Natural and Applied Sciences International Journal (NASIJ)
eISSN: 2788-4619 (online)
https://doi.org/10.47264/idea.nasij/3.1.4
Vol. 3, No. 1, (January-June 2022), 45-60
https://www.ideapublishers.org/index.php/nasij Research Article

Ethnopharmacological evaluation of medicinal plants used to treat diabetes mellitus in Maidan valley, Dir Lower, Pakistan

Muhammad Ali[1] | Muhammad Wahab[2] | Latif Ahmad*[2] | Imran Ahmad[1] | Andrew J. Semotiuk[3] | Hammad Ahmad Jan[4]

1. Department of Botany, Shaheed Benazir Bhutto University Sheringal, Sheringal, Dir Upper, Pakistan.
2. Department of Botany, Women University Swabi, Swabi, Khyber Pakhtunkhwa, Pakistan.
3. Department of Botany and Plant Sciences, University of California, Riverside, California, United States.
4. Department of Botany, University of Buner, Sowari, Buner, Khyber Pakhtunkhwa, Pakistan.

* Corresponding Author Email: latifahmad1989@wus.edu.pk

Received: April 5, 2022 Accepted: June 15, 2022 Published: July 2, 2022

Abstract:
This ethnopharmacological investigation aims to collect, identify, and document distinguishable medicinal plant species and remedies used by the local people for the management of diabetes in the Maidan valley in the district Dir Lower, Khyber Pakhtunkhwa, Pakistan. The local people of the valley have relied on botanical antidiabetic herbal formulations. The ethnobotanical interviews, questionnaires, inquiries, and group discussions were conducted from March 2019–January 2022 to obtain traditional knowledge from the local people. Quantitatively, ethnopharmacological data were analysed using indices, Relative Frequency of Citation (RFC) and Use Value (UV). The study identified 42 plant species belonging to 36 genera and 27 botanical families. Most of the species belong to Poaceae, while leaves were the most frequent morphological parts used. In this study, powder was the primary mode of herbal formulation. The highest RFC value was 0.47 obtained for Ziziphus nummularia (Burm.f.) Wight and Arn, and the highest UV was 0.97 for Sarcococca saligna Mull Arg. Local communities of the area use a large number of plant species for diabetes shows the importance of herbal formulation in the basic human ailments of this remote area. In future studies, we hope these medicinal plants will be further phytochemically screened for new antidiabetic properties.

Keywords: Poaceae, Ziziphus, Sarcococca, ethnopharmacology, morphology, botanical formulation, antidiabetic formulation, herbal formulation, human ailments.

How to Cite: Ali, M., Wahab, M., Ahmad, L., Ahmad, I., Semotiuk, A. J., & Jan, H. A. (2022). Ethnopharmacological evaluation of medicinal plants used to treat diabetes mellitus in Maidan valley, Dir Lower, Pakistan. *Natural and Applied Sciences International Journal (NASIJ), 3*(1), 45-60. https://doi.org/10.47264/idea.nasij/3.1.4

1. Introduction

Since antiquity, native flora has been used for medicines, food, fuel, construction, and many other purposes (Tardío *et al.*, 2006). During this time, different traditional systems like Chinese traditional medicine and Ayurvedic system of medicines have employed medicinal flora and their derivatives as main sources of new phytochemical and have been clinically practiced throughout the world (Fabricant & Farnsworth, 2001). According to a recent research study in Pakistan, approximately 50,000–60,000 tabbies registered and also a huge number of unregistered precautioners are scattered in mostly remote and rural hilly areas (Khan *et al.*, 2018). In Pakistan, nearly 80% of the population lives in rural households where Ethnomedicine are available easily. While unavailability of modern health facilities and lower income situations in the remote rural areas limits the access of local people to modern medications (Kayani *et al.*, 2014). Early people used medicinal plants for the management of human health issues. The healing power of plants has been respected for ages and throughout history, man trusted them for food, medicines, clothing, transportation, and (Simpson, 2009). Currently, many plant species are used extensively either in developed or underdeveloped countries as home remedies (Burns *et al.*, 2010). Drugs from natural sources like animals and plants play a crucial role in drug development in addition to traditional medicine (Sicree *et al.*, 2006). According to the World Health Organization (WHO), nearly 80% of the world population depends on traditional medicines. While another study reported that 25% of secondary metabolite of the plants are used against active infectious diseases (Ferner & Aronson, 2006; WHO, 2015; Punthakee *et al.*, 2018).

The diabetes mellitus is increasingly predominant and continues to be a leading health burden globally, with consistent increases in mortality due to the various complications associated with the disease, such as heart disease, coronary nephropathy, and neurodegeneration (Salleh *et al.*, 2021). Nowadays, diabetes is one of the prevalent chronic disorders in the metabolism of fats, carbohydrate, and proteins in human body. It is described as an increase in blood glucose after any type of meal. Insulin deficiency or malfunction is the main cause of diabetes (Modak *et al.*, 2007). According to a research report in 2015, more than 150 million people are suffering from diabetes worldwide which seems to reach 300 million by 2025 (Tzeng *et al.*, 2015). It is well established that risk factors for diabetes mellitus have found strong association with high intake of fats and carbohydrates (Khatib, 2014). The diabetes mellitus is classified into three types based on duration of life, diabetes type-I which is also termed as insulin dependent or familial diabetes that most frequently occurs in children, diabetes type-II or insulin non-dependent diabetes and gestational diabetes which occurs in pregnancy (Olokoba *et al.*, 2012; Bodeker & Ong, 2005).

The diabetes epidemic is much more prevalent in the Indian subcontinent including Pakistan. According to Unwin *et al.* (2011), predominance of diabetes in adults between the ages of 20 and 79 is as follows: Pakistan 6.72%, Bangladesh 9.85%, India 8.31%, Sri Lanka 7.77%, and Nepal 3.03%. According to the International Diabetes Federation in 2019, approximately 700 USD billion global expenditure on diabetes to control and similarly the adverse effects of conventional drugs consumption for longed time attract the natural treatment like medicinal plants are gaining popularity for prevention of this health burden (Bolen *et al.*, 2007). From early time, it has been known that medicinal plants naturally contain therapeutic properties for various human as well as animal ailments, has been used for generation to generations, and play a very important role in leading modern medications to where it is now (Salleh *et al.*,

2021). The consumption of native plants for medicinal purposes has a long history and still they are being used extensively for the management of various human ailments (Rao *et al.*, 2010). Recently, the use of medicinal plants for the treatment of human diseases are increasing day by day and several plants are investigated for antidiabetic activities across the world (Moradi *et al.*, 2018). Pakistan is one of the high diseases burden countries and the WHO ranked Pakistan as 7th in the prevalence of diabetes. Practices regarding medicinal plants vary from country to country and area to area (Ahmad *et al.*, 2015).

Currently, the documentation of medicinal plants and their uses needs immediate attention. The documentation of the medicinal plants helps to conserve the information for use of these medicines as prospective therapeutics (Bandaranayke, 2006). Preservation and documentation of traditional knowledge are very important because it seems that this knowledge is at risk of extinction due to several reasons. These include industrialization, loss of biodiversity, loss of natural habitats, the migration of people from rural to urban areas, and due to changing lifestyle (Jeyaprakash *et al.*, 2017). Therefore, the present research work is carried out with an aim to identify the collected medicinal plants used by the indigenous communities for the treatment of diabetes mellitus ethnopharmacologically and also document the herbal formulation, vernacular names, and uses of these medicinal plants. We hope that the results of this research study will reveal the importance of documentation of indigenous knowledge as well as native medicinal flora for the development of ethnomedicinal remedies to treat basic human health issues. Moreover, it is hoped that the current study will provide a background for the investigation of phytochemical and pharmacological studies that are key for the development of alternative treatments for anti-diabetic purposes.

2. Materials and methods

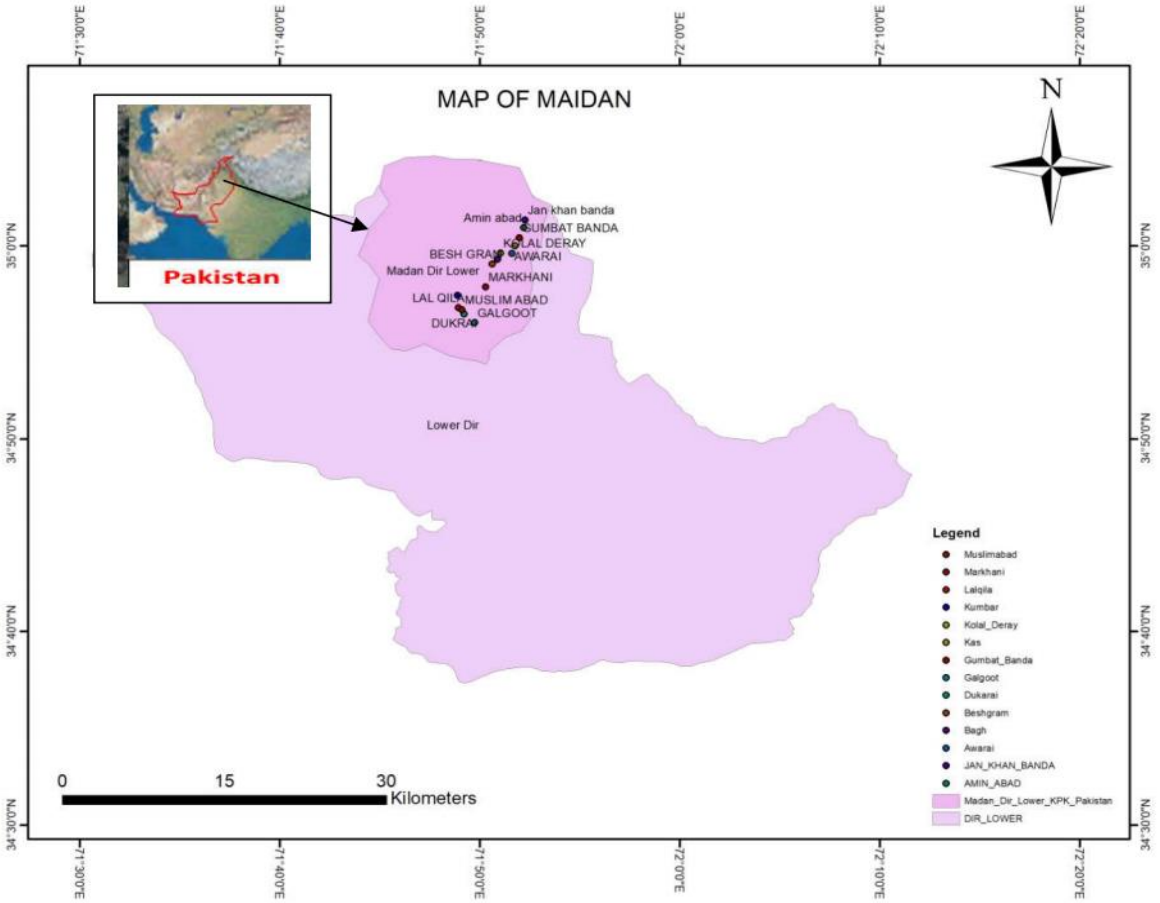
2.1. Study area

The current study was conducted in Maidan Valley located in district Lower Dir, Khyber Pakhtunkhwa, Pakistan. Lower Dir is 134 Km away from Peshawar and its west boundary connects it with Afghanistan, east with district Swat, and north with Upper Dir. The range of elevation of Maidan from sea level is 5150 feet. It coordinates are 35°01’2” N and 71°52’6” E in degree minute seconds. The Lower Dir district has got all the four seasons in rest of all the highest rainy month is March 243.22 and minimum rainfall is in July and November, due to enormous rainfall the area has a great diversity of plants throughout the whole district. The current study included 14 villages of Maidan Lower Dir, Pakistan.

Maidan is connected in the north with Dir Upper, south with Timergara, Khall, Baroon, and east with Sahib Abad north-west with Barawal Bandai and west with Jandool (figure 1). Majority of the area of the Maidan Valley is covered with thick vegetation. The major cultivated plants of Maidan valley are *Triticum aestivum, Zea mays, Saccharum officinarum, Oryza sativa, Curcubita maxima, Hibiscus esculentus, Lycopersicon esculentum, Allium cepa, Allium sativum* etc. The fruits growing in the area includes *Citrus medica, Jugloons regia, Diospyrous lotus, Prunus persica, Punica granatum, Malus Pumila* and *Vitus vinifera.* The most common Gymnosperms are *Pinus roxburghii, Cedrus deodara,* and *Taxus baccata*. While the common angiosperms species are *Celtis australis, Isodon rugosus, Quercus incana, Mentha viridis, Acacia nilotica, Dodonaea viscosa, Justicia adhatoda, Tagetes minuta, Chenopodiastrum murale, Amaranthus viridis, Salvia officinalis, Ajuga bracteosa,* and

Lamium album. Pterodophytes also noticed in the area are, *Pteris cretica, Pteris vittata, Thelypteris palustris, Adiantum incisum, Adiantum capillus-veneris, Adiantum caudatum, Cheilanthes subvillosa,* and *Pteridium revoltum* (Irfan *et al.*, 2018).

Figure 1: Study area map



2.2. Field survey

Regular Ethnopharmacological surveys were arranged from March 2019 to January 2022 in 14 villages of the Maidan valley, with the aim to document, report, and collect traditional knowledge from the native inhabitants. The main and initial target was the local *Hakims* and the objective of the study was explained to them to study treatment of diabetes mellitus in the district. Before starting the ethnobotanical interview and group discussions, we informed local inhabitants that the present investigation regarding diabetes is a student academic project and it is only for our research purposes, not for any economic, commercial or other benefits. Moreover, we strictly followed the code of ethics of International Society of Ethnobiology during this study.

2.3. Data collection form and interview

The duration of study was 6 months, March 2019 – January 2022. A total number of 85 participants were interviewed in 14 villages (Muslimabad, Markhanai, LalQila, Kumbar, KolalDeray, Kas, Gumbat Banda, Galgoot, Dukarai, Beshgram, Bagh, Awarai, Jan Khan Banda, and Amin Abad). Local inhabitants were contacted and invited to express their

knowledge regarding native medicinal plants for an interview. All the ethnobotanical interviews and group discussions were conducted in the local language Pashto. Most of them were illiterate and also of low-income. Only a small number of individuals were literate. The most frequently asked questions were about the vernacular names of the plants along with the medicinal properties and parts used, dosage form, route of administration and preparation of the herbal remedies.

The research work was approved for ethics by the research committee of the Botany Department. The interviewer guided both socially and ethically and they took permission for an interview from the elders of the area. The peoples of the area were extremely cooperative. A total number of 85 participants were involved in the interviews. The researcher met with the participants and the average time for interviews was 15 minutes. In this study, all those plants which were reported by the local informants were included. The maximum number of female participants was excluded due to the local cultural norms.

2.4. Collection, identification, and preservation of plants

A total of 42 plants were collected from 14 various sites of the Maidan Lower Dir. The researcher selected suitable season for the plant collection in which the flora completely developed. Whole plants were collected in case of small plants, leaves of the trees, roots and other parts were also collected depending upon the usage feasibility. The species' information was recorded in a special type of field notebook along with their local name, habitat, collection date, parts of the plants etc. The collected plants were brought to the Botany Department of Shaheed Benzir Bhutto University Sheringal, Upper Dir to the subject specialist Latif Ahmad Ph.D (Ethnobotanist) to identify the unknown species by using their taxonomical expertise. After collection, the plants were pressed, dried and mounted onto herbarium sheets.

2.5. Analysis and documentation of the data

Data was recorded collected analyzed and tabulated using Microsoft excel.

2.5.1. Use value (UV)

UV shows the relative importance of medicinal species and its utility to the informants (Gairola *et al.*, 2013) The UV can be calculated by the following formula:

$$UV = (\sum Ui) / N$$

In the equation Ui is use reports mentioned by number of participants, *i* is the number of informants and N is the number of all informants.

2.5.2. Relative Frequency Citations (RFC)

RFC is a quantitative index that gives us the local importance of a plant species in ethnobotanical research and investigation. Vitalini *et al*. (2013) used the standard method for finding the RFC value as follows.

$$RFC = (0 < RFC < 1)$$

In the above equation, FC is the number of times a species was mentioned as medicinally, and N shows the total number of participants as informants in interviews.

3. Results and discussion

3.1. Demographic distribution of the participants

In this study, a total number of 85 participants were interviewed about the traditional use of medicinal plants in the Maidan area. The age range of informants varied from age 20–80 years in which from 20–30 (14.1%), 30–40 (27.2%), 40–60 (35.2%), and 60–80 (23.5%). The number of participants in interviews were most commonly in the age range of 40–60. The reason behind this range is that it is also the common age range for diabetes mellitus. Regarding gender, 44 (97.8%) were male and only 1 (2.2%) was female. The low number of female informants was due to social and cultural norms of the area. The majority of interviewed people in the area were illiterate (table-1).

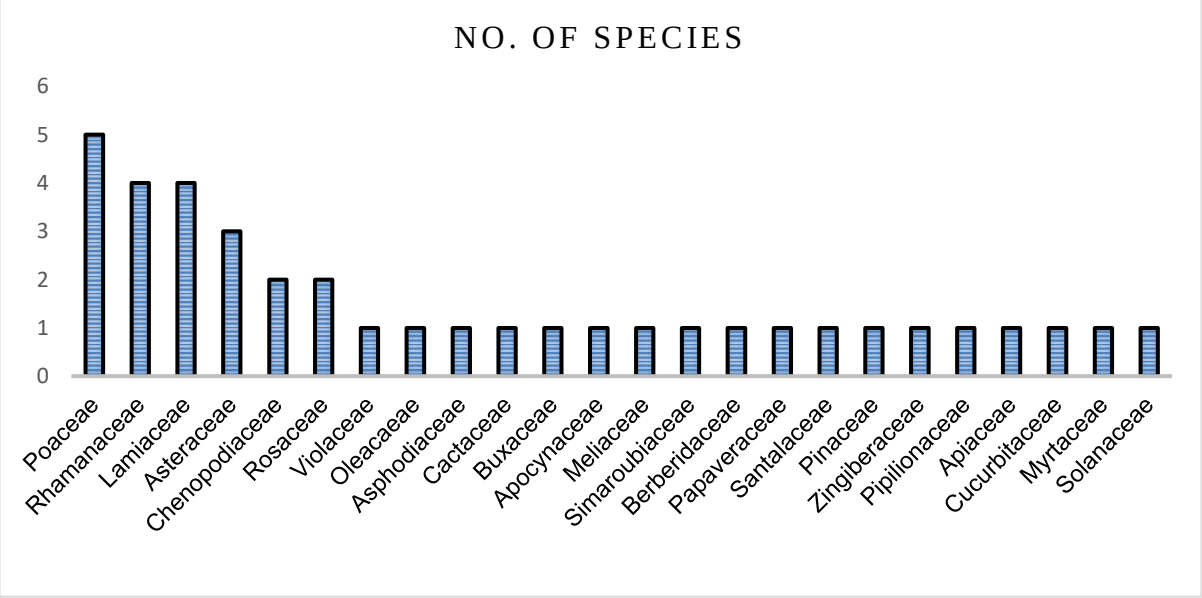
Table-1: Participants' information

S.No	Age	Address of the participants	Interview time	Participants	Percentage (%)
1	20-40	Gumbatbanda	10 minutes	12	14.1
2	20-40	Various areas	15 minutes	23	27.2
3	40-60	Various areas	20 minutes	30	35.2
4	60-80	Various areas	15 minutes	20	23.5
Total				85	

3.2. Diversity of medicinal plants and their growth form

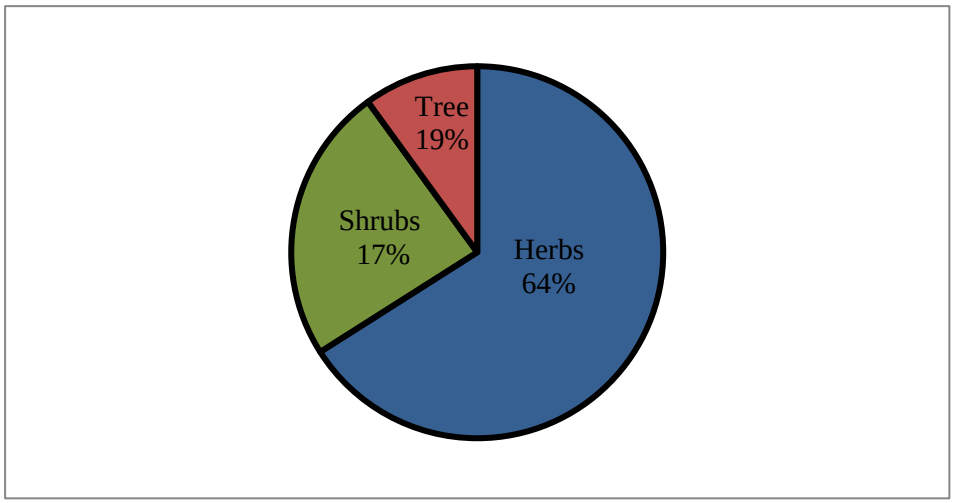
In the present study, the total number of medicinal plant species were 42 in which 36 genera and 27 plant families were represented. The most widely used families were Poaceae with 5 species, followed by Rhamnaceae and Lamiaceae (figure 2).

Figure 2: Medicinal plants families in our studies



In this study, the life form of medicinal plants documented were herbs 64%, trees 19% and shrub 17% (figure 3).

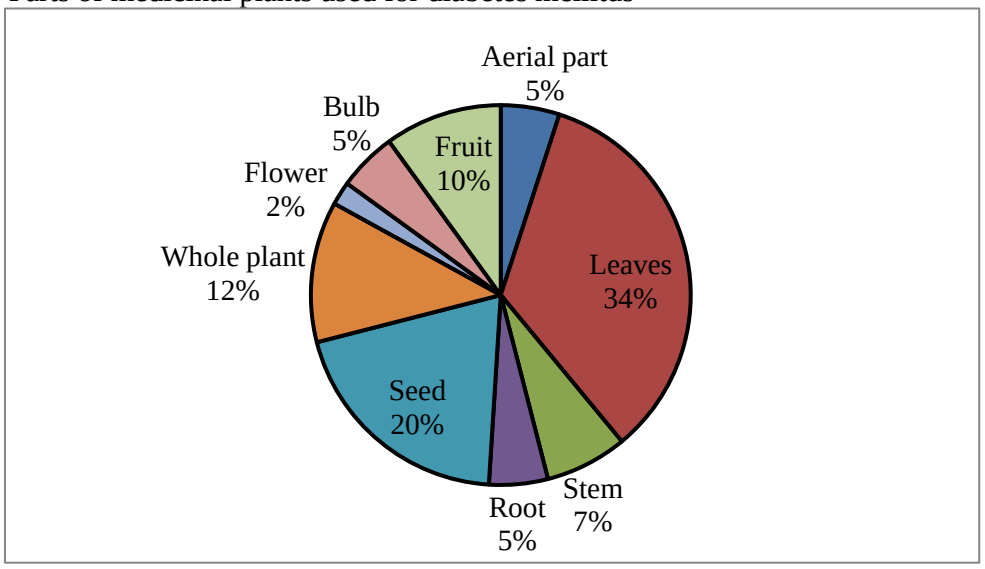
Figure 3: Life forms of medicinal plants



3.3. Morphological parts, cultivation, and mode of preparation of medicinal plants

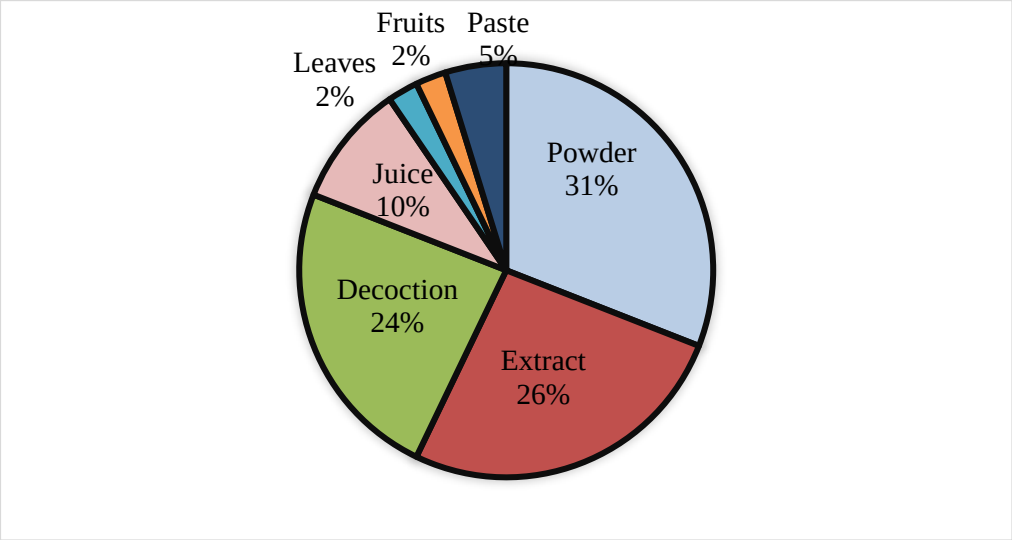
In this study, various parts of the medicinal plants used by the people of Maidan for remedies of diabetes mellitus like roots, stems, seeds, flowers, aerial parts, rhizomes, fruits, and whole plants. This is the first investigation undertaken in the Maidan area to find medicinally active plants against diabetes mellitus. In our study, the most prominently used one was leaves, followed by seed and whole plants (figure 4). The most frequent use of leaves is because it is the photosynthesis centre in green plants, that's why it has high potential for healing (Ahmad *et al.*, 2015). The leaves of plants are generally considered safer than roots, seeds and fruits (Ghimire *et al.*, 2008; Giday *et al.*, 2003).

Figure 4: Parts of medicinal plants used for diabetes mellitus



In this study, all administration routes for medicinal plants were oral except *Calotropis procera* which was used locally the on skin. The most frequently used preparations were powder 31% because it can be easily prepared. Other preparations included extract 26%, decoction 24%, juice 10%, and paste 5% (figure 5).

Figure 5. Dosage form base classification of the mentioned plants



Most Pakistani use extracts orally. This is most frequently done on an empty stomach in diabetes mellitus and this trend is similar to allopathic products (Mahmood *et al.*, 2011). Most of the plants were used in powder and decoction form. Only *Calotropis* was used locally like a bandage on the skin. The reason for the powder form was that it is the market form made available by the herbalists. Sometime the ingredients were used in mixtures to form effective use (Islam *et al.*, 2013).

3.4. Relative importance of medicinal plants: use value (UV) and Relative Frequency of Citation (RFC)

The UV is used to observe the importance of single species of the plant. If the UV is near to 1 for medicinal plants, it means the plant is extensively medicinally active and if it approaches 0 it means the plant is less medicinal valued in the local community. In the present study, most of the plants in the range from 0.97 to 0.02 and were divided into two main categories on the basis of UV ranges: Class 1 having high UV and medicinal value, the range selected for these plants in first class ranges from 0–0.5 in which the common plants were 30 (71.4%) including *Glycine max, Oryza sativa, Zea mays, Ziziphus oxyphylla, Sagertia thea, Ocimum basicillicum, Ocimum album, Ocimum sanctum, Taraxacum officinale, Prunus dulcis, Rosa alba, Melia azedarach, Pinus wallichiana, Psidium guajava, Daucus carota, Allium cepa, Cicer arietinum, Opuntia dilleni* species and in second class the UV ranges 0.6–1 the plants in this range includes 12 species (28.5%) like *Hordeum vulgare, Triticum aestivum, Ziziphus jujuba, Ziziphus nummularia, Ajuga bracteosa, Cichorium intybus, Artemisia annua, Chenopodium ambrosioides, Chenopodium botrys, Ailanthus altissima, Berberis lycium Momordica charantia, Olea ferruginea, Solanum nigrum, Foeniculum vulgare, Allium sativum, Zingiber officinale, Calotropis gigantea, Viola canescens, Aloe vera, Sarcococca saligna, Valeriana officinalis, Viscum album*. The plants in the range 0–0.5 cannot be ignored but can be explored

by future generations and can be evaluated phytochemically for Pharmacological studies (Ahmad *et al.*, 2015).

On the basis of FC value, the plants were divided into 2 categories, 0–20 and 20–45. In 0–20 the common plants includes *Hordeum vulgare, Glycine max, Oryza sativa, Triticum aestivum, Ziziphu soxyphylla, Sagertia thea, Ocimum basicillicum, Ocimum album, Ocimum sanctum, Cichorium intybus, Prunus dulcis, Rosa alba, Chenopodium botrys, Berberis lycium, Pinus wallichiana, Olea ferruginea, Psidium guajava, Daucus carota, Solanum nigrum, Foeniculum vulgare, Zingiber officinale, Cicer arietinum, Viola canescens, Aloe vera, Opuntia dilleni, Taraxacum officinale Ailanthus altissima Allium cepa* while in second category the crucial plants includes *Zea mays, Ziziphus jujuba, Ziziphus nummularia, Ajuga bracteosa, Artemisia annua, Chenopodium ambrosioides, Viscum album, Melia azedarach, Momordica charantia, Allium sativum, Calotropis gigantea, Sarcococca saligna, Valeriana officinalis.*

Similarly, on the basis of RFC, species were divided into 2 groups i.e., 0.2 is the first category and 0.2–0.5 is second category. In first category, the plants include *Hordeum vulgare, Glycine max, Oryza sativa, Triticum aestivum, Ziziphu soxyphylla, Ocimum basicillicum, Ocimum album, Ocimum sanctum, Cichorium intybus, Prunus dulcis, Rosa alba, Chenopodium botrys, Berberis lycium, Fumaria vaillantiivar, Pinus wallichiana, Oleaferruginea, Psidium guajava, Daucus carota, Solanum nigrum, Foeniculum vulgare, Zingiber officinale, Cicer arietinum, Viola canescens, Opuntia dilleni, Taraxacum officinale Allium cepa*andin. Second category include *Zea mays, Ziziphus jujuba, Ziziphus nummularia, Sagertia thea, Ajuga bracteosa, Artemisia annua, Chenopodium ambrosioides, Viscum album, Ailanthus altissima, Melia azedarach, Momordica charantia, Allium sativum, Calotropis gigantea, Aloe vera, Sarcococca saligna, Valeriana officinalis.*

In this study, some plants were previously phytochemically detected while some need to be screened out for further development of new drugs for mechanistic studies. Moreover, in present study, some plants are unique to use for diabetes mellitus like *Calotropis gignatea* leaves and *Valiriana officinalis.*

3.5. Adverse effects of the plants

In most of the cases the excess use of the herbal drugs is considered to have harmful effects (Ahmad *et al.*, 2015). When the dose of herbal products increases more than the limit it causes serious adverse effects. The special evidence arose when some clinicians mistakenly advised the toxic species *Aristolochia* in Belgium in which 100 patients suffered from renal failure and some people died (Teng *et al.*, 2006). In present study, 9 species were toxic in which 2 were poisonous, one species may cause pollen allergy and the remaining 6 species were considered hyperglycemic in large doses (because of high glucose concentration). For example, *Aloe vera* in large doses may leads to hypoglycemia and *Chenopodium ambrosiodes* causes convulsions (Ahmad *et al.*, 2015).

4. Conclusion and future directions

From this research study, we conclude that the native people of the Maidan Valley in the district of Lower Dir depend on Ethnomedicine in their daily lives for the management of basic human ailments. This work showed that consistent traditional knowledge of medicinal plants used in

the treatment of diabetes existed in the study area and remains in active use. To the best of our knowledge, the present investigation to document medicinal plants for the treatment of diabetes mellitus is the first report in Dir Lower Maidan. From this study, 42 plant species were used to treat diabetes. The result of the study clearly indicated that the most dominant family was Poaceae. The plant part which was commonly used to treat diabetes was leaves. Several species were recorded for the first time to use for the management diabetes mellitus such as *Calotropis procera* and *Valiriana officinalis*. The current survey also focused on information obtained about medicinal plant uses, vernacular names and other ethnobotanical information directly from local people of the Maidan Valley.

In the Maidan Valley, the local people are heavily dependent on medicinal plants for health issues because most of the inhabitants live in rural communities far away from modern healthcare facilities. This causes increased demand for medicinal plants. In the study area, there is no available database to deposit the documented indigenous knowledge. It was noted during ethnobotanical interviews that elderly people were by and large pleased when we asked them about plants and their medicinal uses. It is very unfortunate to observe the response from the younger generations which showed a lack of interest in plant related questions (Khan *et al.*, 2018). The response from the elders was quite high with 66.4% of respondents in the age range of 40-80 years, while this ratio was comparatively lower in younger people due to a lack of ethnobotanical and traditional knowledge about the local medicinal plants. In conclusion, it is essential to point out that what remains of the traditional practice of medicinal plants survives and still plays a vital role in residential health of the study region. We suggest that the indigenous knowledge from the elder people should be documented along with quality photography to accompany further evaluation of potential phytochemical principles.

Declaration of conflict of interest

The author(s) declared no potential conflicts of interest(s) with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

Declaration of human and animal rights and informed consent

The author(s) declared no involvement of humans or animals in this research.

References

Ahmad, L., Semotiuk, A., Zafar, M., Ahmad, M., Sultana, S., Liu Q. R., Zada, M. P., … & Yaseen, G. (2015) Ethnopharmacological documentation of medicinal plants used for hypertension among the local communities of DIR Lower, Pakistan. *Journal of Ethnopharmacology, 175*, 138-146. https://doi.org/10.1016/j.jep.2015.09.014

Bandaranayke, W. M. (2006). Quality control, screening, toxicity and regulation of herbal drugs. In I. Ahmad, F. Aqil, & M. Owais (eds.), *Modern phytomedicine: turning medicinal plants into drugs* (pp. 25-57). Wiley. https://doi.org/10.1002/9783527609987.ch2

Bodeker, G., & Ong C. K. (2005). *World Health Organization global atlas of traditional complementary and alternative medicine*. WHO Centre for Health Development, Kobe, Japan. https://apps.who.int/iris/handle/10665/43108

Bolen, S., Feldman, L., Vassy, J., Wilson, L., Yeh, H. C., Marinopoulos, S., Wiley, C., … Brancati, F. L. (2007). Systematic review: Comparative effectiveness and safety of oral medications for type 2 diabetes mellitus. *Annals of Internal Medicine, 147*(6), 386-99. https://doi.org/10.7326/0003-4819-147-6-200709180-00178

Fabricant, D. S., & Farnsworth, N. R. (2001). The value of plants used in traditional medicine for drug discovery. E*nvironmental Health Perspectives, 109*(1), 69–75. https://doi.org/10.1289/ehp.01109s169

Ferner, R. E, & Aronson, J. K. (2006). Clarification of terminology in medication errors. *Drug Safety*, *29*(11), 1011-1022. https://doi.org/10.2165/00002018-200629110-00001

Gairola, S., Sharma, J., Gaur, R. D., Siddiqi, T. O., & Painuli, R. M. (2013). Plants used for treatment of dysentery and diarrhoea by the Bhoxa community of district Dehradun, Uttarakhand, India. *Journal of Ethnopharmacol, 150*(3), 989–1006. https://doi.org/10.1016/j.jep.2013.10.007

Ghimire, S. K., Gimenez, O., Pradel, R., McKey, D., & Aumeeruddy-Thomas, Y. (2008). Demographic variation and population viability in a threatened Himalayan medicinal and aromatic herb Nardostachys grandiflora: Matrix modelling of harvesting effects in two contrasting habitats. *Journal of Applied Ecology, 45*(1), 41-51. https://doi.org/10.1111/j.1365-2664.2007.01375.x

Giday, M., Asfaw, Z., Elmqvist, T., & Woldu, Z. (2003). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. *Journal of Ethnopharmacology, 85*(1), 43-52. https://doi.org/10.1016/S0378-8741(02)00359-8

Irfan, M., Ali, I., & Kashif, R. A. (2018). Ethnobotanical survey of the flora of Maidan Valley, Lower Dir District, Khyber Pakhtunkhwa Province, Pakistan. *Plant Science Today, 5*(2), 68-71. https://doi.org/10.14719/pst.2018.5.2.379

International Diabetes Federation (2019). Facts and figures, IDF Diabetes Atlas, Brussels, Belgium, 9th Edition. https://diabetesatlas.org/atlas/eighth-edition/?gclid=CjwKCAiAlp2fBhBPEiwA2Q10D0jmsFd32ttpl15VUEyqdNC9Mu6hcWR6VvS43QXdAwnFG3x9gN84cxoC_acQAvD_BwE

Islam, M. K., Saha, S., Mahmud, I., Mohamad, K., Awang, K., Uddin, S. J, & Shilpi, J. A. (2014). An ethnobotanical study of medicinal plants used by tribal and native people of Madhupur forest area, Bangladesh. *Journal of Ethnopharmacology, 151*(2), 921-930. https://doi.org/10.1016/j.jep.2013.11.056

Jeyaprakash, K., Lego, Y. J, Payum, T., Rathinavel, S., & Jayakumar K. (2017). Diversity of medicinal plants used by Adi community in and around area of D'Ering wildlife sanctuary, Arunachal Pradesh, India. *World Scientific News,* (65), 135-59.

http://www.worldscientificnews.com/wp-content/uploads/2016/11/WSN-65-2017-135-159-1.pdf

Kayani, S., Ahmad, M., Zafar, M., Sultana, S., Khan M. P., Ashraf, M. A, Hussain, J., Yaseen, G. (2014). Ethnobotanical uses of medicinal plants for respiratory disorders among the inhabitants of Gallies–Abbottabad, Northern Pakistan. *Journal of Ethnopharmacology, 156*, 47-60. https://doi.org/10.1016/j.jep.2014.08.005

Khan, M. T., Ahmad, L., & Rashid W. (2018). Ethnobotanical documentation of traditional knowledge about medicinal plants used by indigenous people in Talash valley of Dir lower. Northern Pakistan. *Journal of Intercult Ethnopharmacol, 7*(1), 8-24. https://www.ejmanager.com/mnstemps/55/55-1499260482.pdf?t=1676132688

Khatib, O. (2004). Noncommunicable diseases: risk factors and regional strategies for prevention and care. *EMHJ-Eastern Mediterranean Health Journal, 10(6), 778-788, 2004*. https://apps.who.int/iris/handle/10665/119479

Mahmood, A., Mahmood, A., Shaheen, H., Qureshi, R. A., Sangi, Y., & Gilani, S. A. (2011). Ethno medicinal survey of plants from district Bhimber Azad Jammu and Kashmir, Pakistan. *Journal of Medicinal Plants Research, 5*(11), 2348-2360. https://academicjournals.org/journal/JMPR/article-full-text-pdf/2B5151122276.pdf

Modak, M., Dixit, P., Londhe, J., Ghaskadbi, S., & Devasagayam, T. P. A. (2007). Indian herbs and herbal drugs used for the treatment of diabetes. *Journal of Clinical Biochemistry and Nutrition, 40*(3), 163-173. https://doi.org/10.3164/jcbn.40.163

Moradi, B., Abbaszadeh, S., Shahsavari, S., Alizadeh, M., & Beyranvand, F. (2018). The most useful medicinal herbs to treat diabetes. *Biomedical Research and Therapy, 5*(8), 2538-2551. http://www.bmrat.org/index.php/BMRAT/article/view/463

Olokoba, A. B., Obateru, O. A., & Olokoba, L. B. (2012). Type 2 diabetes mellitus: a review of current trends. *Oman Medical Journal, 27*(4), 269-273. https://doi.org/10.5001%2Fomj.2012.68

Punthakee, Z., Goldenberg, R., & Katz P. (2018). Definition, classification and diagnosis of diabetes, prediabetes and metabolic syndrome. *Canadian Journal of Diabetes, 42*, S10-S15. https://doi.org/10.1016/j.jcjd.2017.10.003

Rao, M. U., Sreenivasulu, M., Chengaiah, B., Reddy, K. J., & Chetty, C. M. (2010). Herbal medicines for diabetes mellitus: a review. *International Journal PharmTech Research, 2*(3), 1883-1892. https://sphinxsai.com/july-sept_2010_vol2.3/pharmtech/pharmtechvol2.3july-sept210/PT=36%20(1883-1892).pdf

Salleh, N. H., Zulkipli, I. N., Yasin H. M., Ja'afar, F., Ahmad, N., Ahmad W. A. N. W, Ahmad, S. R. (2021). Systematic review of medicinal plants used for treatment of diabetes in human clinical trials: An ASEAN perspective. *Evidence-Based Complementary and Alternative Medicine, 2021*, 5570939. https://doi.org/10.1155/2021/5570939

Sicree, R., Shaw, J., Zimmet, P. (2006). Prevalence and projections. *Diabetes Atlas, 3*, 16-104. https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=1100877

Simpson, J (Ed.). (2009). *Oxford English Dictionary on CD-ROM: including 7000 new words and meanings*. Oxford University.

Tardío J, Pardo-De-Santayana, M., Morales, R. J. (2006). Ethnobotanical review of wild edible plants in Spain. *Botanical Journal of the Linnean Society, 152*(1), 27–71. https://doi.org/10.1111/j.1095-8339.2006.00549.x

Tzeng, T. F., Hong, T. Y., Tzeng, Y. C., Liou, S. S., & Liu, I. M. (2015). Consumption of polyphenol-rich Zingiber Zerumbet rhizome extracts protects against the breakdown

of the blood-retinal barrier and retinal inflammation induced by diabetes. *Nutrients*, *7*(9), 7821-7841. https://doi.org/10.3390/nu7095369

Unwin, N, Whiting, D., Guariguata, L., Ghyoot, G., Gan, D. (2011). I*DF diabetes atlas* (5th edition). International Diabetes Federation, Brussels, Belgium.

Vitalini, S., Iriti, M., Puricelli, C., Ciuchi, D., Segale, A., & Fico, G. (2013). Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—An alpine ethnobotanical study. *Journal of Ethnopharmacology*, *145*(2), 517-529. https://doi.org/10.1016/j.jep.2012.11.024

World Health Organization. (2015). Implementing the end TB strategy: The essentials. https://apps.who.int/iris/bitstream/handle/10665/206499/9789241509930_eng.pdf

Appendence-I:

Scientific name	Local name	Status	Growth	Part used	Preparation form	Duration of therapy	Toxicity	UV	FC	RFC
Poaceae										
Hordeum vulgare L.	Warbasha	Cultivated	Herb	SE	Powder	2 Week	None	0.57	7	0.08
Glycine max (L.) Merr.	Chana	Cultivated	Herb	SE	Powder	1 Week	HrG	0.33	3	0.03
Oryza sativa L.	Chawal	Cultivated	Herb	SE	Powder	2 Week	HrG	0.5	6	0.07
Triticum aestivum L.	Ghanum	Cultivated	Herb	SE	Powder	2 Week	HrG	0.75	4	0.04
Zea mays L.	Jowar	Cultivated	Herb	SE	Powder	2 Week	None	0.28	25	0.29
Rhamnaceae										
Ziziphus jujuba Mill.	Bera	Cultivated	Tree	LV	Extract	2 Week	None	0.56	25	0.29
Ziziphus nummularia (Burm.f.) Wight and Arn	Markhanai	Wild	Tree	LV	Extract	10 Days	None	0.77	40	0.47
Ziziphus oxyphylla Edgew.	Elanay	Wild	Shrub	RT	Dec	1-2 Week	None	0.5	10	0.11
Sageretia thea (osbeck) M.C.Johnst.	Mamana	Wild	Shrub	LV	Extract	3 Week	None	0.47	19	0.22
Lamiaceae										
Ajuga bracteosa Wall.ex Benth.	Gotie	Wild	Herb	WP	Dec	2 Week	None	0.53	32	0.37
Ocimum basillicum L.	Kashmalay	Cultivated	Herb	LV+SE	Dec	1 Week	None	0.44	9	0.1
Ocimum album L.	Tulsi	Wild	Herb	WP	Dec	10 Days	None	0.4	5	0.05
Ocimum sanctum L.	Tulsi	Cultivated	Herb	LV	Powder	10 Days	None	0.2	5	0.05
Asteraceae										
Cichorium intybus L.	Kashni	Wild	Herb	LV	Dec	2 Week	None	0.6	10	0.11
Taraxacum officinale (L.) Weber ex F.H. Wigg.	Shawdapai	Wild	Herb	Stem	Extract	1 Week	None	0.25	12	0.14
Artemisia annua L.	Tarkha	Wild	Herb	LV	Dec	10 Days	None	0.68	22	0.25
Rosaceae										
Prunus dulcis (Mill.) D.A. Webb	Badam	Cultivated	Tree	FR	Powder	5 Days	HrG	0.25	4	0.04
Rosa alba L.	Gulab	Wild	Shrub	FL	Powder	1 Week	None	0.5	2	0.02

Amranthaceae										
Chenopodium ambrosioides L.	Skhaboti	Wild	Herb	LV	Dec	1 Week	Poisonous	0.77	22	0.25
Chenopodium botrys L.	Kharava	Wild	Herb	AP	Dec	1-2 Week	None	0.69	13	0.15
Santalaceae										
Viscum album L.	Boghmaboti	Wild	Shrub	LV	Powder	1 Week	None	0.82	35	0.41
Melia azedarach L.	Tora shandai	Wild	Tree	SE	Extract	2 Week	None	0.44	25	0.29
Berberdaceae										
Berberis lycieum Royle.	Kwarry	Wild	Shrub	Rhizome	Powder	2 Week	None	0.58	12	0.14
Papaveraceae										
Fumaria vaillantii var. *Indica* Hausskn	Krachay	Wild	Herb	WP	Extract	1 Week	None	0.8	5	0.05
Cucurbitaceae										
Momordica charantia L.	Karela	Cultivated	Herb	FR	Juice	3-4 Week	None	0.92	42	0.49
Pinaceae										
Pinus wallichiana A.B.Jacks.	Nakhtar	Wild	Tree	RT	Extract	1 Week	None	0.5	2	0.02
Oleaceae										
Olea ferruginea Royle	Khona	Wild	Tree	LV	Extract	1-2 Week	None	0.6	5	0.05
Myrtaceae										
Psidium guajajava L.	Amrood	Cultivated	Tree	FR	Fruit	1-2 Week	None	0.33	3	0.03
Solanaceae										
Solanum nigrum L.	Kachmacho	Wild	Herb	SE	Extract	1 Week	None	0.9	10	0.11
Apiaceae										
Foeniculumv ulgare Mill.	Kaga	Cultivated	Herb	WP	Powder	2 Week		0.53	15	0.17
Daucus carota L.	Gager	Cultivated	Herb	Stem	Juice	1-2 Week	None	0.5	2	0.02
Liliaceae										
Allium sativum L.	Ugha/thoom	Cultivated	Herb	Bulb	Juice	4 Week		0.67	28	0.32
Allium cepa L.	Piaz	Cultivated	Herb	Bulb	Juice	2-3 Week	HrG	0.46	15	0.17
Zingiberaceae										
Zingiber officinale Rescoe.	Adrak	Cultivated	Herb	Rhizome	Powder	3-4 Week	None	0.73	15	0.17
Apocynaceae										

Calotropis procera (Aiton) Dryand.	Spalmai	Wild	Herb	LV	Leaves	2 Week	Allergy	0.8	26	0.3
Papilionaceae										
Cicer arietinum L.	Chana daal	Cultivated	Herb	SE	Powder	1 Week	HrG	0.5	2	0.02
Violaceae										
Viola canescens Wall.	Benafsha	Wild	Herb	WP	Dec	2 Week	None	0.07	6	0.07
Asphodelaceae										
Aloe vera Mill.	Zoqamboty	Cultivated	Herb	LV	Paste	1-2 Week	None	0.61	18	0.21
Buxaceae										
Sarcococca saligna Mull. Arg.	Shanelay	Wild	Shrub	LV+RT	Dec	1-2 Week	None	0.97	38	0.44
Valerianaceae										
Valeriana officinalis L.	Narayboti	Wild	Herb	AP	Extract	2 Week	None	0.92	39	0.45
Cactaceae										
Opuntia dillenii (Ker Gawl.Haw.	Zoqam	Wild	Herb	LV	Paste	3 Week	Poisonous	0.28	7	0.08

Note: DT= duration of therapy, PU= part used, SE= seed extract, WP= whole plant, AP= aerial parts, LR= Leaves + root, M= month, W= week, D= days, Po= Poisonous, HrG= hyperglycemia, Dec= decoction.