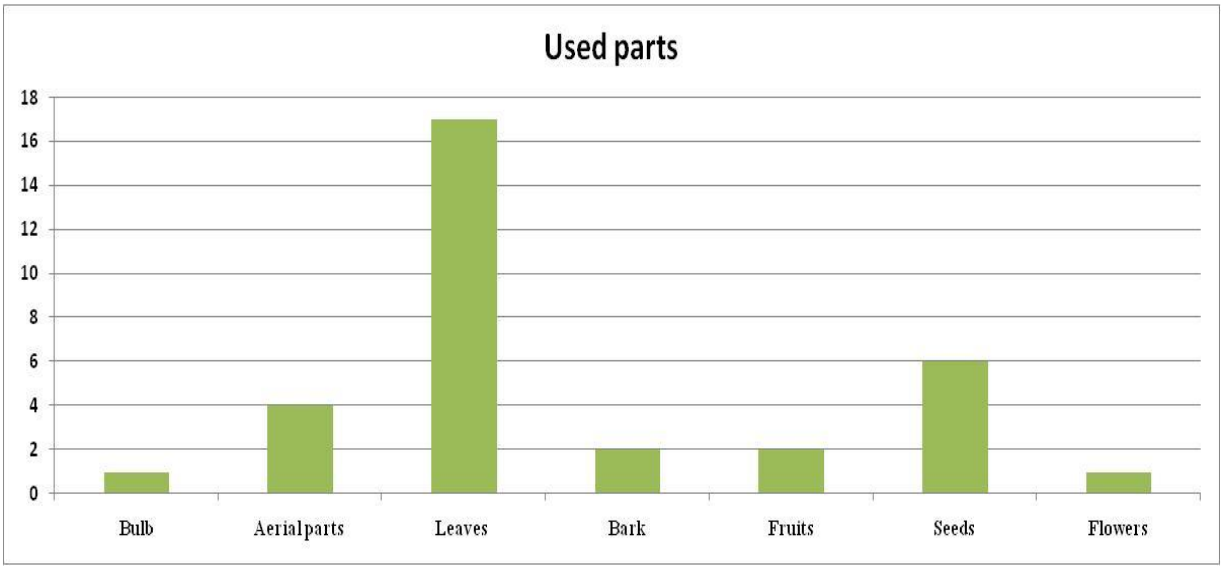

Figure No. 6
Frequency of plant parts reported to be used in preparation of Diabetes mellitus remedies.

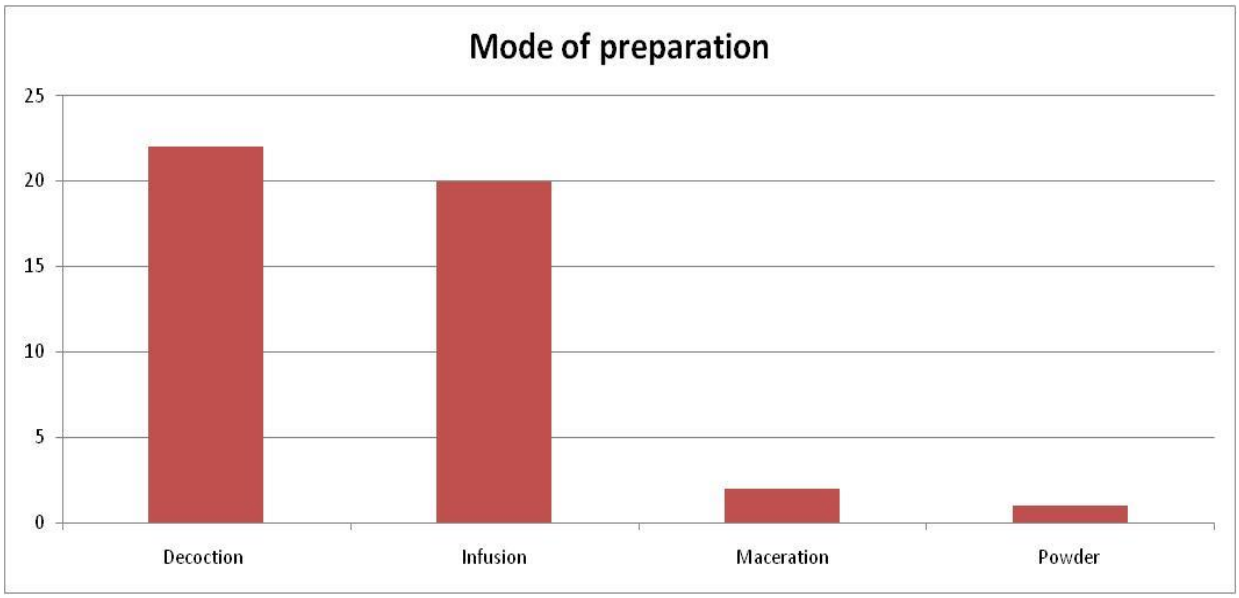

Figure No. 7
Frequency of methods preparation of medicinal plants used in treatment of Diabetes mellitus in Sidi Bel Abbes region

CONCLUSION

Diabetes mellitus (DM) is a major endocrine disorder with serious complications. Hence, the coverage of medical expenses becomes a real social problem, especially in developing countries, where the low economic system induces insufficient resources. Thus, the need to identify and explore the medicinal plants with antidiabetic activity became a necessary. In this context, an ethnobotanical study has been conducted in Sidi Bel Abbes region (north-west Algeria) with the aim to identify the medicinal plants used by the native people to treat DM. A total of 33 medicinal plants grouped in 21 families were identified in the study area. The plants most frequently used were *Trigonella foenum-graecum*, *Olea europoea*, *Cinamomum cassia*, *Artemisia herba-alba*, *Lupinus albus*, *Juniperus communis*, *Rosmarinus officinalis*, *Prunus amygdalus* and *Berberis vulgaris*. *Nerium olender* is noted for the first time to treat DM in Sidi Bel Abbe region. So, it is recommended that the indigenous knowledge about antidiabetic medicinal plants needs to be protected. At the same time, the priority should be given to the conservation of the existing medicinal plants and their habitats.

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