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Ethnopharmacological field study of the plants used to treat type 2 diabetes among the Cakchiquels in Guatemala

Elda Carola Cruz, Adolfo Andrade-Cetto*

Laboratorio de Etnofarmacología, Facultad de Ciencias, Universidad Nacional Autónoma de México, 04510 México DF, Mexico

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A B S T R A C T

Ethnopharmacological relevance: Type 2 diabetes is characterized by tissue resistance to the action of insulin, combined with a relative deficiency in insulin secretion. In Guatemala, type 2 diabetes results in significant mortality rates. The low incomes of the indigenous population results in the use of alternative therapies such as medicinal plants to treat the illness. We could not find any previous study related to the use of medicinal plants to treat diabetes in Guatemala. The aim of this work is to determine the most effective plant species used in traditional medicine to treat type 2 diabetes.

Materials and methods: We performed an ethnopharmacological field study among the Cakchiquels of Chimaltenango to select the most prominent plants used to treat the disease. Type 2 diabetic patients from their community health centers were interviewed using structured questionnaires. Two mathematical tools were used to identify potential plant species: the Disease Consensus Index and the Use Value. International databases, including SCOPUS, PubMed, and Google Scholar, were used to identify whether the plants with the highest scores were known to elicit hypoglycemic effects.

Results: After analyzing the data, we can propose the following plants as the most prominent among the Cakchiquels of Chimaltenango to treat type 2 diabetes: *Hamelia patens* Jacq., *Neurolaena lobata* (L.) R.Br.ex Cass., *Solanum americanum* Mill., *Croton guatemalensis* Lotsy, and *Quercus peduncularis* Née.

Conclusions: The Cakchiquel patients interviewed did not understand type 2 diabetes; however, they associated the onset of their disease with a negative emotion, such as shock, sadness or anger. Despite changes in lifestyle, influences of advertising, the availability of innovative treatments and the use of oral hypoglycemic treatments provided by health facilities serving indigenous communities, the Cakchiquel continue to use medicinal plants as adjunctive treatment. While they are unaware whether the plants can cause additional harm, they consider their consumption beneficial because they feel better. There were 11 plants identified with UVs greater than 0.5 and high DCIs; from these 64% of the plants have been identified as having hypoglycemic effects; this finding supports the traditional selection by the Cakchiquels of medicinal plants to treat T2D.

1. Introduction

Diabetes mellitus is defined as an elevated blood glucose level associated with absent or inadequate pancreatic insulin secretion, which may occur with or without the impairment of insulin signaling. Type 2 diabetes is characterized by tissue resistance to the action of insulin combined with a relative deficiency in insulin secretion. A given individual may exhibit either increased insulin resistance or increased beta-cell deficiency, and these abnormalities may be mild or severe. Although insulin is produced by beta cells in these patients, their production is inadequate to overcome insulin resistance, and therefore, blood glucose increases. Impaired insulin signaling also affects fat metabolism, resulting in increased free fatty acid flux, elevated triglyceride levels and reciprocally low levels of high-density lipoprotein (HDL) (Expert Committee, 2003).

In Guatemala, the indigenous population is estimated at over 6 million people, representing 60% of the total population. Among them are the Cakchiquel. Furthermore, following Bolivia, Guatemala has the second highest proportion of indigenous population in America (IWGIA, 2013). The use of plants for medicinal purposes has been practiced in Guatemala since pre-Hispanic times. The low incomes of the indigenous populations are associated with the prevalence of type 2 diabetes, which accounts for 33% of the mortalities in the country (INE, 2014). As a result, people have used medicinal

Abbreviations: F_{IC}, factor informant consensus; UV, use-value; T2D, type 2 diabetes

* Correspondence to: Apartado Postal 70-359, 04511, Coyoacán, México DF, Mexico.

E-mail address: aac@ciencias.unam.mx (A. Andrade-Cetto).

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plants to treat this illness. We could not find any study in the literature related to the use of medicinal plants to treat diabetes in Guatemala.

The aim of this work is to present the results of an ethnopharmacological field survey conducted between 2011 and 2013 among the Cakchiquel people in Guatemala. The data are analyzed using two different quantitative tools to determine the most effective plant species used in traditional medicine to treat type 2 diabetes.

1.1. Background

The Cakchiquel ethnicity is one of 21 groups of Mayan descent located in Guatemala. They reside in 54 different municipalities, spread throughout the departments of Sacatepéquez, Chimaltenango, Solola, Suchitepequez, Guatemala, parts of Escuintla and Baja Verapaz. According to the INE, 2014, the XI National Census of Population, there are 832,968 Kaqchikel language speakers. The economy is based on small-scale agriculture in rural and suburban areas. Most families grow corn, beans, vegetables and legumes for personal consumption; in addition, they produce crafts.

Historically, the Cakchiquel were an advanced culture that occupied a portion of the area of the present State of Guatemala. Their territory is a tableland approximately 6000 ft above sea level, seamed with numerous deep ravines and supporting lofty mountains and active volcanoes. Although fifteen degrees from the equator, its elevation ensures a temperate climate, while its soil is usually fertile and well-watered. In 1462, the Cakchiquel Iximché founded its capital in Ratzamut, named after the Ramon tree (*Brosimium alicastrum*, Sw.). It is currently an archeological site. The Cakchiquel recorded their history in “The Annals of the Cakchiquel” (Brinton, 2007).

2. Materials and methods

2.1. Case detection

The health authorities of five municipalities from Chimaltenango were contacted, and preliminary lists of patients who regularly visited the health center were obtained. It is important to highlight that the diagnosis of type 2 diabetes was made by a physician.

From the health center, basic information such as name, age, marital status, occupation, language, address and time since the disease was detected, was recorded (list 1). The patients were asked about more diabetic people whom they knew who do not regularly visit the health center (list 2). From visits in 2011, 2012 and 2013, 92% of the patients were interviewed; the purpose of the study was explained, and the patients' participation was voluntary.

For the protection of the biodiversity rights of local government, written permission were acquired directly from the “Community Development Council” (COCODE) who are the legal representatives of the communities.

2.2. Village selection

Based on the information provided from the health center, we selected five towns with the highest number of diabetic patients: Zaragoza, located at 14°39′00″, 90°53′26″ and 1849 m elevation; San José Poaquil, located at 14°49′00″, 90°55′00″ and 1800 m; Santa Apolonia, located at 14°45′37″, 90°59′30″ and 2310 m; San Martín Jilotepeque, located at 14° 46′48″, 90°47′35″ and 1755 m; and San Miguel Pochuta, located at 14°32′28″, 91°05′10″ and 916 m. The towns were then divided by the predominant vegetation type: in the first four towns, the main type of vegetation is cloud forest (Region I), and in the fifth town, the main type of vegetation is rain forest (Region II).

2.3. Interviews

Interviews were conducted using questionnaires with semi-structured questions that included three parts: (A) general information, (B) ethnomedical information and (C) ethnobotanical information, 128 diabetic patients were interviewed 108 women and 20 men.

2.4. Questionnaire

The questionnaire included 35 questions and general patient information.

Ethnomedical information: (1) How did you feel when you learned that you have T2D? (2) How did you know that you have it? (3) What do you think T2D is? (4) Do you think you will be cured? (5) Do you attend a health center? (6) What treatment do you follow?

Ethnobotanical questions, which were specifically used to calculate the index: (1) plant name, (2) plant general description, (3) preparation method, (4) organoleptic characteristics, (5) form of consumption, (6) duration of plant consumption, (7) relief of symp-
toms after plant consumption, (8) whether they found the consumption useful, (9) whether they recommend the use of the plant, (10) whether they know if the plant can cause any damage, (11) whether they knew another use for the plant, (12) who recommended the plant, and (13) where they acquired the plant.

The questions used for the index were analyzed in two ways: firstly, answers were recorded, and freeform notes were taken. Secondly, the binary values for the questions were considered, where an acknowledgment (i.e., “yes,” or an affirmative answer) was given a value of 1, and the lack of knowledge (i.e., “no,” or a negative answer) was assigned a value of 0.

2.5. Plant collection

The plants were collected with the help of the informants. They were gathered from their natural habits or in home gardens; in the case of dried, stored plants, we asked the informants to collect fresh samples. Both a small herbarium sample and a formal herbarium were collected for each plant species. The plant identities of the samples were determined by David Mendieta and Max Mérida of the San Carlos University in Guatemala. Vouchers were deposited at the Deshidrafarmy-Farmaya Herbarium.

2.6. Index

A) Disease Consensus Index (DCI)

The original equation presented in an earlier study (Andrade-Cetto et al., 2006) was adapted for this project. The DCI is a comparison based on mathematical concepts (i.e., limit theory), the ideal answers of informant reports (Cc) and the ideal answers for each species (Vx).

The DCI was calculated as follows:

$$\mathrm{DCI} = \left(\sum_{i=1}^{\infty} \mathrm{Vxi/Cc\ \ mVx} \right) / 100$$

where x is any species, Vxi is the sum of individual values obtained for one species within the community and evaluates the knowledge of and the number of mentions for a plant, mVx is the statistical mean of the individual values for one plant and evaluates the knowledge of that plant, and Cc is the correlation coefficient, defined as the maximum number of informants whom can refer to a plant and evaluates the number of mentions of that plant. Cc is also the number of interviewed informants. Finally, to obtain values between 0.01 and 1, the result was divided by 100.

As previously published by our group (Andrade-Cetto et al., 2006), it is crucial that the index includes various types of data about a single species (see questions above) and the collective knowledge for the same species in a group of informants and, subsequently, a comparison of the individual species.

The DCI is based on the following assumptions:

a) Medicinal plants are not selected and used at random; the use of a plant is a product of a directed selection by the people.
b) People have different degrees of knowledge and appreciation about any one species, which can be analyzed quantitatively.
c) Different species can be differentiated based on this individual knowledge.

Consequently, with the DCI, we can evaluate the knowledge about one plant, the plant knowledge as a remedy (for the specific disease) and how much the people appreciate the plant and its remedy.

B) Use value (UV)

The use value index was used to calculate the citation value of plants during interviews. It is calculated as follows:

$$U\,\mathrm{Vc} = \sum Uis/ns$$

where U is the sum of the total number of use-citations by all informants for a given species, divided by the total number of informants, ns. This method evaluates the relative importance of each medicinal species based on its relative use among informants (Albuquerque et al., 2007).

3. Results

3.1. General analysis of the data

We interviewed 92% of the patients reported by the health center, which comprised 108 women and 20 men, with an average age of 56.7 $\pm$ 11.9 years. From this population, 42.2% never attended school, 54% spoke only Spanish, 37% were bilingual and 8.5% spoke only Cakchiquel. The main activities for men and women were agriculture and housekeeping, respectively. All interviewed patients were diagnosed by a physician: 46% did not know about type 2 diabetes, 16% believed type 2 diabetes was a "sugar disease" and 9% made an association of the disease with thirst or a "thirsty disease." The onset of the disease was associated with a negative emotional state, including fear, anger, sadness or any type of preoccupation. From the interviewed patients, 24% did not follow any special diet, 34% presented complications such as neuropathy or retinopathy, and 47.6% believed that they would recover from the disease.

It is important to note that the diagnosis of type 2 diabetes was performed by a physician and not a traditional healer. The symptoms manifesting at the onset of the disease, as observed by the patients, can be explained physiologically. Typically, before the hyperglycemic phase in a type 2 diabetic patient, there is a period of insulin resistance; T2D begins when the circulating insulin cannot compensate for high blood glucose levels. Then, the classic symptoms of diabetes present: polyphagia, polydipsia, and polyuria. The patients remembered this unique event. For example, after a sudden emotional shock (e.g., fear), hormones with an antagonistic effect to insulin, such as adrenalin and glucagon, are released. At this point, blood glucose levels are elevated and the insulin production is not able to compensate this elevation; as a result, the individual feels ill, which was recognized by the interviewed patients as the start of the illness.

Regarding the population interviewed, we noticed the unbalanced number of men against women (20 against 108); an explanation of this fact is that we are not allowed to diagnose a patient with type 2 diabetes; we select the patients for the health center; this mean that more women seek for medical assistance, but the real ratio of men/woman is unknown because not all the patients seek for assistance at the health center.

3.2. Use of medicinal plants

From the total interviewed population, 97% were under medical prescription, 91% used medicinal plants, and only 3% used medicinal plants exclusively. Almost all patients (94.5%) used plants recommended by a friend or a family member. They obtained the plants from three main sources: gathering from fields (62%), harvesting from home gardens (23%) and other sources, such as neighbors or relatives (15%). Normally, 80% of the plants were drank as an infusion and consumed over the period of a day. In the Region I (see Table 1) they drink and average of 580 $\pm$ 142 ml per day and they take the plant 20 $\pm$ 5 days/month. While in the Region II (see Table 2) the daily average is 565 $\pm$ 143 ml, used 21 $\pm$ 5 days/month. The plants are mainly prepared by boiling an average of 20 g of the plant (a pucho in Spanish). After consumption, they reportedly felt better (98%) and recommended the use (98%) to other people. A majority of the patients did not know (99%) whether the ingested plants could cause harm. For all the plants, the main preparation way is an infusion 88.68%, less common is the use of the raw plant crushed in water 9.43% and for only one plant the juice of the fruit is used. The patients associate a bitter taste with hypoglycemic plants 71.7% of the used plants are bitter, 22.64% have no special taste; they describe this as herb tasting and 5.66% have an acid taste (Tables 1 and 2).

In the cloud forest (i.e., Region I), we interviewed 96 patients, while in the rain forest (i.e., Region II), we interviewed 32 patients.

Here, we provide an example of how the DCI and UV were calculated using the data from *Lantana camara* tabulated using Microsoft Excel© 360. In the DCI, the Vxi, which is the sum of the individual values obtained for one species, was 640.47. This value was obtained by adding the individual values of each interview using the function =SUM(), where the range of values to be added was provided within the parentheses. The statistical mean of the individual values for one plant, mVx, was calculated to be 8.42 using the function =AVERAGE(), for which the same range must be provided. The correlation coefficient, or the number of interviewed informants, was 76. This number is fixed for all plants and is the number of informants who respond with the plant with the highest value, not the number of interviewed patients (i.e., 96 for Region I), which we assumed was the limit for answers for any plant.

The final equation for this plant is then: DCI=((647.4/76)8.42)/100=0.71.

The use value was calculated by adding the number of use-citations by all informants for a given species (i.e., 76) and dividing that number by the total number of informants (i.e., 96).

The final equation for this plant is UV=76/96=0.79.

The data analysis for each region is as follows.

Region I (Table 1): the main plant families used were Asteraceae and Myrtaceae (13.3% each), followed by Asparagaceae, Rubiaceae, Rutaceae, Solanaceae, Urticaceae and Verbenaceae (6.6% each). The mainly used parts were the leaves (83.3%). The most prominently used species were *Lantana camara* L. (UV=0.79 and DCI=0.71), *Taraxacum officinale* Webb. (UV=0.75 and DCI=0.69), *Solanum americanum* Mill. (UV=0.69 and DCI=0.65), *Artemisia absinthium* Mill. (UV=0.61 and DCI=0.55), and *Aloe vera* L. (UV=0.57 and DCI=0.53).

Table 1
Plants used by the diabetic patients in the Region I, sorted by UV.

Scientific name	Family	Name	Used part	Preparation	Taste	Intake per 1 day	Days/ month	Voucher	Uv	DCI
Lantana camara L.	Verbenaceae	Cinco negritos	Leaves	Infusion	Bitter	2 cups	15	CFEH 1243	0.79	0.71
Taraxacum officinale Webb	Asteraceae	Amargón	Leaves	Infusion	Bitter	4 cups	20	CFEH 1240	0.75	0.69
Solanum americanum Mill.	Solanaceae	Quilete	Leaves	Infusion	Bitter	3 cups	20	CFEH 1262	0.69	0.65
Artemisia absinthium Mill.	Asteraceae	Ajenjo	Leaves	Infusion	Bitter	2 cups	18	CFEH 1228	0.61	0.55
Aloe vera L.	Asparagaceae	Sábila	Leaves	Raw crushed in water	Bitter	1 cup	15	CFEH 1237	0.57	0.53
Syzygium jambos L. Alston	Myrtaceae	Manzana rosa	Leaves	Infusion	Herb	3 cups	30	CFEH 1226	0.56	0.51
Quercus peduncularis Née	Fagaceae	Encino	Leaves	Infusion	Herb	3 cups	15	CFEH 1229	0.52	0.46
Psidium guajava L.	Myrtaceae	Guayaba	Leaves	Infusion	Bitter	3 cups	20	CFEH 1241	0.51	0.46
Tecoma stans (L.) Juss. Ex Kunth	Bignonaceae	Timboque	Leaves	Infusion	Bitter	4 cups	20	CFEH 1235	0.41	0.38
Verbena litoralis Kunth	Verbenaceae	Verbena	Leaves	Infusion	Bitter	2 cups	15	CFEH 1233	0.31	0.28
Chamaedorea tepejilote Liebm.	Areceacea	Pacaya	Fruit	Infusion	Bitter	3 cups	20	CFEH 1247	0.26	0.24
Persea americana Mill.	Lauraceae	Aguacate	Leaves	Infusion	Herb	4 cups	20	CFEH 1230	0.24	0.22
Physalis philadelphica Lam.	Solanaceae	Miltomate	Fruit	Infusion	Acid	2 cups	15	CFEH 1250	0.19	0.18
Bidens pilosa L.	Asteraceae	Mozote	Leaves	Infusion	Herb	3 cups	25	CFEH 1236	0.18	0.16
Yucca elephantipes Regel	Asparagaceae	Izote	Flower	Infusion	Bitter	3 cups	20	CFEH 1225	0.08	0.07
Morinda citrifolia L.	Rubiaceae	Noni	Fruit	Raw crushed in water	Herb	2 cups	15	CFEH 1224	0.05	0.04
Nasturtium officinale R.Br.	Brassicaceae	Berro	Leaves	Infusion	Bitter	3 cups	25	CFEH 1254	0.04	0.03
Myrtus communis L.	Myrtaceae	Mirto	Leaves	Infusion	Bitter	3 cups	20	CFEH 1257	0.04	0.03
Hamelia patens Jacq.	Rubiaceae	Chichipín	Leaves	Infusion	Bitter	3 cups	15	CFEH 1242	0.04	0.03
Plantago major L.	Plantaginaceae	Llanten	Leaves	Infusion	Herb	4 cups	30	CFEH 1248	0.02	0.02
Eucalyptus globulus Labill.	Myrtaceae	Eucalipto	Leaves	Infusion	Bitter	3 cups	20	CFEH 1234	0.02	0.02
Cecropia obtusifolia Bertol	Urticaceae	Guarumo	Leaves	Infusion	Bitter	3 cups	15	CFEH 1260	0.02	0.02
Citrus x limon (L.) Osbeck	Rutaceae	Limón	Fruit	Juice with water	Acid	3 cups	30	CFEH 1261	0.02	0.02
Citrus aurantium L.	Rutaceae	Naranja agria	Leaves	Infusion	Bitter	3 cups	30	CFEH 1232	0.02	0.02
Tridax procumbens L.	Asteraceae	Hierba del toro	Leaves	Infusion	Bitter	4 cups	20	CFEH 1246	0.02	0.02
Punica granatum L.	Lythraceae	Granada	Leaves	Infusion	Herb	3 cups	15	CFEH 1221	0.02	0.02
Terminalia catappa L.	Combretaceae	Almendro	Leaves	Infusion	Bitter	3 cups	15	CFEH 1222	0.02	0.01
Anacardium occidentale L.	Anacardiaceae	Marañón	Leaves	Infusion	Bitter	3 cups	15	CFEH 1253	0.02	0.01
Nopalea cochenillifera (L.) Salm-Dyck	Cactaceae	Nopal	Leaves	Infusion	Acid	3 cups	20	CFEH 1223	0.02	0.01
Chenopodium ambrosioides L.	Amaranthaceae	Apazote	Leaves	Infusion	Bitter	2 cups	15	CFEH 1245	0.02	0.01

Region II (Table 2): the main plant family used was Asteraceae (13%), followed by Bignoniaceae, Combretaceae and Rubiaceae (6.6% each). The most frequently used parts were the leaves (74%). The most prominently used species were *Hamelia patens* Jacq. (UV=0.9 and DCI=0.68), *Neurolaena lobata* (L.) R.Br.ex Cass. (UV=0.77 and DCI=0.58), *Croton guatemalensis* Lotsy. (UV=0.57 and DCI=0.41), *Carica papaya* L. (UV=0.43 and DCI=0.31), and *Cecropia obtusifolia* Bertol. (UV=0.4 and DCI=0.28).

The plants mentioned from both regions were *Aloe vera* (L.) Burm. f., *Artemisia absinthium* Mill., *Cecropia obtusifolia* Bertol., *Chamaedorea tepejilote* Liebm., *Lantana camara* L. *Morinda citrifolia* L., *Persea americana* Mill., *Psidium guajava* L., *Taraxacum*

Table 2
Plants used by the diabetic patients in the Region II, sorted by UV.

Scientific name	Family	Name	Used part	Preparation	Taste	Intake per 1 day	Days/ month	Voucher	Uv	DCI
Hamelia patens Jacq.	Rubiaceae	Chichipín	Leaves	Infusion	Bitter	4 cups	30	CFEH 1242	0.9	0.68
Neurolaena lobata (L.) R.Br.ex Cass.	Asteraceae	Tres puntas	Leaves	Infusion	Bitter	4 cups	20	CFEH 1239	0.77	0.58
Croton guatemalensis Lotsy.	Euphorbiaceae	Copalchí	Bark	Infusion	Bitter	4 cups	30	CFEH 1259	0.57	0.41
Carica papaya L.	Caricaceae	Papaya	Leaves	Infusion	Bitter	3 cups	20	CFEH 1244	0.43	0.31
Cecropia obtusifolia Bertol.	Urticaceae	Guarumbo	Leaves	Infusion	Bitter	3 cups	25	CFEH 1260	0.4	0.28
Psidium guajava L.	Myrtaceae	Guayaba	Leaves	Infusion	Herb	3 cups	20	CFEH 1241	0.4	0.27
Combretum fruticosum (Loefl.) Stuntz	Combretaceae	Chupamiel	Leaves	Infusion	Bitter	2 cups	20	CFEH 1258	0.33	0.22
Eysenhardtia adenostylis Baill	Leguminosae	Taray	Bark	Infusion	Bitter	3 cups	20	CFEH 1255	0.27	0.2
Aristolochia anguicida Jacq.	Aristolochiaceae	Guaco	Bark	Infusion	Bitter	3 cups	20	CFEH 1251	0.23	0.16
Solanum americanum Mill.	Solanaceae	Quilete	Leaves	Infusion	Bitter	3 cups	20	CFEH 1262	0.2	0.15
Chamaedorea tepejilote Liebm.	Arecaceae	Pacaya	Fruit	Infusion	Bitter	3 cups	20	CFEH 1247	0.17	0.12
Tecoma stans (L.) Juss. Ex Kunth	Bignoniaceae	Timboque	Leaves	Infusion	Bitter	3 cups	20	CFEH 1235	0.17	0.11
Artemisia absinthium L.	Asteraceae	Ajenjo	Leaves	Infusion	Bitter	2 cups	15	CFEH 1228	0.13	0.1
Aloe vera (L.) Burm. f.	Asparagaceae	Sábila	Leaves	Raw crushed in water	Bitter	2 cups	15	CFEH 1237	0.13	0.1
Persea americana Mill.	Lauraceae	Aguacate	Leaves	Infusion	Herb	4 cups	20	CFEH 1230	0.1	0.09
Terminalia catappa L.	Combretaceae	Almendro	Leaves	Infusion	Bitter	2 cups	15	CFEH 1222	0.06	0.05
Lantana camara L.	Verbenaceae	Cinco negritos	Leaves	Infusion	Bitter	2 cups	15	CFEH 1243	0.06	0.05
Cucumis sativus L.	Cucurbitaceae	Pepino	Fruit	Raw crushed in water	Herb	2 cups	30	CFEH 1249	0.06	0.05
Dolichandra uncata (Andrews) L.G.	Bignoniaceae	Uña de gato	Leaves	Infusion	Bitter	3 cups	20	CFEH 1252	0.06	0.05
Taraxacum officinale Webb.	Asteraceae	Amargon	Leaves	Infusion	Bitter	3 cups	30	CFEH 1240	0.05	0.04
Apium graveolens L.	Apiaceae	Apio	Leaves	Infusion	Herb	3 cups	20	CFEH 1231	0.03	0.02
Morinda citrifolia L.	Rubiaceae	Noni	Fruit	Raw crushed in water	Herb	2 cups	20	CFEH 1224	0.03	0.02
Ruta chalepensis L.	Rutaceae	Ruda	Leaves	Infusion	Bitter	2 cups	15	CFEH 1238	0.03	0.02

officinale Webb., *Tecoma stans* (L.) Juss. ex Kunth and *Terminalia catappa* L.

3.3. Literature search

After the selection of the most prominent plants based on the index (i.e., plants with UV ≥ 0.5), we reviewed international databases for any previous reports on potential hypoglycemic effects for these plants. We consulted Scopus, PubMed and Google Scholar. Based on these reviews, we discarded plants that had already been reported to have hypoglycemic effects in the international literature. Then, we determined plant species with the potential for further pharmacological and phytochemical studies, related to their traditional use to treat type 2 diabetes.

For the Region I, *Solanum americanum* Mill., and *Quercus peduncularis* Née were selected while *Lantana camara* L., *Artemisia absinthium* Mill., *Taraxacum officinale* Webb, *Aloe vera* L. *Syzygium jambos* L. Alston and *Psidium guajava* L., were excluded because previous works report their hypoglycemic effect. For the Region II; *Hamelia patens* Jacq, *Neurolaena lobata* (L.) R.Br.ex Cass., and *Croton guatemalensis* Lotsy were selected (Table 3).

4. Discussion

One of the goals of an ethnopharmacological field study is to identify the main plants in a region that are used for a singular purpose; in this case, we selected plants used for the treatment of type 2 diabetes. It is important to note that type 2 diabetes cannot be cured, and most medical treatments aim to keep the blood glucose levels under control to prevent complications (Neuropathy, Nephropathy Retinopathy and Cardiovascular disease (WHO, 2014)).

Regarding the high level of complexity of the disease, it is important to perform further studies on the selected plants to determine whether they can elicit hypoglycemic effects and to identify the active principle or principles (i.e., the phytochemical composition) responsible for any effects and the mechanism of action of such effect. This work contributes by identifying the plants used by Cakchiquel patients to assess their potential hypoglycemic effects and ensures that the identified plants are the main plants used by the Cakchiquels of Chimaltenango. Further studies are required to confirm hypoglycemic, toxic or placebo effects of the selected plants. It is know that type 2 diabetes without control while cause severe damages to the body mainly, retinopathy with a potential loss of vision, nephropathy leading to renal failure; peripheral neuropathy with risk of

Table 3
Literature Information about plants with UV > 5, sorted by alphabetical name, Regions I and II.

Scientific name	Name	Hypoglycemic studies	Phytochemistry related to the Hypoglycemic effect	Source
Aloe vera L.	Sábila	Proved insulin sensitivity in alloxan induced insulin dependent diabetic mouse model.	Standardized chromone UP780.	Yimam et al. (2014)
Artemisia absinthium Mill.	Ajenjo	Alfa glucosidase inhibition. Antihyperglycemic effect in alloxan induced diabetic rats.	Not available.	Ramírez et al. (2012) Daradka et al. (2014)
Croton guatemalensis Lotsy.	Copalchí	Not available	Not Available	
Hamelia patens Jacq.	Chichipín	Not available	Not Available	
Lantana camara L.	Cinco negritos	Hypoglycemic effect in Streptozotocin induced diabetic rats.	Triterpens Stearoyl glucoside of ursolic acid.	Kazmi et al. (2012)
Neurolaena lobata (L.) R. Br.ex Cass.	Tres puntas	Not available	Not Available	
Psidium guajava L.	Guayaba	Hypoglycemic effect and protective effect on altered glucose metabolism in streptozotocin-induced diabetic rats. Inhibition of dipeptidyl peptidase IV.	Flavonoid glycosides, guaijaverin, hyperin, isoquercitrin.	Khan et al. (2014) Eidenberger et al. (2013)
Quercus peduncularis Née	Encino	Not available	Not Available	
Solanum americanum Mill.	Quilete	Not available	Not Available	
Syzygium jambos L. Alston	Manzana rosa	In a randomized, parallel, placebo controlled trial, the plant did not present any antihyperglycernic effect in 30 non-diabetic young volunteers submitted to a glucose blood tolerance test.	Not Available	Teixeira et al. (2000)
Taraxacum officinale Webb	Amargon	Insulin secretagogue activity found in INS-1 cells.	Not Available	González-Castejón et al. (2012)
		Hypoglycemic effect in streptozotocin-induced diabetic rats. Inhibition adipocyte differentiation and lipogenesis	Caffeic and chlorogenic acids	González-Castejón et al. (2014)

foot ulcers, amputations, autonomic neuropathy causing gastrointestinal, genitourinary, and cardiovascular symptoms, and sexual dysfunction (Expert Committee, 2003), for this reason the use of plants that only produce a placebo effect which may result in severe diabetic complications must be avoided, as example we mention *Syzygium jambos* L. Alston, which in a randomized, parallel, placebo controlled trial, did not present any antihyperglycernic effect in 30 non-diabetic young volunteers submitted to a glucose blood tolerance test (Teixeira et al., 2000).

In this study, one approach is presented to select the most prominent plants used by a group of diabetic patients who share the same language (e.g., Cakchiquel) and the same type of vegetation. The main aspect is to determine whether there is a consensus or agreement about the use of medicinal plants. We used two mathematical tools to calculate the Use Value and the Disease Consensus Index. The UV is used to analyze a single species and to compare plants that are used for the same purpose, e.g., the treatment of the same disease. The DCI is used to select the plants that the informants (i.e., patients) use most frequently to treat a single disease within a specific community. In the presented results, we observed that plants with a high DCI also possess high UV. The analysis of plants with these two tools can help us select the plants that are most appreciated or valued by a community.

It is important to note that the interviewed Cakchiquel patients did not understand type 2 diabetes; however, they associated the onset of their disease with negative emotions such as shock, sadness or anger. They mainly use de plants as an infusion they take between 565 and 580 ml per day more or less 20 days-month, this means that they do not take the plant every day, sometimes they forgot to prepare the infusion, or they are not on the mood to drink the tea. This correlates with the intake of prescribed hypoglycemic drugs because they refer that they do not take the drug daily. It is important to mention that people believed that type 2 diabetes is a disease in which excess of sugar is in the blood; for this reason they look for bitter plants (the opposite) to balance the extra sugar with a bitter substance.

Table 4
Recommended plants for further studies, of both regions.

Scientific name	Name	Family	Uvc	DCI
Hamelia patens Jacq.	Chichipín	Rubiaceae	0.9	0.68
Neurolaena lobata (L.) R.Br.ex Cass.	Tres puntas	Asteraceae	0.77	0.58
Solanum americanum Mill.	Quilete	Solanaceae	0.69	0.65
Croton guatemalensis Lotsy.	Copalchí	Euphorbiaceae	0.57	0.41
Quercus peduncularis Née	Encino	Fagaceae	0.52	0.46

Despite changes in lifestyle, the influences of advertising and media, and the available innovative treatments for type 2 diabetes and oral hypoglycemic treatments provided by health facilities that serve indigenous communities, Cakchiquel patients have continued to use herbal teas as adjunctive treatment of their disease. While Cakchiquel is unaware whether the plant-based teas can cause damage, they consider the consumption of the plants to be useful because they feel better.

As a result of the present study, we can recommend the plants listed in Table 4 for further studies; from *Hamelia patens* Jacq., *Neurolaena lobata* (L.) R.Br.ex Cass., and *Solanum americanum* Mill., the phytochemical composition is partially known although is not associated with an hypoglycemic effect, while from *Croton guatemalensis* Lotsy and *Quercus peduncularis* Née there is no information about the phytochemical composition or an hypoglycemic effect available in the international literature.

5. Conclusions

There were 11 plants identified with UVs greater than 0.5 and high DCIs, from these 64% of the plants have been identified in the literature as having hypoglycemic effects, from the other 36% there is no information available; this finding supports the traditional selection by the Cakchiquels of medicinal plants to treat type 2 diabetes. Because there is no information about *Croton guatemalensis* Lotsy and *Quercus peduncularis* Née we can recommend them for further studies.

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