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Full Length Research Paper

Complementary and alternative medicine for type 2 diabetes mellitus: Role of medicinal herbs

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Complementary and alternative medicine (CAM) with glucose-lowering effect is increasingly being sought by patients and health care professionals. Its use is estimated at 17 to 80% among diabetic patients. Not only is this rarely reported to healthcare providers, but also that some CAM therapies have no empirical evidence. A review of commonly used CAM is therefore essential for safe and effective control of blood glucose level. A PubMed search was done using the following key terms: "natural products" "herbal medicine" "vitamins" "minerals" "herbs" "botanicals" "complementary and alternative medicine" "extract" "food" "diet" combined with the terms "diabetes" "diabetes mellitus" or "anti-diabetic". Some papers were found through tracking citations from other publications. Commonly used glucose-lowering herbs include *Ginseng species, Momordica charantia* (Karela), *Trigonella foenum graecum, Gymnema sylvestre, Allium cepa* (onion), *Allium sativum* (garlic), *Pterocarpus marsupium, Vaccinium myrtillus, Atriplex halimus* and *Aloe vera*. Other alternative therapies were chromium, vanadium, magnesium, vitamin E, acupuncture and hot-tub therapy. In conclusion, research and use of CAM therapy is on the increase worldwide. Stringent regulatory policies and guidelines on CAM use are required to ensure that safe and appropriate CAM use is guided by empirical evidence.

Key words: Complementary and alternative medicine, traditional, diabetes, glucose lowering, herbal medicine, regulatory policies.

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder characterized by increased blood glucose levels. This disease is characterized by either lack of insulin production or deficient activity in the presence of normal or even elevated levels of insulin. Type 2 DM, which accounts for over 90% of the cases, is associated with disordered carbohydrate and fat metabolism. Chronically, the disease causes micro-vascular (retinopathy, nephropathy and neuropathy) and macro-vascular (hypertension, dyslipidemia, myocardial infarction and stroke) complications (Lucy et al., 2002).

Diabetes poses great challenge to the world's health care system. Its worldwide prevalence was estimated at 366 million in 2011. Of these, 183 million people were believed to be unaware of their condition. If no measures taken, the prevalence is projected to rise to 552 million people by 2030, representing around 10% of the global adult population (International Diabetes Federation, 2011a). In 2011, it was reported that one person died from diabetes related causes every seven seconds. Annual global health care spending on diabetes was up to US$465 billion in 2011 (International Diabetes Federation, 2011a).

In the management of type 2 DM, life style modification (exercise, weight control and nutrition) is crucial. A sedentary lifestyle was associated with the increased risk of impaired glucose tolerance and diabetes. Exercise and diet programs significantly reduce the risk for type 2 DM. A low-fat, vegetarian (vegan) diet has been reported to reverse the effects of DM. Oral glucose-lowering drugs and insulin injections are the conventional management modalities. They are however expensive and often associated with adverse effects, with the commonest

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being weight gain and hypoglycaemia (Sinha et al., 1996). Taking into consideration the aforementioned, the use of complementary and alternative medicine (CAM) has been on the increase.

Complementary and alternative medicine is defined as the practices, approaches, knowledge and beliefs that incorporate plant, animal and mineral-based medicines, spiritual therapies, manual techniques and exercise. UN National Institute of Health categorizes CAM into: alternative or whole medical systems, mind-body medicine, biologically based practices, manipulation and body-based therapies, and energy therapies. The prevalence of CAM use among people living with diabetes ranges from 17 to 80% (Chang et al., 2007). The frequency of CAM use is at 80% in Africa, 52 to 70% in Australia, 31% in Belgium, 40% in China, 49% in France, 60% in Japan, 46% in Switzerland, 24% in UK and 42% in USA (WHO Traditional Medicine Strategy, 2002). There is however a high rate of CAM use non-disclosure to physicians by patients (Khalaf and Whitford, 2010). This brings about the need for health care professionals to be aware of CAM use alongside conventional drugs.

The commonly used therapies among diabetic patients are herbal medicines, nutritional supplements, diet modifications, spiritual healing and relaxation techniques. The factors influencing CAM use include age, duration of diabetes, degree of complications and self-monitoring of blood glucose. Scientific literature on the efficacy of CAM in the management of DM is relatively sparse and heterogeneous. Moreover, there have not been comprehensive reviews incorporating diet, vitamins and mineral supplements in addition to herbal medicine, for glucose control among patients with diabetes. Our aim was therefore to explore the commonly used CAM products so as to inform clinical practice, education and research. This review is unique since it also explores various philosophies and underlying factors behind CAM use.

MATERIALS AND METHODS

A Medline search was performed using the following terms: “natural products” “herbal medicine” “vitamins” “minerals” “herbs” “botanicals” “complementary and alternative medicine” “extract” “food” “diet” combined with the terms “diabetes” “diabetes mellitus” or “anti-diabetic”. Time filters were not applied during the search. Some papers were found through tracking citations from other publications. The plants identified were confirmed using http://www.ipni.org for spellings and family names. Botanical descriptions were checked using Medline and by referring to http://www.wikipedia.org. CAM therapies included were those supported by two or more publications and had insights on their mechanism of action. Expert judgement rather than a formal quality appraisal was used in determining the studies included. Publications without human trials and those in a language other than English were excluded. Some CAM therapies supported by limited trials but with proven glucose-lowering effect were included. Emphasis was made on herbs hence supplements from animal components (such as fish oil, among others) were not reviewed.

RESULTS

Of the 960 titles and abstracts retrieved, 72 (7.5%) were identified as potentially relevant to the review. These focused mainly on medicinal herbs (Table 1), vitamins, minerals, acupuncture and hot-tub therapy.

Herbal medicine

Momordica charantia

Momordica charantia (MC), also known as bitter melon, balsam pear or karela, is a plant commonly used in traditional medicine for its glucose-lowering effects (Shane, 2001; Chaturvedi et al., 2004; Sridhar et al., 2008). It is a climber of the family *Cucurbitaceae,* and is widely cultivated in Africa, Asia and South America both for food and for its medicinal use (Ooi et al., 2010). The parts used include the whole plant, fruit and seeds, which are bitter due to the presence of the chemical momordicin (Beloin et al., 2005). Preparations used include injectable extracts, juice extracts, and fried melon bits, among others (Welihinda et al., 1986; Shane, 2001). The glucose-lowering effect of its unripe fruit juice has been demonstrated in both experimental animal models (Welihinda et al., 1986) and human clinical trials (Srivastava et al., 1993). Active components of the fruit include charantin, vicine and insulin-like polypeptide (Lucy et al., 2002). Alcohol-extracted charantin from MC consists of mixed steroids and was reported to be more potent than tolbutamide (an oral glucose lowering drug) in an animal study (Sarkar et al., 1996). It has been shown to decrease blood glucose levels when injected subcutaneously into type 1 DM patients (Baldwa et al., 1977). Oral administration of bitter melon preparations also showed significant results when tried clinically in type 2 DM patients (Srivastava et al., 1993).

Several mechanisms of action have been postulated including: enhanced insulin secretion, insulin-like action, tissue glucose uptake, liver muscle glycogen synthesis, glucose oxidation, and decreased hepatic gluconeo-genesis (Akhtar et al., 1981; Bailey and Day, 1989). Hepatic portal inflammation and testicular lesions in dogs were reported in excessive administration of cerasee (a component of the wild variety of MC) (Dixit et al., 1978). It is furthermore contraindicated in pregnancy and when other glucose-lowering agents are being used (Basch et al., 2003).

Ginseng species

Ginseng species include Chinese or Korean ginseng (*Panax ginseng*), Siberian ginseng (*Eleutherococcus senticosus*), American ginseng (*Panax quiquefolius*) and Japanese ginseng (*Panax japonicas*). The roots of the herb have extensively been used for their medicinal

Table 1. Common Glucose-Lowering Medicinal Herbs.

Botanical name (Common name)	Parts used	Reported pharmacological profile	References
Abelmoschus moschatus Medik (Malvaceae)	Whole plant	Contains Myricelin which enhances insulin sensitivity through increasing post-receptor transduction in muscle cells	(Liu et al., 2007)
Acacia arabica	Seeds	Increases insulin secretion by pancreatic β cells	(Wadood et al., 1989)
Achyranthes aspera (Prickly Chaff Flower)	Whole plant	Increases insulin secretion by pancreatic β cells	(Akhtar and Iqbal, 1991)
Acosmium panamense (Guayacán)	Bark	Lowers blood glucose by unclear mechanisms	(Andrade-Cetto and Helmut, 2004)
Aegle marmelos (bael tree)	Leaves	Increases insulin secretion by pancreatic β cells	(Arumugama et al., 2008)
Agrimony eupatoria (agrimony)	Leaves	Increases insulin secretion by pancreatic β cells	(Gray and Flatt, 1998b)
Ajuga iva (Herb Ivy)	Whole plant	Enhances glucose uptake into cells	(Hilaly and Lyoussi, 2002)
Allium cepa (Onion) and *Allium Sativum* (Garlic)	Bulb	Lowers glucose by inhibiting insulin breakdown, resulting in increased levels of plasma insulin	(Sheela and Augusti, 1992; Lucy et al., 2002)
Aloe barbadensis	Whole plant	Increases insulin secretion by pancreatic β cells	(Ajabnoor, 1990)
Aloe vera	Whole plant	Contains glucomannan, a hydro-soluble fibre which has a glucose-lowering effect	(Shane et al., 2001)
Andrographis paniculata ("king of bitters")	Leaves	It enhances the uptake of glucose into cells through its effects on glucose transporter 4 gene expression	(Reyes et al., 2006)
Annona squamosa (Custard Apple)	Leaves	Inhibits the enzymes of gluconeogenesis-glucose-6-phosphatase	(Panda and Kar, 2007)
Artemisia herba-alba (Wormwood)	Leaves and bark	Lowers blood glucose	(Khazraji and Shamaony, 1993; Kamal et al., 2007)
Artemisia dracunculus (dragon herb)	Whole plant	Lowers blood glucose	(Ribnicky et al., 2009)
Artemisia pallens (Davana)	All aerial parts	Enhances the uptake of glucose into cells	(Mansi et al., 2007)
Artocarpus heterophyllus (Jack fruit)	Leaves and bark	Contains phenols and flavanoids which regenerate insulin producing β cells	(Priya et al., 2012)
Atriplex halimus (Salt bush)	Leaves	Sand rats develop type 2 diabetes when deprived of this plant	(Collier et al., 1997)
Averrhoa bilimbi (Bilimbi)	Leaves	Inhibits the enzymes of gluconeogenesis (glucose-6-phosphatase)	(Pushparaj et al., 2001)
Azadirachta Indica (Neem)	Leaves	Increases insulin secretion by pancreatic β cells and regenerates the insulin producing β cells	(Jelodar et al., 2005)
Bauhinia candicans	Leaves	Enhances peripheral glucose metabolism	(Fuentes et al., 2004)
Bauhinia forficate (cow's hoof)	Leaves	Increases sensitivity of cells to the residual insulin present in diabetics	(Pepato et al., 2002)
Beta vulgaris (Beet root)	Root	Lowers blood glucose by unclear mechanisms	(Yoshikawa et al., 1996)
Biophytum sensitivum	Leaves	Regenerates insulin producing β cells	(Puri et al., 1998)
Bixa orellana	Seeds	Increases peripheral glucose utilization	(Russell et al., 2008)
Boerhavia diffusa (tar vine)	Leaves	Increases insulin secretion by pancreatic β cells	(Satheesh et al., 2004)
Brassica juncea (mustard greens)	Whole plant	Inhibits glycogenolysis and gluconeogenesis	(Khan et al., 1995)
Brassica nigra (black mustard)	Seeds	Lowers blood glucose by unclear mechanisms	(Anand et al., 2007)
Bumelia sartorum	Roots and bark	Increases insulin secretion by pancreatic β cells	(Naik et al., 1991)
Caesalpinia bonducella (Gray Nicker)	Seeds	Increases insulin secretion by pancreatic β cells	(Sharma et al.,1997)
Cajanus cajan (pigeon pea)	Leaves and stem	Increases insulin secretion by pancreatic β cells	(Ezike et al., 2010)
Camellia sinensis (tea flower)	Leaves	Contains epigallocatechin gallate which enhances insulin activity	(Gomes et al.,1995)
Carum carvi (Carroway)	Fruits	Inhibits hepatic gluconeogenesis, increases peripheral glucose utilization and inhibits renal glucose reabsorption	(Brucelin et al., 1995; Eddouks et al., 2004)
Casearia esculenta (Wild cowrie fruit)	Root	Inhibits enzymes of gluconeogenesis (glucose-6-phosphatase and fructose-1,6-biphosphate) to reduce glucose synthesis, and enhances the activity of hexokinase in the liver to increase glycolysis	(Prakasam et al., 2002)
Cassia auriculata (Tanner's Cassia)	Flower	Increases peripheral glycolysis	(Latha et al.,2003; Abesundara et al., 2004)
Catharanthus roseus (Madagascar periwinkle)	Leaves	Enhances uptake of glucose into cells	(Singh et al., 2001)

Table 1. Contd.

Chamaemelum nobile (Chamomile)	Areal part	Inhibits gluconeogenesis and glycogenolysis	(Eddouks et al., 2005)
Citrullus colocynthis (bitter apple)	Roots	Stimulates residual pancreatic mechanism, increases peripheral uptake and utilization of glucose	(Agarwal et al., 2012)
Cinnamomym tamala (bay leaves)	Leaves	Increases insulin secretion by pancreatic β cells	(Bisht and Sisodia, 2011)
Cichorium intybus (chicory)	Whole plant	Inhibits enzyme of gluconeogenesis-glucose-6-phosphatase	(Pushparaj et al., 2007)
Clausena anisata (Horse wood)	Root	Lowers blood glucose	(Ojewole, 2002)
Clerodendrum species	Roots and leaves	Lowers blood glucose	(Shrivastava and Patel, 2007)
Coccinia indica (Ivy gourd)	Leaves	Inhibits gluconeogenesis and enhances glycolysis	(Shibib et al.,1993; Kamble et al.,1994)
Coriandrum sativum (Coriander)	Seeds	Increases insulin secretion by pancreatic β cells	(Eidi et al., 2009)
Cuminum cyminum (Cumin)	Seeds	Increases insulin secretion by pancreatic β cells	(Jagtap and Patil, 2010)
Cuminum nigrum (kala zeera)	Seeds	Contains flavanoids which have insulin-like activity	(Ahmad et al., 2000)
Eclipta alba (False daisy)	Leaves	Inhibits the enzymes of gluconeogenesis (glucose-6-phosphatase and fructose-1,6-biphosphate) to reduce glucose synthesis, and enhances the activity of hexokinase in the liver to increase glucose breakdown	(Ananthi et al., 2003)
Emblica officinalis (Gooseberry)	Fruits	Inhibits α-amylase and α-glucosidase from breaking down starch and glycogen into glucose	(Nampoothiri et al., 2010)
Enicostemma littorale (Nahi)	Leaves	Inhibits glucose-6-phosphatase required for gluconeogenesis	(Maroo et al., 2002; Srinivasan et al., 2005)
Eucalyptus Globulus (Blue Gum)	Bark and leaves	Increases peripheral glucose utilization, and increases insulin secretion by pancreatic β cells	(Gray and Flatt,1998a)
Eugenia jambolana (Java plum)	Seeds	Enhances glucose tolerance	(Ravi et al.,2004)
Ficus carica (fig leaf)	Leaves	Enhances uptake and utilization of glucose into cells	(Campillo et al., 1991)
Ficus bengalensis (Banyan tree)	Bark	Inhibits insulin breakdown	(Kumar et al.,1989)
Fraxinus excelsior (Ash)	Seeds	Inhibits renal reabsorption of glucose	(Eddouks and Maghrani, 2004)
Garcinia kola (bitter kola)	Seeds	Inhibits glucose-6-phosphatase required for gluconeogenesis	(Iwu et al., 1990)
Ginkgo biloba (Maidenhair tree)	Leaves	Increases insulin secretion by pancreatic β cells in type 2 diabetes	(Kudolo, 2001)
Ginseng species	Roots	Decreases gut carbohydrate absorption, increases glucose uptake by cells, increases glycogen synthesis and storage, and increases insulin secretion by pancreatic β cells	(Kimura et al., 1981; Ohnishi et al., 1996; Gillis et al., 1997; Roy et al., 1998; Yuan et al., 1998)
Gongronema latifolium	Leaves	Enhances hepatic hexokinase and inhibits glucokinase	(Ugochukwu and Babady, 2003)
Gymnema sylvestre (Gurmar)	Leaves	Increases glucose uptake and utilization, and increases insulin secretion by pancreatic β cells	(Persaud et al., 1999; Shane et al., 2001)
Helicteres isora (Nut leaved screw tree)	Fruit	Insulin sensitizing properties	(Chakrabarti et al., 2002)
Hibiscus rosa sinensis (Hibiscus Flower)	Whole Plant	Increases insulin secretion by pancreatic β cells, and increases tissue glucose uptake	(Sachdewa et al., 2001)
Inula racemosa (Inula)	Roots	β adrenergic blocker	(Tripathi et al., 1988)
Lagerstroemia speciosa (Crepe Myrtle)	Leaves	Lowers blood glucose	(Judy et al., 2003)
Lantana camara (lantanas)	Leaves	Lowers blood glucose through unclear mechanisms	(Kazmi et al., 2012)
Lepidium sativum (Garden cress)	Whole plant	inhibits renal glucose reabsorption	(Eddouks and Maghrani, 2008)
Mangifera indica (mango)	Leaves	Contains 3β-taraxerol, which enhances insulin induced glucose uptake through translocation of the glucose transporter, GLUT 4	(Sangeetha et al., 2010)
Morus indica	Leaves	Increases tissue glucose uptake and utilization	(Andallu et al., 2002)
Momordica charantia (Bitter melon, karela)	Fruit, seeds	Lowers blood glucose through several mechanisms	(Chen et al., 1995)
Murraya koenigi (curry leaf)	Leaves	Increases glycogenesis, and decreases glycogenolysis and gluconeogenesis	(Khan et al.,1995)
Musa sapientum (banana)	Fruits	Increases insulin secretion by pancreatic β cells and enhances peripheral glucose utilization	(Ojewole and Adewunmi, 2003)

Table 1. Contd.

Nigella sativa (Black cumin)	Seeds	Inhibits hepatic gluconeogenesis	(Al-Awadi et al., 1991)
Ocimum sanctum (holy basil)	Leaves	Increases insulin secretion by pancreatic β cells	(Chattopadhyay et al., 1993)
Origanum vulgare (Zaatar)	Leaves	Inhibits hepatic gluconeogenesis and/or stimulation of glucose utilization by peripheral tissues	(Eddouks et al., 2003; Lemhadri et al., 2004)
Opuntia streptacantha (paddle cactus)	Leaves	It contains soluble fibres and pectin which reduce intestinal glucose absorption, also enhanced insulin sensitivity and secretion	(Frati et al., 1990; Shapiro et al., 2002)
Panax ginseng	Roots	Increases peripheral glucose uptake and utilization	(Lim et al., 2009)
Psidium guajava (Guava)	Bark	Lowers blood glucose	(Rai et al., 2010)
Pterocarpus marsupium (Kino Tree)	Bark	Regenerates pancreatic β-cells thereby preventing diabetes induction	(Chakravarthy et al., 1982)
Retama raetam (Weeping broom)	Whole plant	Inhibits renal glucose reabsorption	(Maghrani et al., 2005)
Salacia reticulate (Marking Nut Tree)	Whole plant	Prevents the breakdown of starch to glucose by inhibiting alpha-glucosidase activity	(Jayawardena et al., 2005)
Sambucus nigra (Elder berry)	Flower	Increases insulin secretion by pancreatic β cells, and peripheral glucose utilization	(Gray et al., 2000)
Scoparia dulcis (Licorice weed)	Leaves	Increases insulin secretion by pancreatic β cells	(Pari and Venkateswaran, 2002)
Silibum marianum (Milk thistle)	Seeds	Reduces insulin resistance	(Huseini et al., 2006)
Spergularia purpurea	Whole plant	Inhibits gluconeogenesis	(Eddouks et al., 2003)
Suaeda fruticosa (Alkali seepweed)	Whole plant	Increases peripheral glucose uptake and utilization	(Benwahhoud et al., 2001)
Swertia chirayita (Bitter Stick)	Whole plant	Increases insulin secretion by pancreatic β cells	(Saxena et al., 1991; Saxena et al., 1993)
Syzygium cumini (Black plum)	Seed	Inhibit breakdown of starch to glucose	(Pandey et al., 2002)
Syzigium cumini (black berry, Jamun)	Leaves	Lowers blood glucose	(Schoenfelder et al., 2010)
Tamarindus indica	Seeds	Inhibits insulinase activity	(Maiti et al., 2005)
Telfaria occidentalis	Leaves and seeds	Lowers blood glucose	(Aderibigbe et al., 1999a)
Trigonella foenum graecum	Leaves and seeds	Enhances peripheral glucose metabolism; inhibits enzymes of gluconeogenesis (glucose-6-phosphalase and fructose -1, 6-biphosphatase)	(Gupta et al., 1999)
Vinca rosea (Periwinkle)	Whole plant	Prevents the breakdown of starch to glucose	(Ghosh et al., 2001)
Withania somnifera (Winter cherry)	Leaves	Regenerates pancreatic β-cells thereby preventing diabetes induction	(Andallu et al., 2000)
Zingiber officinale (Ginger)	Roots	Lowers blood glucose	(Akhani et al., 2004; Jafri et al., 2011)

effect. Constituents of all ginseng species include ginsenosides, polysaccharides, peptides, polyacetylenic alcohol and fatty acids (Lee, 1992). Most pharmacological actions of ginseng are attributable to ginsenosides, a family of steroids named steroidal saponins (Attele et al., 1999; Huang, 1999). They have glucose-lowering, improved psycho-physiological performance and immune stimulant effects. Animal studies have reported significant glucose-lowering effects in both Asian ginseng (Liu and Xiao, 1992; Ohnishi et al., 1996) and American ginseng (Oshima et al., 1987). This effect is attributable to ginsenoside Rb-2 and more specifically to panaxans I, J, K and L in type 1 DM models (Konno et al., 1985; Yokozawa et al., 1985). The reported mechanisms of action include slowed digestion of food hence, the decreased rate of carbohydrate absorption into the portal hepatic circulation (Yuan et al., 1998); increased glucose transport and uptake by cells, mediated by nitric oxide (NO) (Ohnishi et al., 1996; Gillis, 1997; Roy et al., 1998); increased glycogen storage and NO-mediated insulin secretion (Lucy et al., 2002). It has been shown that NO stimulates glucose-dependent secretion of insulin in islet cells.

Reported side effects include nervousness, immune-stimulant effects and excitation, which diminish with continued use or dosage reduction. Ginseng may exert an oestrogen-like effect in postmenopausal women, resulting in diffuse mammary nodularity and vaginal bleeding (Hammond and Whitworth, 1997). Ginseng may

also inhibit the effects of warfarin (Janetzky and Morreale, 1997) and interact with the monoamine oxidase (MAO) inhibitor, phenelzine (Jones and Runikis, 1987). Massive overdose can bring about ginseng abuse syndrome, characterized by hypertension, insomnia, hypertonia and oedema (Punnonen and Lukola, 1984). It is contraindicated when using hypoglycaemic drugs, corticosteroids, oral contraceptives, anticoagulant drugs, digoxin, diuretics, MAO inhibitors and tricyclic depressants.

Trigonella foenum graecum (*Fenugreek*)

Fenugreek is a legume that grows in India, North Africa and Mediterranean regions. Its seeds are rich in alkaloid trigonelline, nicotinic acid and coumarin. Animal and human studies have reported that the legume lowers blood glucose and lipid levels, as well as increases HDL cholesterol levels (Ribes et al., 1984; Madar et al., 1988). Its seeds are rich in proteins, saponins and fibre. The high fibre content is a potential mechanism of the beneficial effect in DM patients (Madar et al., 1988). Purported mechanisms of action include delayed gastric emptying, slowed carbohydrate absorption and inhibition of glucose transport by the fibre content, as well as increased erythrocyte insulin receptors and modulation of peripheral glucose utilization. Urine may have a maple syrup smell after fenugreek consumption (Bartley et al., 1981). No other side effects have been reported, though, it is contraindicated in pregnancy, and when using glucose-lowering drugs, anticoagulants and MAO inhibitors.

Gymnema sylvestre (*Gurmar*)

This is a woody climber native to the tropical forests of central and southern India. It lowers glucose by increasing glucose uptake and utilization, and enhancing the production of endogenous insulin through cell permeability, increase in β-cell number and stimulation of β-cell function (Persaud et al., 1999; Shane, 2001). Side effects include reduction or loss of taste sensation of sweetness and bitterness if the plant is directly exposed to the tongue (Mozersky, 1999).

Allium cepa (Onion) and Allium Sativum (Garlic)

Allium cepa and *Allium sativum* are members of the lily family, having blood glucose lowering, anti-oxidant, antihypertensive and antihyperlipidemic effects (Sharma et al., 1977; Sheela and Augusti, 1992). Volatile oils in raw onion and garlic have been reported to lower fasting blood glucose level in both animal and human trials (Jain et al., 1973). The active compounds are believed to be sulphur-containing compounds: allyl propyl disulfide (APDS) in onions and diallyl disulfide (allian) in garlic. These active compounds lower glucose levels by competing with insulin (a disulfide) for insulin-inactivating sites in the liver, resulting in increased levels of plasma insulin (Sheela and Augusti, 1992; Lucy et al., 2002).

Aloe vera

Aloe vera is a well-known species of aloe, a desert plant resembling cactus. The dried sap of *Aloe vera* is a traditional remedy used in DM management in the Arabian Peninsula. Aloe gel obtained from the inner portion of the leaves contains glucomannan, a hydro-soluble fibre which has a glucose-lowering effect (Shane, 2001). This has been investigated in both animal models and type 2 DM patients. Oral administration of the juice has also been reported to reduce fasting blood glucose and triglyceride levels in type 2 DM patients with or without combination of conventional anti-diabetic agents (Yongchaiyudha et al., 1996; Vogler and Ernst, 1999). No adverse effects have been reported.

Pterocarpus marsupium and epicatechin-containing plants

Pterocarpus marsupium has been used for DM management in India. The flavonoid, epicatechin, extracted from the bark of the plant has been shown to prevent β-cell damage in rats. In addition, both epicatechin and a crude alcohol extract of *Pterocarpus marsupium* have been shown to regenerate functional pancreatic β-cells in diabetic animals (Chakravarthy et al., 1982). They therefore have the potential to prevent induction and development of DM. On the other hand, epicatechin and catechin consist of glycosides and esters. They are flavan-3-ols, a group of flavanols with glucose-lowering properties (Subramanian et al., 1981). *Camellia sinensis* (green tea polyphenols) and *Acacia catechu* (Burma cutch) are also good sources of flavan-3-ols.

Vaccinium myrtillus (Bilberry)

Bilberry (European blue berry) is a shrubby plant that grows in Europe. Its leaves were widely used in DM management before the availability of insulin (Bailey et al., 1989). Oral administration of bilberry leaf tea reduced blood glucose levels in normal and diabetic dogs, even when glucose was concurrently injected intravenously. Bilberry also has a beneficial role in preventing micro-vascular complications of DM, particularly, retinopathy (Caselli, 1985). The leaves are also useful against vascular complications, whereby anthocyanosides are

the most important constituents (Mills and Bone, 2000).

Atriplex halimus (Salt bush)

This plant is native to Israel, where much of the clinical data has been collected. Human trials have been used to report its glucose-lowering effect in type 2 DM (NYU Langone Medical Center). Sand rats develop type 2 DM when deprived of this plant (Collier et al., 1997).

Coccinia indica (Ivy gourd)

This creeping plant, used to treat "sugar urine", grows widely in India. Human and animal trials have widely been used to report its glucose-lowering effects (Kuppurajan et al., 1986; Kamble et al., 1998). Its mechanism of action is unknown, though insulin-like properties have been postulated (Kamble et al., 1998). No adverse effects have been demonstrated.

Ocimum sanctum (holy basil)

This plant is commonly used in Ayurveda. Related species include *Ocimum album* and *Ocimum basilicum*. Its glucose-lowering effects have been demonstrated in animal model studies (Chattopadhyay, 1993). Its mechanism of action is unknown, though enhanced β-cell function and insulin secretion have been postulated. Although no adverse effects have been reported, further studies are warranted.

Ficus carica (fig leaf)

This plant is used in Spain and South Western Europe. Animal studies have shown its glucose-lowering effect. The mechanism of action is unknown, but some studies suggest facilitation of peripheral glucose uptake. No effect has been noted in c-peptide, thus, indicating non-insulin mediated effect. No adverse effects have been reported (Lucy et al., 2002).

Bauhinia forficata and Myrcia uniflora

Bauhinia forficata (Pata de vaca), indigenous to rainforests and tropical areas of South America, has been used in traditional management of DM. It has been referred to as "vegetable insulin" in Brazil. *Myrcia uniflora*, a South American herb, has also demonstrated glucose-lowering effect. No adverse effects have been reported. The glucose-lowering roles of both herbs warrant further study (Russo et al., 1990).

Opuntia streptacantha (nopal)

Opuntia streptacantha (nopal) is found in the Western hemisphere, including the south-western US, and is commonly used for its glucose-lowering effect in Mexico. It has a high-soluble fibre and pectin content, which may affect intestinal glucose uptake, partially, accounting for its glucose-lowering actions (Shapiro and Gong, 2002). Trials have reported improvements in patients with type 2 DM with decreased insulin levels, suggesting enhanced insulin sensitivity and secretion (Yeh et al., 2003). No adverse effects were reported.

Eucalyptus globulus

This tree is widely found in tropical regions and is commonly used to control diabetes in India. The parts used include the bark and leaves. An aqueous extract (0.5 g/ml) of *E. globulus* increased peripheral glucose utilization in mice abdominal muscle, and stepwise enhanced insulin secretion from the clonal pancreatic β-cells (Gray and Flatt, 1998a). Administration of *E. globulus* leaves to normal rats for 12 days however, did not result in hypoglycaemia. Streptozocin (STZ) administration to these pre-treated rats did not produce hyperglycaemia as severely as it was seen in the controls. In addition, pre-treated rats also showed less polydypsia and body weight loss (Swanston-Flatt et al., 1989). A study of the effects of the leaves on STZ-induced damage in pancreatic islets on normal Wistar rats suggested that the plant ameliorates diabetic states by partial restoration of pancreatic β-cells and repair of the STZ-induced damage. This study suggests a beneficial effect of *E. globulus* in DM management (Mahmoudzadeh et al., 2010). No adverse effects have been reported.

Mangifera indica (mango)

This mango species is commonly found in tropical regions. It has been used as an anti-diabetic agent in Ayurvedic and Nigerian folk medicine. The glucose-lowering effect of aqueous extract of the leaves has been reported in normal and diabetic rats (Aderibigbe et al., 1999b). The active component, 3β-taraxerol, enhances insulin induced glucose uptake through translocation of the glucose transporter, GLUT 4 (Sangeetha et al., 2010).

Syzygium cumini (Black berry, Jamun, Jambul)

This is an evergreen tree found in Sri Lanka, Nepal, Pakistan, India, America, Brazil and Caribbean islands. Alcohol extracts of the seeds were shown to significantly decrease blood glucose and urine sugar in alloxan-induced albino rats (Prince et al., 2004). Aqueous leaf extract (60 to 1000 µg/ml) administered to diabetic subjects, caused a dose dependent inhibition of adenosine

deaminase (ADA) activity and a decrease in blood glucose level (Bopp et al., 2009).

Musa sapientum (banana)

This is a hybrid of wild seeded bananas (*Musa balbasiana* and *Musa acuminata*) found in tropical countries, especially Philippines. Aqueous and methanol root extracts have been reported to have anti-oxidant and glucose-lowering effects comparable to glibenclamide (Pari and Maheswari, 1999; Dhanabal et al., 2005; Adewoye et al., 2009).

Lantana camara

This flowering plant of the Verbena family is native to the American tropics: Mexico, Central America and Venezuela. It is also found in Africa, Australia and India. A stearoyl glucoside of ursolic acid isolated from its leaves, showed significant blood glucose level reduction in STZ-induced diabetic rats (Kazmi et al., 2012). Once daily, administration of the leaves juice (1500 mg/kg) for 14 days showed significant glucose-lowering effect in rats (Garg et al., 1997).

Catharanthus roseus (Madagascar Periwinkle)

This plant, also known as *Vinca rosea* and *Ammocallis rosea*, is found in Madagascar. In Traditional Chinese Medicine, its extracts have been used to treat DM and malaria. Crude aqueous extracts of its leaves has been shown to reduce blood glucose level in normal and diabetic rats. It has however been shown to be cytotoxic (Nammi et al., 2003; Ahmed et al., 2007).

Other medicinal herbs

Other herbs with reported glucose-lowering effects include: *Aegle marmelos, Andrographis paniculata, Artemisia pallens, Artocarpus heterophyllus, Asteracanthus longifolia, Azadirachta india, Biophytum sensitivum,* berberine, *Beta vulgaris, Brassica juncea, Boerhavia diffusa, Cassia auriculata, Caesalpinia bonducella, Cajanus cajan, Citrullus colocynthis, Casearia esculenta, Cinnamomym tamala, Clerodendrum myricoides,* curry, *Enicostemma littorale, Eugenia jambolana, Ficus bengalensis, Foeniculium officinale,* gingko, *Hibiscus rosa sinensis, Lepidium latifolium, Lepidium sativum, Morus indica*, *Murraya koeingii,* Native American herb combination, *Phyllanthus amanis, Salacia reticulata, Sambucus nigra, Sambucus Mexicana*, *Swertia chirayita, Syzygium cumini, Scoparia dulcis, Silibum marianum* (Milk thistle), *Sorlanum torvum*, Traditional Chinese Medicine (TCM), *Vinca rosea, Withania somnifera*, and *Zingiber officinale,* among others (Table 1).

Mineral and vitamin supplements

Chromium

Chromium is an essential micronutrient in humans. It serves as a cofactor in all insulin regulating activities, being a major determinant of insulin sensitivity (Offenbacher and Pi-Sunyer, 1990). Chromium facilitates insulin binding and subsequent uptake of glucose into the cell. Without chromium, insulin's action is blocked and glucose levels are elevated (Mooradian et al., 1994). Supplemental chromium has been shown to decrease fasting glucose levels, improve glucose tolerance, lower insulin levels and decrease total cholesterol and triglycerides, while increasing HDL cholesterol in normal, elderly and type 2 DM subjects (Mooradian et al., 1994). Foods rich in chromium include brewer's yeast, barley flour, broccoli, grape juice, whole wheat, potatoes, garlic, basil, orange juice and red wine (Castro et al., 1998; Miller, 1998). On the other hand, refined sugars, white flour products, and lack of exercise can deplete chromium levels.

Vanadium

Vanadium was used to control blood glucose levels prior to the discovery of insulin. Two studies confirmed the effectiveness of vandal sulphate at a dose of 100 mg/day in improving insulin sensitivity (Halberstam et al., 1996).

Magnesium

Magnesium deficiency is more common in type 2 diabetics than in the general population (Sjogren et al., 1988). It is essential in glucose metabolism and in the prevention of DM complications. Magnesium deficiency has been associated with complications of DM, especially, retinopathy. Magnesium is contraindicated when administering antibiotics, drugs to prevent osteoporosis, calcium channel blockers, muscle relaxants and diuretics. Increased magnesium intake can be achieved through diet without the use of supplements. Foods rich in magnesium include whole grains (brown rice, barley and oats), green vegetables (spinach and Swiss chard) and many bean varieties (Lucy et al., 2002).

Vitamin E

Diabetes produces a state of increased free radical activity. The purported effects of vitamin E on glucose

control relate to the vitamin's potent lipophyllic anti-oxidant activity, with possible influences on protein glycation, lipid oxidation, and insulin sensitivity and secretion. Although its mechanism of action is unknown, it may also affect non-oxidative glucose metabolism (O'Connell, 2001).

Other supplements

Other glucose-lowering supplements include zinc, niacin, vitamin B12, vitamin C, vitamin D, vitamin E, manganese, CQ 10, fish oil supplements (omega 3), cinnamon, alpha-lipoic acid, and green drinks "phytogreens" such as Elotin tea, among others (Lucy et al., 2002; Yeh et al., 2003).

Physical interventions

Acupuncture

Acupuncture is a well known alternative therapy for chronic pain. In addition, experimental and clinical trials have reported its role in the management of DM and its complications (Hui, 1995; Huang, 1996). Acupuncture can act on the pancreas to enhance insulin synthesis, increase the number of receptors on target cells, and accelerate the utilization of glucose, resulting in blood glucose-lowering (Hui, 1995). Acupuncture also has an anti-obesity effect, the most modifiable risk factor for type 2 DM. Its precise mechanisms of action remain unclear.

Hydrotherapy (Hot-tub therapy)

Hot-tub therapy increases blood flow to skeletal muscles hence has been recommended to diabetic patients who are unable to exercise (Hooper, 1999). Hot-tub therapies also lead to decreased patient body weight, mean plasma glucose level and mean glycosylated haemoglobin (Hooper, 1999). Proper water sanitation and appropriate guidance should however be considered when administering hot-tub therapy for diabetic patients (Hooper, 2000). Caution must be taken to ensure that the water is not too hot, as neuropathy, a complication of diabetes, may prevent the patients from realizing that they are burning themselves, resulting in injury.

DISCUSSION

Thousands of plants are attributed with glucose-lowering effects. These herbs are used singly or in combination, to address various underlying factors contributing to hyperglycaemia (Sikha et al., 2012). This review summarizes the commonly used herbs in DM management, as well as explores some philosophies behind CAM use.

Though conventional practitioners pose great concern about CAM use, its use is widely gaining popularity (Yeh et al., 2003; Chang et al., 2007). The use of CAM is grounded on culture, knowledge, beliefs, experience and the advice of family and friends (Coulter and Willis, 2004). The people most likely to use CAM therapies thus include: people in poor health with chronic diseases, people committed to the environment, well-educated women (67%) interested in self-care, some cultural groups, those whose philosophies and values are congruent with CAM, those who think CAM is culturally relevant, on advice of family and friends, or after a traumatic event (International Diabetes Federation, 2011b).

The World Health Organisation (WHO) encourages member states to integrate traditional and CAM therapy into national health care systems and ensure their rational use (WHO Traditional Medicine Strategy, 2002). China is one of the countries with a truly integrated system (International Diabetes Federation, 2011b). This integration entails collaboration between conventional and CAM practitioners through sharing of information and negotiating careful plans with achievable goals. Empowering CAM practitioners through appropriate education and skills is thus crucial (WHO Traditional Medicine Strategy, 2002).

Having more than one active ingredient, CAM is attributed with a range of actions (International Diabetes Federation, 2011b). It takes a while for an effect to show and may produce fewer side effects. Adverse effects associated with CAM include: ketoacidosis due to stoppage of insulin in type 1 DM, trauma and burns from moxibustion (TCM), cupping on neuropathic legs, hypoglycaemia, interaction with conventional medicines, hypertension, bruising from massage, allergy, inappropriate weight loss, renal and hepatic toxicity, and infections (WHO Traditional Medicine Strategy, 2002; Yeh et al., 2003).

Some concerns regarding CAM use are justified; hence, legislation to govern CAM use is inevitable. Only CAM therapies with established empirical evidence should be used. Regulatory systems should ensure product quality, as well as report any herb/herb or herb/drug interactions. CAM products with no empirical evidence or with serious adverse effects should not be used.

This review is not without limitations. Thousands of herbs have demonstrated glucose-lowering effects, thus, they cannot all be included within the scope of this one review. Moreover, the review of CAM use is complicated by inconsistency of definition and research design. The number of subjects used in the trials, the methods of extracting the fruits, the parts of the plants used, and the amount of dose used, are different in the various trials. The various non-standardized forms of the drugs have been the basis for some trials hence results have been difficult to replicate. We thus recommend the preparation

of standardized medicinal herbs for future studies and therapies. CAM safety and efficacy needs better evaluation by well-designed, controlled clinical studies.

Conclusion

Research and use of CAM therapy in DM is on the increase worldwide. Commonly used CAM products include herbal medicine, mineral and vitamin supplements, acupuncture and hot-tub therapy, among others. Of these, medicinal herbs have demonstrated better efficacy. However, exercise, weight control and nutrition remain key pillars in DM management, in addition to conventional therapy. Adverse effects have been reported in CAM; hence, empirical evidence should guide the safe and appropriate use of CAM. Stringent regulatory policies and guidelines of CAM use are required.

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REFERENCES

Abesundara KJ, Matsui T, Matsumoto K (2004). Alpha-glucosidase inhibitory activity of some Sri Lanka plant extracts, one of which, *Cassia auriculata*, exerts a strong antihyperglycemic effect in rats comparable to the therapeutic drug acarbose. J. Agric. Food Chem. 52:2541-2545.

Aderibigbe AO, Lawal BA, Oluwagbemi JO (1999a). The antihyperglycaemic effect of *Telfaria occidentals* mice. Afr. J. Med. Med. Sci. 28:171-175.

Aderibigbe A, Emudianughe T, Lawal B (1999b). Anti-diabetic effect of *Mangifera indica* in mice. Phytother. Res. 16:504-507.

Adewoye E, Taiwo V, Olayioye F (2009). Anti-oxidant and antihyperglycemic activities of *Musa sapientum* root extracts in alloxan induced diabetic rats. Afr. J. Med. Med. Sci. 38:109-117.

Agarwal V, Sharma AK, Upadhyay A, Singh G, Gupta R (2012). Hypoglycemic effects of *citrullus colocynthis* roots. Acta Pol. Pharm. 69:75-79.

Ahmad M, Akhtar MS, Malik T, Gilani AH (2000). Hypoglycaemic action of the flavonoid fraction of *Cuminum nigrum* seeds. Phytother. Res. 14:103-106.

Ahmed A, Ferdous A, Sara S, Nahar S, Awal M, Parvin F (2007). Hypoglycemic effect of *Catharanthus roseus* in streptozocin induced diabetic rats. Mymensingh Med. J. 16:143-148.

Ajabnoor MA (1990). Effect of aloes on blood glucose levels in normal and alloxan diabetic mice. J. Ethnopharmacol. 28:215-220.

Akhani SP, Vishwakarma SL, Goyal RK (2004). Anti-diabetic activity of *Zingiber officinale* in streptozotocin induced type I diabetic rats. J. Pharm. Pharmacol. 56:101-105.

Akhtar M, Athar M, Yaqub M (1981). Effect of *Momordica charantia* on blood glucose level of normal and alloxan-diabetic rabbits. Planta Med. 42:205-212.

Akhtar MS, Iqbal J (1991). Evaluation of the hypoglycaemic effect of *Achyranthes aspera* in normal and alloxan-diabetic rabbits. J. Ethnopharmacol. 31:49-57.

Al-Awadi F, Fatima H, Shamte U (1991). The effect of a plant mixture extract on liver gluconeogenesis in streptozotocin-induced diabetic rats. Diabetes Res. 18:163-168.

Anand P, Murali KY, Tandon V, Chandra R, Murthy PS (2007). Preliminary studies on antihyperglycemic effect of aqueous extract of *Brassica nigra* (L.) Koch in streptozotocin induced diabetic rats. Indian J. Exp. Biol. 45:696-701.

Ananthi J, Prakasam A, Pugalendi KV (2003). Antihyperglycemic activity of *Eclipta alba* leaf on alloxan-induced diabetic rats. Yale J. Biol. Med. 76:97-102.

Andallu B, Radhika B (2000). Hypoglycemic, diuretic and hypocholesterolemic effect of winter cherry (*Withania somnifera Dunal*) root. Indian J. Exp. Biol. 38:607-609.

Andallu B, Varadacharyulu NC (2002). Control of hyperglycemia and retardation of cataract by mulberry (*Morus indica L.*) leaves in streptozotocin diabetic rats. Indian J. Exp. Biol. 40:791-795.

Andrade-Cetto A, Helmut W (2004). Hypoglycemic effect of *Acosmium panamense* bark on streptozotocin diabetic rats. J. Ethnopharmacol. 90:217-220.

Arumugama S, Kavimani S, Kadalmani B, Ahmed A, Akbarsha M, Rao M (2008). Antidiabetic activity of leaf and callus extracts of *Aegle marmelos* in rabbit. Sci. Asia 34:317-321.

Attele A, Wu J, Yuan C (1999). *Ginseng* pharmacology: multiple constituents and multiple actions. Biochem. Pharmacol. 58:1685-1693.

Bailey CJ, Day C (1989). Traditional plant medicines as treatments for diabetes. Diabetes Care 12:553-564.

Baldwa V, Bhandari C, Pangaria A, Goyal R (1977). Clinical trial in patients with diabetes mellitus of an insulin-like compound obtained from plant sources. Upsala J. Med. Sci. 82:39-41.

Bartley GB, Hilty MD, Andreson BD, Clairmont AC, Mashke SP (1981). "Maple syrup" urine odor due to *fenugreek* ingestion. N. Engl. J. Med. 305:467.

Basch E, Gabardi S, Ulbricht C (2003). Bitter melon (*Momordica charantia*): a review of efficacy and safety. Am. J. Health-Syst. Pharm. 60:356-359.

Beloin N, Gbeassor M, Akpagana K, Hudson J, de Soussa K, Koumaglo K, Arnason JT (2005). Ethnomedicinal uses of *Momordica charantia* (Cucurbitaceae) in Togo and relation to its phytochemistry and biological activity. J. Ethnopharmacol. 96:49-55.

Benwahhoud M, Jouad H, Eddouks M, Lyoussi B (2001).Hypoglycemic effect of Suaeda fruticosa in streptozotocin-induced diabetic rats. J. Ethnopharmacol. 76:35-38.

Bisht S, Sisodia SS (2011). Assessment of antidiabetic potential of *Cinnamomum tamala* leaves extract in streptozotocin induced diabetic rats. Indian J. Pharmacol. 43:582-585.

Bopp A, De-Bona K, Belle L, Moresco R, Moretto M (2009). *Syzygium cumini* inhibits adenosine deaminase action and reduces glucose levels in hyperglycemic patients. Fund. Clin. Pharmacol. 23:501-507.

Campillo JE, Pe´rez C, Ramiro JM, Torres MD (1991). Hypoglycaemic activity of an aqueous extract from *Ficus carica* in streptozotocin diabetic rats. Diabetologia 34:A-181.

Caselli L (1985). Clinical and electroretinographic study on activity of anthocyanosides. Int. Arch. Med. 37:29-35.

Castro V (*1*998). Chromium in a series of Portuguese plants used in the herbal treatment of diabetes. Biol. Trace Elem. Res. 62:101-106.

Chakrabarti R, Vikramadithyan RK, Mullangi R, Sharma VM, Jagadheshan H, Rao YN, Sairam P, Rajagopalan R (2002). Antidiabetic and hypolipidemic activity of Helicteres isora in animal models. J. Ethnopharmacol. 81:343-349.

Chakravarthy B, Gupta S, Gode K (1982). Functional beta cell regeneration in the islets of pancreas in alloxan-induced diabetic rats by (-)-epicatechin. Life Sci. 31:2693-2697.

Chang H, Wallis M, Tiralongo E (2007). Use of complementary and alternative medicine among people living with diabetes: literature review. J. Adv. Nurs. 58:307-319.

Chattopadhyay R (1993). Hypoglycemic effect of *Ocimum sanctum* leaf extract in normal and streptozotocin diabetic rats. Indian J. Exp. Biol. 31:891–893.

Chaturvedi P, George S, Milinganyo M, Tripathi YB (2004). Effect of *Momordica charantia* on Lipid profile and oral glucose tolerance in Diabetic rats. Phytother. Res. 18:954-956.

Chen F, Nakashima N, Kimura I, Kimura M (1995). Hypoglycemic activity and mechanisms of extracts from mulberry leaves (*Folium mori*) and cortex mori radicis in streptozotocin-induced diabetic mice. J. Pharmaceut. Soc. Jap. 115:476-482.

Collier GR, Collier FM, Sanigorski A, Walder K, Cameron-Smith D,

Sinclair AJ (1997). Non-insulin dependent diabetes mellitus in *Psammomys obesus* is independent of changes in tissue fatty acid composition. Lipids 32:317-322.
Coulter I, Willis E (2004). The rise and rise of complementary and alternative medicine: a sociological perspective. Med. J. Australia. Epublication.
Dhanabal S, Sureshkumar M, Ramanthan M, Suresh B (2005). Hypoglycemic effect of ethanolic extract of *Musa sapientum* on alloxan induced diabetes mellitus and its relation with antioxidant potential. J. Herb. Pharmacother. 5:7-19.
Dixit V, Khanna P, Bhargava S (1978). Effects of *Momordica charantia* L fruit extract on the testicular function of dog. Planta Med. 34:280-286.
Eddouks M, Jouad H, Maghrani M, Lemhadri A, Burcelin R (2003). Inhibition of endogenous glucose production accounts for hypoglycaemic effect of Spergularia purpurea in diabetic mice. Phytomed. 10:594-599.
Eddouks M, Lemhadri A, Michel JB (2004). Caraway and Caper: potential anti-hyperglycaemic plants in diabetic rats. J. Ethnopharmacol. 94:143-148.
Eddouks M, Lemhadri A, Zeggwagh NA, Michel JB (2005). Potent hypoglycaemic activity of the aqueous extract of *Chamaemelum nobite* in normal and streptozotocin-induced diabetic rats. Diabet. Res. Clin. Pract. 67:189-195.
Eddouks M, Maghrani M (2004). Phlorizin-like effect of Fraxinus excelsior in normal and diabetic rats. J. Ethnopharmacol. 94:149-154.
Eddouks M, Maghrani M (2008). Effect of *Lepidium sativum L.* on renal glucose reabsorption and urinary TGF-beta 1levels in diabetic rats. Phytother. Res. 22:1-5.
Eidi M, Eidi A, Saeidi A, Molanaei S, Sadeghipour A, Bahar M, Bahar K (2009). Effect of coriander seed (*Coriandrum sativum L.)* ethanol extract on insulin release frompancreatic beta cells in streptozotocin-induccd diabetic rats. Phytother. Res. 23:404-406.
Ezike AC, Akah PA, Okoli CC, Okpala CB (2010). Experimental evidence for the antidiabetic activity of cajanus cajan leaves in rats. J. Basic Clin. Pharm. 1:81-84.
Fuentes O, Arancibia-Avila P, Alarcón J (2004). Hypoglycemic activity of *Bauhinia candicans* in diabetic induced rabbits. Fitoterapia 75:527-532.
Garg S, Shah M, Garg K, Farooqui N, Sabir M (1997). Antilymphocytic and immunosuppressive effects of *Lantana camara* leaves in rats. Indian J. Exp. Biol. 35:1315-1318.
Ghosh S, Suryawanshi SA (2001). Effect of *Vinca rosea* extract in treatment of alloxan diabetes in male albino rats. Indian J. Exp. Biol. 39:748-759.
Gillis C (1997). *Panax ginseng* pharmacology: a nitric oxide link? Biochem. Pharmacol. 54:1-8.
Gomes A, Vedasiromoni JR, Das M, Sharma RM, Ganguly DK (1995). Antihyperglycemic effect of black tea (*Camellia sinensis*) in rat. J. Ethnopharmacol. 45:223-226.
Gray AM, Abdel-Wahab YH, Flatt PR (2000). The traditional plant treatment, *Sambucus nigra* (elder), exhibits insulin-like and insulin-releasing actions in vitro. J. Nutr. 130:15-20.
Gray AM, Flatt PR (1998a). Antihyperglycemic actions of *Eucalyptus globus* (Eucalyptus) are associated with pancreatic and extrapancreatic effects in mice. J. Nutr. 128:2319-2323.
Gray AM, Flatt PR (1998b). Actions of the traditional anti-diabetic plant, *Agrimony eupatoria* (agrimony): effects onhyperglycaemia, cellular glucose metabolism and insulin secretion. Brit. J. Nutr. 80:109-114.
Gupta D, Raju J, Baquer NZ (1999). Modulation of some gluconeogenic enzyme activities in diabetic rat liver and kidney: effect of antidiabetic compounds. Indian J. Exp. Biol. 37:196-199.
Halberstam M, Cohen N, Shlimovich P, Rossetti L, Shamoon H (1996). Oral vanadyl sulfate improves insulin sensitivity in NIDDM but not in obese nondiabetic subjects. Diabetes 45:659-666.
Hammond TG, Whitworth JA (1997). Adverse reactions to ginseng. Med. J. Australia 1:492.
Hilaly J, Lyoussi B (2002). Hypoglycaemic effect of the lyophilised aqueous extract of *Ajuga ivain* normal and streptozotocin diabetic rats. J. Ethnopharmacol. 80:109-113.
Hooper PL (1999). Hot-tub therapy for type 2 diabetes mellitus. N. Engl. J. Med. 341:924-925.
Huang K (1999). The Pharmacology of *Chinese Herbs*. Boca Raton, CRC Press, FL.
Huang KC (1996). Diabetes mellitus. In: Huang KC, ed. Acupuncture: The Past and the Present, 1st ed. Vantage Press, New York. p.202.
Hui H (1995). A review of treatment of diabetes by acupuncture during the past forty years. J. Trad. Chin. Med. 15:145-154.
Huseini HF, Larijani B, Heshmat R, Fakhrzadeh H, Radjabipour B, Toliat T, Raza M (2006). The efficacy of *Silybum marianum* (L.) Gaertn. (Silymarin) in the Treatment of Type II Diabetes: A Randomized, Double-blind, Placebo-controlled, Clinical Trial. Phytother. Res. 20:1036-1039.
International Diabetes Federation (2011a). Diabetes Atlas, 5th Edition. http://www.idf.org/diabetesatlas/news/fifth-edition-release. Accessed 14th April 2012.
International Diabetes Federation (2011b). Diabetes Education Modules, 2nd Edition.
Iwu MM, Igboko OA, Okunji CO, Tempesta MS (1990). Antidiabetic and aldose reductase activities of biflavanones of *Garcinia kola*. J. Pharm. Pharmacol. 42:290-292.
Jafri SA, Abass S, Qasim M (2011). Hypoglycemic effect of ginger (*Zingiber officinale*) in alloxan induced diabetic rats (Rattus norvagicus). Pakistan Vet. J. 31:160-162.
Jagtap AG, Patil PB (2010). Antihyperglycemic activity and inhibition of advanced glycation end product formation by *Cuminum cyminum* in streptozotocin induced diabetic rats. Food Chem. Toxicol. 48:2030-2036.
Jain R, Vyas C, Mahatma O (1973). Letter: Hypoglycemic action of onion and garlic. Lancet 2:1491.
Janetzky K, Morreale AP (1997). Probable interaction between warfarin and *ginseng*. Am. J. Health Syst. Pharm. 54:692-693.
Jayawardena MH, de-Alwis NM, Hettigoda V, Fernando DJ (2005). A double blind randomised placebo controlled cross over study of a herbal preparation containing *Salacia reticulata* in the treatment of type 2 diabetes. J. Ethnopharmacol. 97: 215-218.
Jelodar GA, Maleki M, Motadayen MH, Sirus S (2005). Effect of fenugreek, onion and garlic on blood glucose and histopathology of pancreas of alloxan-induced diabetic rats. Indian J. Med. 59:64-69.
Jones BD, Runikis AM (1987). Interaction of ginseng with phenelzine. J. Clin. Psychopharmacol. 7:201-202.
Judy WV, Hari SP, Stogsdill WW, Judy JS, Naguib YM, Passwater R (2003). Antidiabetic activity of a standardized extract (Glucosol) from *Lagerstmemia speciosa* leaves in Type II diabetics. A dose-dependence study. J. Ethnopharmacol. 87: 115-117.
Kamal M, Masalmeh A, Hamzah N (2007). The Hypolipidemic Effects of *Artemisia sieberi* (A. herba-alba) in Alloxan Induced Diabetic Rats. Intl. J. Pharmacol. 3:487-491.
Kamble SM, Kamlakar PL, Vaidya S, Bambole VD (1998). Influence *of Coccinia indica* on certain enzymes in glycolytic and lipolytic pathway in human diabetes. Indian J. Med. Sci. 2:143-146.
Kazmi L, Rahman M, Afzal M, Gupta G, Saleem S, Afzal O, Shaharyar M, Nautiyal U, Ahmed S, Anwar F (2012). Antidiabetic potential of ursolic acid stearoyl glucoside: a new triterpenic glycosidic ester from *Lantana camara*. Fitoterapia 83:142-146.
Khalaf AJ, Whitford DL (2010). The use of complementary and alternative medicine by patients with diabetes mellitus in Bahrain: a cross-sectional study. BMC Complement. Alt. Med. 10:35.
Khan BA, Abraham A, Leelamma S (1995). Hypoglycemic action of *Murraya koeingii* (curry leaf) and *Brassica juncea* (mustard): mechanism of action. Indian J. Biochem. Biophys. *32*:106-108.
Khazraji SM, Shamaony LA, Twaij HA (1993). Hypoglycaemic effect of Artemisia herba alba. Effect of different parts and influence of the solvent on hypoglycemic activity. J. Ethnopharmacol. 40:163-166.
Konno C, Murakami M, Oshima Y, Hikino H (1985). Isolation and hypoglycemic activity of panaxans Q, R, S, T, and U, glycans of *Panax ginseng* roots. J. Ethnopharmacol. 14:69-74.
Kudolo GB (2001). The effect of 3-month ingestion of *Ginkgo biloba* extract (EGb 761) on pancreatic beta-cell function in response to glucose loading in individuals with non-insulin dependent diabetes mellitus. J. Clin. Pharmacol. 41:600-601.
Kumar RV, Augusti KT (1989). Hypoglycemic effect of a leucocyanidin derivative isolated from the bark of *Ficus bengalensis* Linn. Indian J. Biochem. Biophys. 26:400-404.

Kuppurajan K, Seshadri C, Revathi R, Venkataraghavah S (1986). Hypoglycaemic effect of *Coccinia indica* in diabetes mellitus. Nagarjun 29:1-4.
Latha M, Pari L (2003). Preventive effects of *Cassia auriculata L.* flowers on brain lipid peroxidation in rats treated with streptozotocin. Mol. Cel. Biochem. 243:23–28.
Lee F (1992). Facts about *Ginseng,* the Elixir of Life. Elizabeth, NJ: Hollyn International Corp.
Lemhadri A, Zeggwagh NA, Maghrani M, Jouad H, Eddouks M (2004). Antihyperglycemic activity of the aqueous extract of *Origanum vulgare* growing wildin Tafilalet region. J. Ethnopharmacol. 92:251-256.
Lim S, Yoon JW, Choi SH, Cho BJ, Kim JT, Chang HS, Park HS, Park KS, Lee HK, Kim YB, Jang HC (2009). Effect of ginsam, a vinegar extract from Panax ginseng, on body weight and glucose homeostasis in an obese insulin-resistant rat model. Metabolism 58:8-15.
Liu C, Xiao P (1992). Recent advances on *ginseng* research in China. *J.* Ethnopharmacol. 36:27-38.
Liu IM, Tzeng TF, Liou SS, Lan TW (2007). Improvement of insulin sensitivity in obese Zucker rats by myricetin extracted from *Abelmoschus moschatus*. Planta Med. 73:1054-1060.
Lucy D, Anoja S, Chu-Su Y (2002). Alternative therapies for Type 2 diabetes. Altern. Med. Rev. 7:45-58.
Madar Z, Abel R, Samish S, Arad J (1988). Glucose lowering effect of *fenugreek* in non-insulin dependent diabetics. Eur. J. Clin. Nutr. 42:51-54.
Maghrani M, Michel JB, Eddouks M (2005).Hypoglycaemic activity of Retama raetam in rats. Phytother. Res. 19:125-128.
Mahmoudzadeh-Sagheb H, Heidari Z, Bokaeian M, Moudi B (2010). Antidiabetic effects of *Eucalyptus globus* on pancreatic islets: a stereological study. Folia Morphol. 69:112-118.
Maiti R, Das UK, Ghosh D (2005). Attenuation of hyperglycemia and hyperlipidemia in streptozolocin-induced diabetic rats by aqueous extract of seed of *Tamarindus indica*. Biol. Pharmaceut. Bull. 28:1172-1176.
Maroo J, Vasu VT, Aalinkeel R, Gupta S (2002). Glucose lowering effect of aqueous extract of *Enicostemma littorale Blume* in diabetes: a possible mechanism of action. J. Ethnopharmacol. 81:317-320.
Miller L (1998). Herbal medications, nutraceuticals, and diabetes. In: Miller LG, Murray WJ, eds. *Herbal Medicinals, A Clinician's Guide*. Binghamton, NY: Pharmaceutical Products Press, Imprint of the Haworth Press, Inc. pp.115-133.
Mills S, Bone K (2000). Materia medica In: Mills S, Bone K, eds. *Principles and Practice of Phytotherapy*. Churchill Livingstone Publishing pp.297-302.
Mooradian A, Failla M, Hoogwerf B, Maryniuk M, Wylie-Rosett J (1994). Selected vitamins and minerals in diabetes. Diabetes Care 17:464–479.
Mozersky R (1999). Herbal products and supplemental nutrients used in the management of diabetes. J. Am. Osteo. Ass. 99:S4-S9.
Naik SR, Barbosa Filho JM, Dhuley JN, Deshmukh V (1991). Probable mechanism of hypoglycemic activity of bassic acid, a natural product isolated from *Bumelia sartorum*. J. Ethnopharmacol. 33:37-44.
Nammi S, Boini M, Lodagala S, Behara R (2003). The juice of fresh leaves of *Catharanthus roseus linn* reduces blood glucose in normal and alloxan diabetic rabbits. BMC complement. Alt. Med. Sept 2, 3:4.
Nampoothiri SV, Prathapan A, Cherian OL, Raghu KG, Venugopalan VV, Sundaresan A (2010). In vitro antioxidant and inhibitory potential of *Tetminalia bellerica* and *Emblica officinalis* fruits against LDL oxidation and key enzymes linked to type 2 diabetes. Food Chem. Toxicol. 49:125-131.
National Institute of Health http://nccam.nih.gov/health/whatiscam. Accessed 14th April 2012.
NYU Langone Medical Center. http://www.med.nyu.edu/content?ChunkIID=21862. Accessed 14th April 2012.
O'Connell B (2001). Select vitamins and minerals in the management of diabetes. Diabetes Spectr. 14:133–148.
Offenbacher E, Pi-Sunyer F (1980). Beneficial effect of chromium-rich yeast on glucose tolerance and blood lipids in elderly subjects. Diabetes 29:919-925.
Ohnishi Y, Takagi S, Miura T, Usami M, Kako M, Ishihara E, Yano H, Tanigawa K, Seino K (1996). Effect of *ginseng* radix on GLUT2 protein content in mouse liver in normal and epinephrine-induced hyperglycemic mice. Biol. Pharmaceut. Bull. 19:1238-1240.
Ojewole JA (2002). Hypoglycaemic effect of Clausena anisata (Willd) Hook methanolic root extract in rats. J. Ethnopharmacol. 81:231-237.
Ojewole JA, Adewunmi CO (2003). Hypoglycemic effect of methanolic extract of *Musa paradisiaca* (Musaceae) green fruits in normal and diabetic mice. Meth. Find. Exp. Clin. Pharmacol. 25:453-456.
Ooi CP, Yassin Z, Hamid TA (2010). *Momordica charantia* for type 2 diabetes mellitus. Cochrane Database Syst. Rev. 17, CD007845.
Oshima Y, Sato K, Hikino H (1987). Isolation and hypoglycemic activity of quinquefolans A, B, and C, glycans of *Panax quinquefolium* roots. J. Nat. Prod. 50:188-190.
Panda S, Kar A (2007). Antidiabetic and antioxidative effects of Annona squamosa leaves are possibly mediated throughquercetin-3-O-glucoside. Biofactors 31:201-210.
Pandey M, Khan A (2002). Hypoglycemic effect of defatted seeds and water soluble fibre from the seeds of *Syzygium cumini* Linn Skeels in alloxan diabetic rat. Indian J. Exp. Biol. 40:1178-1182.
Pari L, Maheswari J (1999). Hypoglycemic effect of *Musa sapientum* in alloxan induced diabetic rats. J. Ethnopharmacol. 68:321-325.
Pari L, Venkateswaran S (2002). Hypoglycemic activity of *Scoparia dulcis L.* in alloxan induced hyperglycemic rats. Phytother. Res. 16:662-664.
Pepato MT, Keller EH, Baviera AM, Kettelhut IC, Vendramini RC, Brunetti IL (2002). Anti diabetic activity of *Bauhinia forficata* decoction in streptozotocin-diabetic rats. J. Ethnopharmacol. 81:191-197.
Prakasam A, Sethupathy S, Pugalendi KV (2002). Antihyperglycaemic effect of *Casearia esculenta* root extracts in streptozotocin-induced diabetic rats. Pharmazie 57:758-760.
Prince P, Kamalakkannan N, Menon V (2004). Antidiabetic and antihyperlipidaemic effect of alcoholic *Syzigium cumini* seeds in alloxan induced diabetic albino rats. J. Ethnopharmacol. 91:209-213.
Priya E, Gothandam K, Karthikeyan S (2012). Antidiabetic activity of *Feronia limonia* and *Artocarpus heterophyllus* in Streptozotocin Induced Diabetic Rats. Am. J. Food Technol. 7:43-49.
Punnonen R, Lukola A (1980). Oestrogen-like effect of *ginseng*. Brit. Med. J. 281:1110.
Puri D, Baral N (1998). Hypoglycaemic effect of *Biophytum sensitivum* in the alloxan diabetic rabbits. Indian J. Physiol. Pharmacol. 42:401–406.
Pushparaj PN, Low HK, Manikandan J, Tan BK, Tan CH (2007). Anti-diabetic effects of *Cichorium intybus* in streptozotocin-induced diabetic rats. J. Ethnopharmacol. 111:430-434.
Pushparaj PN, Tan BK, Tan CH (2001).The mechanism of hypoglycemic action of the semi-purified fractions of *Averrhoa bilimbi* in streptozotocin-diabetic rats. Life Sci. 70:535-547.
Rai PK, Mehta S, Watal G (2010). Hypolipidaemic & hepatoprotective effects of *Psidium guajava* raw fruit peel in experimental diabetes. Indian J. Med. Res. 131:820-824.
Ravi K, Ramachandran B, Subramanian S (2004). Protective effect of *Eugenia jambolana* seed kernel on tissue antioxidants in streptozotocin induced diabetic rats. Biol. Pharmaceut. Bull. 27:1212–1217.
Reyes BAS, Bautista ND, Tanquilut NC, Anunciado RV, Leung AB, Sanchez GC, Magtoto RL, Castronuevo P, Tsukamura H, Maeda KI (2006). Anti-diabetic potentials of *Momordica charantia* and *Andrographis paniculata* and their effects on estrous cyclicity of alloxan-induced diabetic rats. J. Ethnopharmacol. 105:196–200.
Ribes G, Sauvaire Y, Baccou JC, Valette G, Chenon D, Trimble ER, Marian MML (1984). Effects of *fenugreek* seeds on endocrine pancreatic secretions in dogs. Ann. Nutr. Metab. 28:37-43.
Ribnicky DM, Kuhn P, Poulev A, Logendra S, Zuberi A, Cefalu WT, Raskin I (2009). Improved absorption and bioactivity of active compounds from an anti-diabetic extract of *Artemisia dracunculus L.* Intl. J. Pharmacol. 370:87-92.
Roy D, Perreault M, Marette A (1998). Insulin stimulation of glucose uptake in skeletal muscle and adipose tissue *in vivo* is NO dependent. Am. J. Physiol. 274:E692-E699.
Russell KR, Omoruyi FO, Pascoe KO, Morrison EY (2008). Hypoglycaemic activity of *Bixa orellana* extract in the dog. Meth. Find.

Exp. Clin. Pharmacol. 30:301-305.
Russo E, Reichelt A, De-Sa J, Furlanetto R, Moises R, Kasamatsu T, Chacra A (1990). Clinical trial of *Mycia uniflora* and *Bauhinia forficata* leaf extracts in normal and diabetic patients. Brazilian J. Med. Biol. Res. 23:11-20.
Sachdewa A, Nigam R, Khemani LD (2001). Hypoglycemic effect of *Hibiscus rosa sinensis L.* leaf extract in glucose and streptozotocin induced hyperglycemic rats. Indian J. Exp. Biol. 39:284-286.
Sangeetha K, Sujatha S, Muthusamy V, Anand S, Nithya N, Velmurugan D, Balakrishnan A, Lakshmi B (2010). 3 beta-taraxerol of *Mangifera indica*, a PI3K dependent dual activator of glucose transport and glycogen synthesis in 3T3-L1 adipocytes. Bioch. Biophy. Acta 1800:359-366.
Sarkar S, Pranava M, Marita R (1996). Demonstration of the hypoglycemic action of *Momordica charantia* in a validated animal model of diabetes. Pharmacol. Res. 33:1-4.
Satheesh MA, Pari L (2004). Antioxidant effect of *Boerhavia diffusa L*. in tissues of alloxan- induced diabetic rats. Indian J. Exp. Biol. 42:989-992.
Saxena AM, Bajpai MB, Mukherjee SK (1991). Swerchirin induced blood sugar lowering of streptozotocin treated hyperglycemic rats. Indian J. Exp. Biol. 29:674-675.
Saxena AM, Bajpai MB, Murthy PS, Mukherjee S (1993). Mechanism of blood sugar lowering by a Swerchirin-containing hexane fraction (SWI) of *Swertia chirayita*. Indian J. Exp. Biol. 31:178-181.
Schoenfelder T, Warmlin CZ, Manfredini MS, Pavei LL, Réus JV, Tristão TC, Fernandes MS, Costa-Campos L (2010). Hypoglycemic and hypolipidemic effect of leaves from *Syzygium cumini (L.)* Skeels, Myrtaceae in diabetic rats. Braz. J. Pharmacogn. 20:222-227.
Shane-McWhorter L (2001). Biological complementary therapies: a focus on botanical products in diabetes. Diabetes Spectrum 14:199–208.
Shapiro K, Gong W (2002). Natural products used for diabetes. J. Am. Pharmaceut. Assoc. 42:217–226.
Sharma K, Gupta R, Gupta S, Samuel K (1977). Antihyperglycemic effect of onion: effect on fasting blood sugar and induced hyperglycemia in man. Indian J. Med. Res. 5:422-429.
Sharma SR, Dwivedi SK, Swarup D (1997). Hypoglycemic, antihyperglycemic and hypolipidemic activities of *Caesalpinia bonducella* seeds in rats. J. Ethnopharmacol. 58:39–44.
Sheela C, Augusti K (1992). Antidiabetic effects of S-allyl cysteine sulphoxide isolated from garlic *Allium sativum Linn*. Indian J. Exp. Biol. 30:523-526.
Shibib BA, Khan LA, Rahman R (1993). Hypoglycemic activity of *Coccinia indica* and *Momordica charantia* in diabetic rats: depression of the diabetic mice. J. Asian Nat. Prod. Res. 2:321-327.
Shrivastava N, Patel T (2007). Clerodendrum and Healthcare: An Overview. Med. Aromatic Plant Sci. Biotechnol. 1:142-150.
Sikha S, Vijay KL, Kamlesh KP (2012). Polyherbal formulations based on Indian medicinal plants as antidiabetic phytotherapeutics. Phytopharmacol. 2:1-15.
Singh SN, Vats P, Suri S, Shyam R, Kumria MM, Ranganathan S, Sridharan K (2001). Effect of an hypoglycemic extract of *Catharanthus roseus* on enzymic activities in streptozotocin induced diabetic rats. J. Ethnopharmacol. 76:269-277.
Sinha A, Formica C, Tsalamandris C, Panagiotopoulos S, Hendrich E, DeLuise M, Seeman E, Jerums G (1996). Effects of insulin on body composition in patients with insulin-dependent and non insulin-dependent diabetes. Diabet. Med. 13:40-46.
Sjogren A, Floren C, Nilsson A (1988). Magnesium, potassium and zinc deficiency in subjects with type II diabetes mellitus. Acta Med. Scand. 224:461-466.
Sridhar MG, Vinayagamoorthi R, Arul SV, Bobby Z, Selvaraj N (2008). Bitter gourd (*Momordica charantia*) improves insulin sensitivity by increasing skeletal muscle insulin-stimulated IRS-1 tyrosine phosphorylation in high-fat-fed rats. Brit. J. Nutr. 99:806-812.
Srinivasan M, Padmanabhan M, Prince PS. (2005). Effect of aqueous *Enicostemma littorale* Blume extract on key carbohydrate metabolic enzymes, lipid peroxides and antioxidants in alloxan-induced diabetic rats. J. Pharm. Pharmacol. 57:497-503.
Srivastava Y, Venkatakrishna-Bhatt H, Verma Y, Venkaiah K, Raval BH (1993). Antidiabetic and adaptogenic properties of *Momordica charantia* extract. An experimental and clinical evaluation. Phytother. Res. 7:285-289.
Swanston-Flatt S, Day C, Flatt P, Gould B, Bailey C (1989). Glycemic effects of traditional European plant treatments for diabetes. Studies in normal and streptozotocin diabetic mice. Diabetes Res. 10:69-73.
Tripathi YB, Tripathi P, Upadhyay BN (1988). Assessment of the adrenergic beta-blocking activity of *Inula racemosa*. J. Ethnopharmacol. 23:3-9.
Ugochukwu NH, Babady NE (2003). Antihyperglycemic effect of aqueous and ethanolic extracts of *Gongrone malatifolium* leaves on glucose and glycogen metabolism in livers of normal and streptozotocin-induced diabetic rats. Life Sci. 73:1925-1938.
Vogler B, Ernst E (1999). *Aloe vera*: a systemic review of its clinical effectiveness. Br. J. Gen. Pract. 49:823-828.
Wadood A, Wadood N, Shah SA (1989). Effects of *Acacia arabica* and *Caralluma edulis* on blood glucose levels on normal and alloxan diabetic rabbits. J. Pak. Med. 39:208-212.
Welihinda J, Karunanayake EH, Sheriff MH, Jayasinghe KS (1986). Effect of *Momordica charantia* on the glucose tolerance in maturity onset diabetes. J. Ethnopharmacol. 17:277-282.
World Health Organization (WHO) Traditional Medicine Strategy 2002. www.who.int/medicines/publications/traditionalpolicy/en/. Accessed 14th April 2012.
Yeh GY, Eisenberg DM, Kaptchuk TJ, Phillips RS (2003). Systematic Review of Herbs and Dietary Supplements for Glycemic Control in Diabetes. Diabetes Care 26:1277-1294.
Yokozawa T, Kobayashi T, Oura H, Kawashima Y (1985). Studies on the mechanism of the hypoglycemic activity of *ginsenoside-Rb2* in streptozotocin-diabetic rats. Chem. Pharmaceut. Bull. (Tokyo) 33:869-872.
Yongchaiyudha S, Rungpitarangsi V, Bunyapraphatsara N, Chokechaijaroenporn O (1996). Antidiabetic activity of *Aloe vera* L. juice: I. Clinical trial in new cases of diabetes mellitus. Phytomed. 3:241-243.
Yoshikawa M, Murakami T, Kadoya M, Matsuda H, Muraoka O, Yamahara J, Murakami N (1996). Medicinal foodstuff. III. Sugar beet. Hypoglycemic oleanolic acid oligoglycosides, βvulgarosides I, II, III, and IV, from the root of *Bvulgaris L.* (Chenopodiaceae). Chem. Pharmaceut. Bull. (Tokyo) 44:1212-1217.
Yuan C, Wu J, Lowell T, Gu M (1998). Gut and brain effects of American ginseng root on brainstem neuronal activities in rats. Am. J. Chin. Med. 26:47-55.