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Revisión / Review

Medicinal plants with antidiabetic activity used in the traditional medicine in Bolivia: A review

[Plantas medicinales con actividad antidiabética utilizadas en la medicina tradicional de Bolivia: una compilación]

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Abstract: The present study aimed to document the traditional use of medicinal plants used to treat Diabetes mellitus Type II in Bolivia. Based on the scientific literature were identified 35 medicinal plant species distributed in 21 botanical families, of which 52 % are native to Bolivia and 48 % are introduced. The botanical families with the highest representation of species were Asteraceae (7 species, 19%) and Fabaceae (17%). The most frequented growth forms were herbs (34%) and trees (29%). Leaves (30%) were the most frequently used plant parts, followed by roots (14%), and bark (9%), mostly prepared as an infusion (40%) and decoction (33%). From the available scientific studies, 25 medicinal species were verified for their antidiabetic properties with positive results, but it is necessary provide more biochemical and clinical analysis of medicinal plants to make better use of their potential.

Keywords: Diabetes; Ethnobotany; Medicinal plants; Traditional medicine; Pharmacological evaluation.

Resumen: El objetivo del presente estudio fue documentar el uso tradicional de plantas medicinales para el tratamiento de la Diabetes mellitus tipo II en Bolivia. Con base en la literatura científica se identificaron 35 especies medicinales, distribuidas en 21 familias botánicas, de las cuales el 52% son nativas de Bolivia y el 48% son introducidas. Las familias botánicas con mayor representación de especies fueron Asteraceae (7 especies, 19%) y Fabaceae (17%). Las formas de crecimiento más frecuentes fueron hierbas (34%) y árboles (29%). Las hojas (30%) fueron la parte de la planta más utilizada, seguidas de las raíces (14%) y la corteza (9%), preparadas especialmente como infusión (40%) y decocción (33%). Así mismo, con base en estudios científicos disponibles, se confirmó la actividad antidiabética de 25 especies medicinales. Sin embargo, es necesario aportar más análisis bioquímicos y clínicos de las plantas medicinales para aprovechar mejor su potencial.

Palabras clave: Diabetes; Etnobotánica; Plantas medicinales; Medicina tradicional; Evaluación farmacológica

INTRODUCTION

Diabetes mellitus is one of the leading causes of death in the world according to the World Health Organization (WHO) and about 422 million people worldwide have diabetes, particularly in low- and middle-income countries (WHO, 2019). Although Lago *et al.* (2007) suggested an increase in the number of people with diabetes to 366 million by 2030, so the number in 2019 was already higher and the cost is increasing dramatically, especially because of the new advanced of diabetes drugs (Rowley *et al.*, 2017).

In Latin America, many people with diabetes have limited access to health care, and according to a study by Barceló *et al.* (2003), the cost of diabetes mellitus (DM) was estimated between US$ 102 and US$ 123 billion, representing challenges to be solved by health systems and society in Latin America. The use of traditional medicine has been reported as an alternative to the high cost of conventional medicine. About 800 species of plants with antidiabetic properties have been reported based on ethnobotanical studies of medicinal plants worldwide (Amurugam *et al.*, 2013) and the scientific studies have confirmed the antidiabetic effects of most of them (Patel *et al.*, 2012; Zehad *et al.*, 2017). The antidiabetic activity of medicinal species is generally proven in a model of diabetes-induced by alloxan and streptozotocin in rats (Kameswararao *et al.*, 2003; Bequer *et al.*, 2014).

Between 65-80% of the world's population in developing countries, due to poverty and lack of access to modern medicine, depends on traditional medicine. Medicinal plants are generally easily accessible, cheap, and have very low side effects. Different parts of plants are used such as leaves, flowers, fruits, seeds, roots, bulbs, etc.; and plants that grow in the wild or are cultivated are used (Cussy-Poma *et al.*, 2017; Fernández *et al.*, 2019).

Every day more attention is paid to the use of medicinal plants to treat chronic diseases, including diabetes. Phytotherapy has an irreplaceable role in the treatment of diabetes, mainly due to its adjuvant ~~the~~ effect, which can lead to a reduction in the consumption of conventional pharmaceutical products and delay the onset of late diabetes complications (Koupý & Rudá-Kucerová, 2015; Gallego Muñoz & Ferreira Alfaya, 2015).The hypoglycemic activity of the phytopreparations is due to their ability to restore the functions of pancreatic β cells, stimulate insulin release, reduce absorption glucose in the intestine or influencing metabolic-dependent processes of insulin (Sychrová, 2017).

According to WHO data 6.6 % of the Bolivian population have a prevalence of diabetes (WHO, 2016; WHO, 2019). There are patients with type II diabetes in Bolivia making use of medicinal plants as a primary source to treat their disease or in a complementary way to their treatment with medications recommended by conventional medicine (WHO, 2002). Diabetes accounts about 4% of all mortality in Bolivia (WHO, 2016).

The present study aimed to document the traditional use of medicinal plants used to treat Diabetes mellitus Type II summarizing knowledge about the management of medicinal plants with antidiabetic activity, within the framework of traditional medicine, practiced in Bolivia.

Data collection

The data were compiled from available online scientific publications which were published between the years 2000-2021 in English, Spanish or Portuguese. The online databases were searched based on keywords like, the traditional use of plants to treat diabetes, medicinal uses of plants to treat diabetes, indigenous use of plants to treat diabetes, ethnobotanical surveys and ethnopharmacological studies of Bolivia. For all plants at the species level, the taxonomy according to a working list The plant list (The Plant List, 2010) and their habit and origin according to Plants of the World Online (POWO, 2019) were unified.

A main list was generated enlisting all the medicinal plants used in Bolivia for the treatment of type II diabetes (Table No. 1) with the following data: Botanical family, Scientific name, Local name, Plant part(s), Preparations, Habit, Phytogeographic Origin, and References. All the data has been summarized in one table and four figures.

Medicinal plants with antidiabetic potential used in traditional medicine of Bolivia

Based on the literature the review has identified a total of 35 medicinal plants used for the treatment of diabetes mellitus in Bolivia, of these, 33 plants were identified at the species level and 2 plants at genus level, totally distributed in 21 families (Table No. 1). The botanical families with the highest representation of species (Figure No. 1) were *Asteraceae* with 7 species (19%) and *Fabaceae* with 6 species (17%), followed by three other families containing 2 species each and 16 families containing only 1 species each. A total of 17 founded plants (52%) were native to

Bolivia and 16 (48%) introduced. *Asteraceae* is one of the most widely used families in ethnomedicine in the world and South America has the highest number of *Asteraceae* species of followed by Asia (Panero & Crozier, 2016). Many species along with the secondary metabolites (volatile oils and terpenoids among others), are mainly responsible for the relevance of this family in traditional medicine. Also other ethnobotanical studies focused on treatment of diabetes mellitus with medicinal plants from around the world shows that *Asteraceae* is the most frequent botanical family (Semenya *et al.*, 2012; Kpodar *et al.*, 2015; Katiri *et al.*, 2017).

Table No. 1
Medicinal plants for the treatment of diabetes in traditional medicine in Bolivia

Scientific name	Local name	Plant part	Preparations	Habit	Origin	References
Amaryllidaceae						
Allium cepa L.	Ajo macho	bulb	infusion, decoction	herb	I	7; 13
Allium sativum L.	Ajo	bulb	eaten raw	herb	I	15
Anacardiaceae						
Anacardium occidentale L.	Cayo, Cayú	bark	decoction	tree	N	1; 14
Apocynaceae						
Aspidosperma rigidum Rusby	Gabetillo	trunk	decoction	tree	N	3
Arecaceae						
Euterpe precatoria Mart.	Ehuid'a	root	decoction	tree	N	9
Asteraceae						
Artemisia absinthium L.	Ajenko	aerial part	infusion	herb	I	13
Baccharis genistelloides (Lam.) Pers	Carqueja; Charara; Kimsa kkuchu	aerial part, leaves	infusion	herb/shrub	N	7;8;15
Cynara cardunculus L.	Alcachofa	aerial part	decoction	herb	I	13
		leaves	infusion	herb	I	15
Smallanthus sonchifolius (Poepp.) H.Rob. Griseb	Yacón	leaves, roots	infusion, juice	herb	N	11
Schkuhria octoaristata DC.	Kanchalawa	roots	decoction	herb	N	15
Schkuhria pinnata (Lam.) Kuntze ex Thell.	Jayaq pichana	whole plant	decoction	herb	N	2
Stevia rebaudiana (Bertoni) Bertoni	Estevia	leaves	infusion	herb	I	11; 16
Brassicaceae						
Nasturtium officinale W.T.Aiton	Berros, Ukururu, Willkayuyu	aerial part	eaten raw	herb	I	6
Cactaceae						
Opuntia ficus-indica (L.) Mill	Penca	stem, root, flower	decoction, juice, powder	shrub	I	13
Erythroxylaceae						
Erythroxylum coca Lam.	Coca	leaves	chewed	shrub	N	11
Fabaceae						
Acacia sp.	Sipamë; Tipa	bark	powder	tree/shrub		1
Bauhinia guianensis Aubl.	Nishi isanuma, Nishi para; Bejuco blana	leaves	infusion	liana	N	1; 14
Bauhinia rufa (Bong.) Steud.	Patevaca, Patebuey	leaves	infusion	shrub/tree	N	3
Bauhinia sp.	Camanó pahoqui	trunk	decoction	herb		1

Otholobium pubescens (Poir.) J.W.Grimes	Wallak'aya	leaves	infusion	shrub	N	13
Prosopis ruscifolia Griseb.	Aatek	leaves	infusion	tree	N	10
Juglandaceae						
Juglans boliviana Dode	Nogal	leaves	infusion	tree	N	7;13
Linaceae						
Linum usitatissimum L.	Linaza	seed	infusion	herb	I	15
Meliaceae						
Swietenia macrophylla King	Mara	seed	infusion	tree	N	3
Menispermaceae						
Abuta grandifolia (Mart.) Sandwith	Abuta	bark, branches, Root	decoction	shrub	N	11
Myrtaceae						
Eucalyptus globulus Labill.	Eucalipto	leaves	tincture	shrub/tree	I	15
Psidium guajava L.	Guayaba	young leaves	infusion	small tree	N	3
Passifloraceae						
Passiflora mollissima (Kunth) L.H. Bailey	Tumbo	flower	infusion	lianavine	N	7; 13
Pedaliaceae						
Sesamum indicum L.	Ajonjolí/Sésamo	seed	eaten	herb	I	11
Rosaceae						
Rubus fruticosus L.	Mora/Blackberry	fruit	juice	shrub	I	11
Rubiaceae						
Coffea arabica L.	Sultana	fruits	decoction	shrub/small tree	I	7
Uncaria guianensis (Aubl.) J.F. Gmel.	Uña de gato	stems, bark	decoction	liana	N	12
Rutaceae						
Citrus medica L.	Cidra	fruit	juice	shrub/small tree	I	8
Smilacaceae						
Smilax aspera L.	Zarzaparrilla, Wila layu	root	decoction	shrub	I	13;17
Xanthorrhoeaceae						
Aloe vera (L.) Burm.f.	Sábila	leaves	Infusion	herb	I	13

Origin: (N) native, (I) introduced

References: (1) (Fernández *et al.*, 2003) ; (2) (Atahuachi & Saravia, 2002); (3) (Hajdu & Hohmann, 2012); (4) (Quiroga *et al.*, 2012); (5) (Quiroga & Meneses, 2012); (6) (Paniagua *et al.*, 2017); (7) (Macía *et al.*, 2005); (8) (Justo-Chipana & Moraes, 2015); (9) (Bourdy *et al.*, 2000); (10) (Quiroga, 2017); (11) (Ceuterick *et al.*, 2011); (12) (Gupta, 2006); (13) (Bussmann *et al.*, 2016a); (14) (Paniagua & Bussmann, 2017); (15) (De Lucca & Zalles, 2006); (16) (Cornejo & Blacutt, 2009); (17) (Bhatta *et al.*, 2021)

The most dominant growth form (Figure No. 2) were herbs (14 reports, 34%), followed by trees (12 reports, 29%), shrubs (12 reports, 29%) and climbing plants (3 reports, 3% which agrees with another ethnobotanical study focused on treatment diabetes mellitus in which herb were the most dominant growth form (Katiri *et al.*, 2017).

The analysis of herbal recipes revealed that infusion (40%), and decoction (33%) are the most frequent preparation methods used, followed by juice (10%), eating (8%) and powder (5%). All preparation methods are shown in Figure No. 4. Also other ethnobotanical studies shows that infusion or decoction is the most common way of preparation herbal medicine (Kadir *et al.*, 2012; Kargioglu & Ari, 2017; Skalli *et al.*, 2019). Infusion involves the plant material in boiling water and decoction involves grinding and then boiling the plant material in water to produce a liquid extract to be taken orally or applied topically (Yang & Ross, 2010).

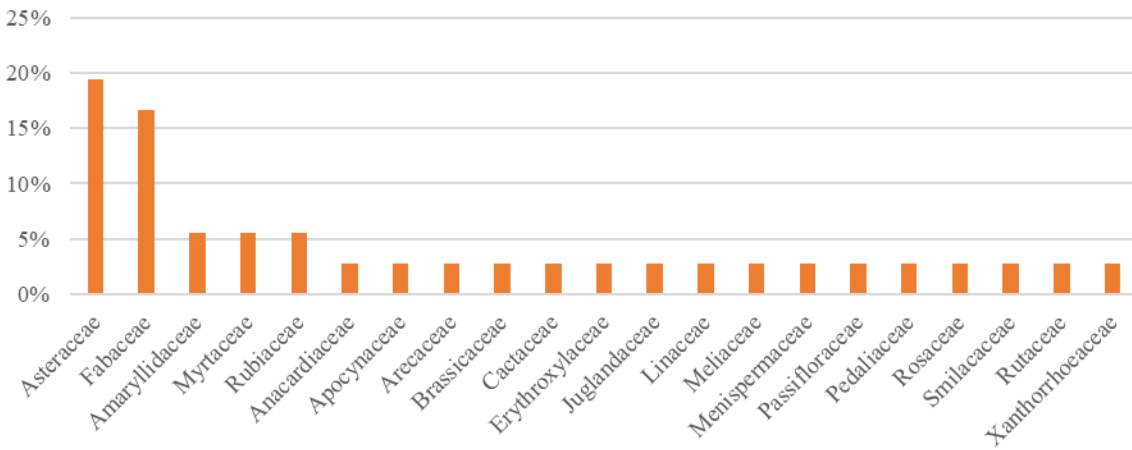

Figure No. 1
The most frequented botanical family of medicinal plants

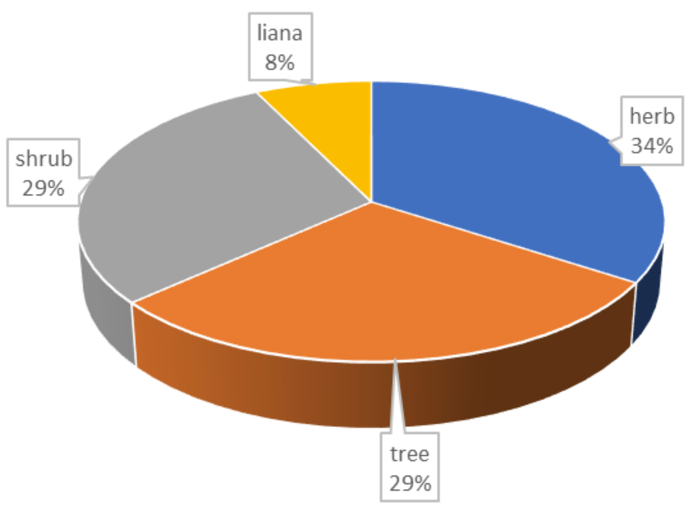

Figure No. 2
Habit of medicinal plants

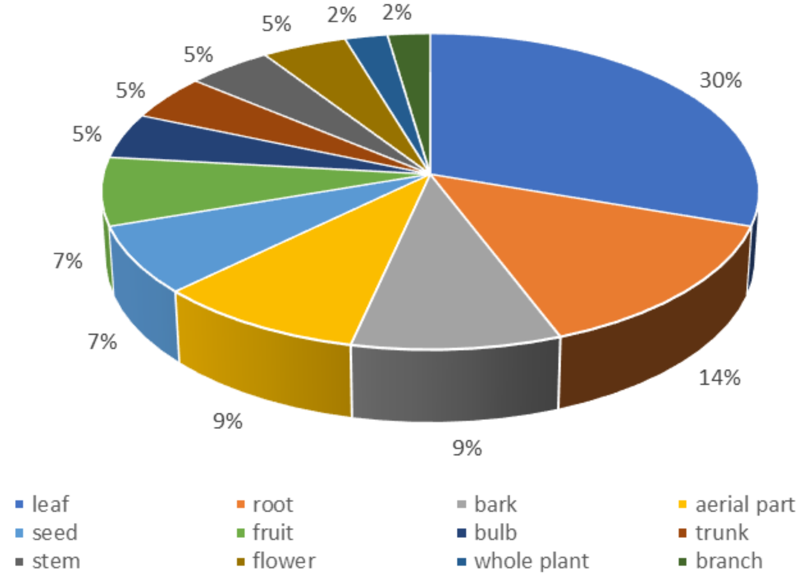

Figure No. 3
Plant part used

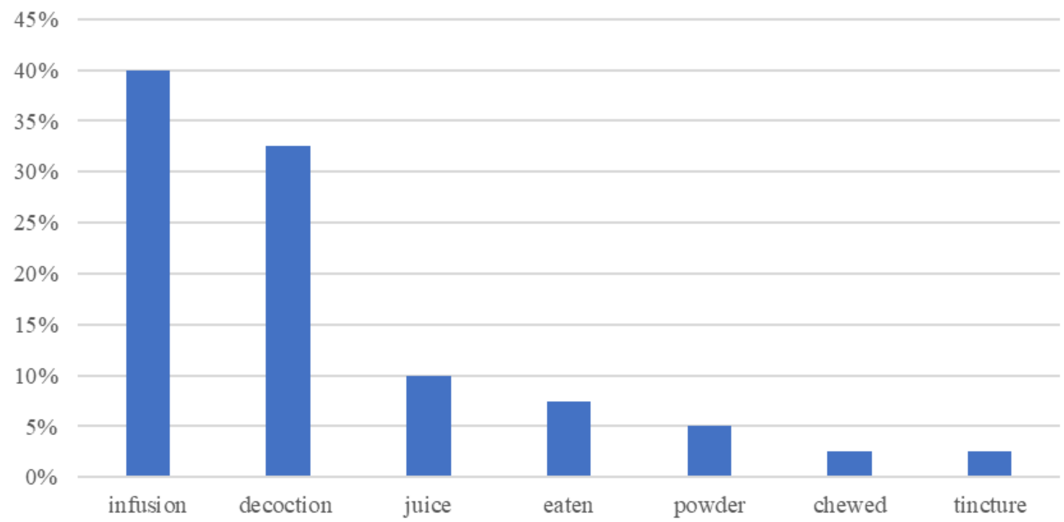

Figure No. 4
Methods of preparations

Literature findings of clinical trials related to the use of species in the treatment of Diabetes mellitus type II in Bolivia

A total of 25 species have their antidiabetic properties verified on the basis of available scientific studies. All of these species have had their antidiabetic effect confirmed, so traditional healers in Bolivia use the medicinal plants correctly. But the antidiabetic activity was mostly proven in a model of diabetes-induced by streptozotocin and alloxan in rats. Only three clinical studies have been performed in people with *Erythroxylum coca*, *Opuntia ficus-indica* and *Linum usitatissimum*. No studies investigating or confirming the pharmacological effect of *Aspidosperma rigidum, Euterpe precatoria, Schkuhria octoaristata, Bauhinia guianensis, Bauhinia rufa, Juglans boliviana, Uncaria guianensis*, *Smilax aspera* have been found.

***Allium cepa* L.**

A study in male Wistar rats showed that *A. cepa* has hypoglycemic and hypolipidemic effects, and is associated with free radical scavenging properties (Campos *et al.*, 2003). The antidiabetic activity is also indicated by a study in which alloxan-induced diabetic rats were administered sulphur-containing S-methyl amino acid cysteine sulfoxide (200 mg/kg for 45 days). These rats significantly controlled both glucose and lipid levels in blood and tissue, and liver hexokinase, glucose-6-phosphatase, and HMG Co A reductase activity were also normalized (Kavishankar *et al.*, 2011).

***Allium sativum* L.**

Garlic (*A. sativum*) antidiabetic activities were demonstrated in a study in streptozotocin-induced diabetic rats given oral garlic extract (0.1; 0.25; 0.5 g/kg for 14 days). Administration of garlic extract was found to significantly reduce serum glucose, total cholesterol, triglycerides, urea, uric acid and creatinine. A comparison was also made between the effect of garlic extract and the known antidiabetic drug glibenclamide, where *A. sativum* extract was more effective (Eidi *et al.*, 2006).

***Anacardium occidentale* L.**

The hypoglycemic effect of *A. occidentale* was observed in a study in Wistar rats in which streptozocin-induced diabetes (STZ) was induced. Rats given oral leaf extract (35, 175, 250 mg/kg) showed a decrease in blood glucose levels. The maximum reduction in blood glucose (37 and 35%) was observed 180 minutes after administration, at doses of 175 and 250 mg/kg (Sokeng *et al.*, 2007).

***Nasturtium officinale* W.T. Aiton**

A study performed on STZ-induced diabetic rats confirmed that oral administration of various concentrations of *N. officinale* extracts (ethyl acetate, methanol, aqueous) for one week has positive effects on lowering blood glucose. This reduction was comparable to the antidiabetic drug glibenclamide (Hoseini *et al.*, 2009). The hypoglycemic effect of *N. officinale* is also confirmed by studies in diabetic mice, where there was a significant reduction in blood glucose after administration of a hydroalcoholic extract (Romina & Norozi, 2009).

***Opuntia ficus-indica* (L.) Mill**

A clinical study in Mexico confirmed that ingestion of *O. ficus-indica* has low glycemic, insulinemic and glucose-dependent insulinotropic peptide indices (GIP) and is a suitable agent for patients with type II diabetes without any side effects. The inclusion of this medicinal plant in a high-carbohydrate breakfast or in high soy protein (HSBP) has anthohergic and antihyperinsulin effects and even prevented postprandial blood glucose peaks in HSPB. Its consumption also increased the antioxidant activity (López-Romero *et al.*, 2014). This agrees with the results of a study performed on diabetic rats induced by low doses of STZ. The rats were fed a high fat diet and supplemented with aqueous extract / dry powder for research purposes. The results show that *O. ficus-indica* significantly lowers blood glucose levels (Hwang *et al.*, 2017).

***Artemisia absinthium* L.**

The hypoglycemic effects on diabetes of *A. absinthium* extract were demonstrated in a study in rats in which diabetes was induced by alloxan. The most significant results were with high doses of the extract (500 and 1000 mg/kg), which significantly reduced blood glucose levels and the results were comparable to glibenclamide treatment. The extract has also been shown to prevent weight loss and improve the biochemical parameters associated with D. mellitus, such as total cholesterol, urea, creatinine and serum protein (Daradka *et al.*, 2014).

***Baccharis genistelloides* (Lam.) Pers.**

The hypoglycemic effect of *B. genistelloides* was demonstrated in rats with streptozotocin-induced diabetes. The rats were treated for 7 days and twice a day with 2000 mg/kg body weight, with an aqueous fraction of ethanolic extract of *B. genistelloides* (Oliveira *et al*, 2015). A similar result was obtained in healthy rats treated with aqueous extract of *B. genistelloides*, with a dose of 4.2 mg/kg, for 37 days. A reduction was observed not only in blood glucose but also in serum triglyceride levels (Coelho *et al*., 2004).

***Cynara cardunculus* L.**

The antidiabetic activity of *C. cardunculus* was addressed in a study performed in STZ-induced diabetic rats. It has been found that the plant extract is rich in polyphenols and thus has an antioxidant and anti-glycation effect. Daily oral administration of *C. cardunculus* extract has also been shown to significantly lower glycemia, and improvements in vascular dilatation functions in diabetic animals have been shown after experiments on isolated aortas (Kuczmannová *et al.*, 2016).

***Smallanthus sonchifolius* (Poepp.) H.Rob.**

For the treatment of diabetes, tuberous roots and leaves are used from *S. sonchifolius* (Gonzales De La Cruz *et al.*, 2014; Bussmann and Sharon, 2016). The hypoglycemic activity of “yacón” leaves was demonstrated in laboratory studies with healthy and diabetic rats. Diabetes in rodents was induced by streptozotocin (STZ). Aqueous leaf extracts (tea/decoction) reduce glucose levels and increase plasma insulin levels (Aybar *et al.*, 2001). In other studies, the antidiabetic activity of “yacón” leaves was investigated by tests of inhibition of the activity of α-amylase and α-glucosidase. According to the results obtained, expressed as LC_{50} in mg/mL, the methanolic extracts of “yacón” leaves are stronger inhibitors of α-amylase ($IC_{50} = 0.26 \pm 0.02$ mg/mL) than of α-glucosidase ($IC_{50} = 1.30 \pm 0.04$ mg/mL) (Russo *et al.*, 2015).

***Schkuhria pinnata* (Lam.) Kuntze ex Thell.**

In a study conducted to validate hypoglycemic activity by evaluating the inhibitory effects on carbohydrate hydrolyzing enzymes: α-glucosidase and α-amylase, it was concluded that the species *S. pinnata* showed hypoglycemic activity *in vitro* although it is not recommended in the treatment of chronic disease due to the toxicity found (Deutschländer *et al*., 2009).

***Stevia rebaudiana* (Bertoni) Bertoni**

The chemical composition of stevia leaves contains a high amount of total phenols, which is a positive indication for antioxidant and antidiabetic properties. Through *in vitro* and *in vivo* (STZ-induced rats) studies, it has been shown that consumption of stevia leaves can prevent or alleviate polydipsia, polyphagia and polyurea. According to the results, long-term use of stevia (1 year) also has the ability to improve glucose tolerance and increase cellular sensitivity to insulin (Shivanna *et al.*, 2013).

***Erythroxylum coca* Lam.**

A hypoglycemic effect popularly called coca was studied in Bolivia, in which 90 patients without a personal pathological history were selected. *E. coca* leaves (5 g) were administered as an infusion (“mate”) and chewed. The results of the postprandial glycemic patients of the control group (the group that did not eat *E. coca* leaves in any form) were 100.4 (± 11.9) mg, while the values of 82.07 (± 8.8) mg were measured in the patients who chewed coca and in the infusion form 81.8 (± 7.5) mg, indicating that *E. coca* has a positive effect on lowering postprandial glycaemia (Pedro & Revilla, 2013).

***Otholobium pubescens* (Poir.) J.W.Grimes**

Bakuchiol (meroterpenoid isolated from the leaves) was isolated from the extract by biologically determined fractionation for diabetes type 2 and tested for its effect on diabetic streptozotocin-induced rats. The results show that *O. pubescens* has dose-dependent antidiabetic properties (the best results are 150 mg/kg) and significantly lowers plasma glucose and low triglyceride levels (Kreninsky *et al.*, 1999).

***Prosopis ruscifolia* Griseb.**

The antidiabetic effects of *P. ruscifolia* are confirmed by studies in Wistar rats in which diabetes was induced by alloxan. The results showed that the administration of the hydroalcoholic extract of *P. ruscifolia* significantly reduced the blood glucose level in hyperglycemic rats during acute and chronic treatment and did not show high toxicity (Campuzano-Bublitz *et al.*, 2016).

***Linum usitatissimum* L.**

Flaxseed (*L. usitatissimum*) is a functional food rich in omega 3 fatty acids and low carbohydrate antioxidants. The *L. usitatissimum* extract was administered as a dietary supplement to study participants (10 g for 1 month), the results of which were evaluated on the basis of clinical-biochemical parameters. Flaxseed supplementation has been shown to have a positive effect on lowering blood glucose (19.7% reduction) and glycated hemoglobin (15.6%). The addition of the extract also had an effect on total cholesterol (a decrease of 14.3%) and triglycerides (17.5%) (Mani *et al.*, 2011).

***Swietenia macrophylla* King**

Swietenin, tetranortriterpenoid isolated from *S. macrophylla* seeds, was orally administered daily to diabetic streptozotocin-induced rats at doses of 25 and 50 mg/kg. The study showed that swietenin treatment significantly reduced blood glucose levels (fasting) and also contributed to lowering elevated cholesterol, triglycerides and improving liver glycogen levels (Dewanjee *et al.*, 2009).

***Abuta grandifolia* (Mart.) Sandwith**

The species was scientifically determined the reducing efficacy of blood glucose level in rats with induced diabetes with *A. grandifolia* aqueous extract. The aqueous extract obtained from the bark of this species was supplied to the rats orally in a dose of 250 mg/kg, for 4 days (Justil *et al.*, 2015).

***Eucalyptus globulus* Labill.**

Effects on antidiabetic properties such as lipid peroxidation, protein oxidation, antioxidant power in plasma and liver homogeneity were investigated in a study on STZ-induced rats. *Eucalyptus* was administered at doses of 20 g/kg for 4 weeks. At the end of treatment, *E. globulus* was shown to have a significant effect on lowering plasma glucose levels, plasma and has antioxidant effects. A positive decrease was also observed for lipid peroxidation products and for carbonyl protein (protein oxidation product) (Nakhaee *et al.*, 2009).

This agrees with other studies which, based on their results, also identify *E. globulus* as a suitable adjunct in the treatment of diabetes mellitus in traditional medicine (Jouad *et al.*, 2004; Eidi *et al.*, 2009).

***Psidium guajava* L.**

According to the results of the study, butanol extract from *P. guajava* leaves has positive effects in diabetic mice on the treatment and prevention of glycemia associated with type 2 diabetes. It has been shown to be effective in inhibiting PTP1B (protein tyrosine phosphatase 1B), which is a major mediator of insulin signaling and insulin resistance (Oh *et al.*, 2005). Also other studies focusing on the antidiabetic properties of *P. guajava* also confirm that plant extracts are a suitable supplement in the treatment of diabetes (Shen *et al.*, 2008; Rai *et al.*, 2010; Huang *et al.*, 2011).

***Passiflora mollissima* (Kunth) L.H. Bailey**

Ethanolic extract from the leaves and aerial parts of *P. mollissima* was administered to alloxan-induced diabetic rats. The experiment showed that treatment with *P. mollissima* extract had a significant effect on lowering sugar levels in hyperglycemic animals (Edwin *et al.*, 2007).

***Sesamum indicum* L.**

A nephroprotective and antidiabetic effects were shown in a study in streptozotocin-induced diabetic rats given ethanol extract of *S. indicum* seeds for 8 weeks. The results showed that STZ-induced diabetic rats showed a significant reduction in serum protein, creatinine and urea levels, which are among the basic biochemical parameters in renal damage associated with D. mellitus. The results further suggest that ethanol seed extract has a potential effect on the control and treatment of hyperglycemia (Bhuvaneswari & Krishnakumari, 2012).

***Rubus fruticosus* L.**

The effect of hydroethanolic extracts of *R. fruticocus* was studied on STZ-induced diabetic Wistar rats. The extract was administered at doses of 50, 100 and 200 mg/kg for 4 weeks, at which end samples were taken to measure malondialdehyde, glutathione and total oxidation status. The study concludes that diabetes causes oxidative damage and subsequent serum levels of inflammation, and *R. fruticocus* may have potential antidiabetic properties, mainly due to its high content of antioxidants (Mirazi & Hosseini, 2020).

***Coffea arabica* L.**

Coffee, as the second most popular beverage in the world (George *et al.*, 2008), is known for its antioxidant properties. Her antidiabetic properties were studied in diabetic rats, in which they were given an aqueous extract of coffee green beans (63 and 93 mg/kg) once a day for 15 days. Diabetic rats showed significantly lower blood glucose levels at the end of the aqueous extract course and are thus a potential means of relieving diabetes hyperglycemia (Campos-Florián *et al.*, 2013).

***Citrus medica* L.**

The antidiabetic, hypocholesterolemic and hypolipidemic activities of *C. medica* are confirmed by studies in rats treated with ether seed extract. The results showed a significant reduction in fasting blood glucose, serum cholesterol and serum triglycerides (Sah *et al.*, 2011).

***Aloe vera* (L.) Burm.f.**

The antioxidant properties of *A. vera* were studied in diabetic rats. *A. vera* gel was administered orally at a concentration of 300 mg/kg. After the treatment, there was a significant reduction in blood glucose levels, as well as glycosylated hemoglobin. Increased levels of lipid and hydroperoxide peroxidation in tissues returned to normal values. *A. vera* gel treatment also resulted in increased glutathione, superoxide dismutase, catalase and glutathione-S-transferase in the liver and kidney. Thus, the results confirm the clear antioxidant property of the *A. vera* gel, and even this treatment was more successful than the treatment with glibenclamide (Rjasekaran *et al.*, 2005).

CONCLUSIONS

The present review demonstrates that there is a great diversity of plant species used by the population of Bolivia for the treatment of the symptoms related to Diabetes mellitus Type II, according to ethnobotanical studies of medicinal plants carried out in recent years, 35 species with antidiabetic activity are used. Scientific studies show the antidiabetic activity for most of the plants used in traditional medicine in Bolivia. The information obtained can give some clues for future analyzes in order to develop new medications. More biochemical and clinical analysis of medicinal plants is still needed to make better use of their potential.

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