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Anti-diabetic potential of *Ocimum sanctum* Linn.

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Abstract
Ocimum sanctum L., also known as Tulsi or the Holy Basil in Bangladesh and India. It is a vastly underutilized potential traditional medicinal plant. Its leaves and seed oil are used for treating many diseases, including coughs and colds. According to scientific evidence, it has a variety of traditional uses and can be used in oxidative stress, hypertension, cancers, neurological diseases and disorders, inflammation and inflammatory syndromes, and so on. These, this medicinal plant and its derivatives can be used in diabetes and metabolic syndromes. In this literature-based study, it has been seen that *O. sanctum* has promising anti-diabetic effects in various experimental models using mice, rats, rabbits etc. For its significant anti-diabetic effect, a tetracyclic triterpenoid known as 16-hydroxy-4, 4, 10, 13-tetramethyl-17-(4-methyl-pentyl)-hexadecahydro-cyclopenta[a]phenanthren-3-one has been introduced. More research is needed on its anti-diabetic effects.

Keywords: *Ocimum sanctum*, diabetes, metabolic syndromes, protective effects

Introduction
Diabetes mellitus, a complex metabolic disease which has significant harmful effects on humans. Diabetes is managed with conventional drugs in conjunction with lifestyle changes. They are not, however, completely successful, which is never recovered. Many medicinal plants have been used in many traditional medical systems worldwide to control diabetes mellitus because they are rich in biological elements. Several of them have been shown to be beneficial in the treatment of diabetes. Plants with hypoglycemic properties are becoming increasingly popular due to their inexpensive cost and lack of adverse effects. To date, hundreds of anti-diabetic medicinal herbs have been recognized (Khan *et al*., 2012) [16].
Ocimum sanctum Linn. (Figure 1) (Family: Lamiaceae) is known to act against obesity and diabetes (Satapathy *et al*., 2017) [27]. For this purpose, the plant is also used in combination as a polyherbal preparations with other medicinal plants (Kumar *et al*., 2016a, b) [17-18].

Fig 1: Different parts of *Ocimum sanctum* Linn.

This review aims to summarize anti-diabetic effects of *O. sanctum* (also called Tulsi in Bangladesh and India) on the basis of available literature in the PubMed database.

Ocimum sanctum against diabetes

Traditional remedies made from medicinal plants are used by around 67 percent of the world's population. Tulsi (*O. sanctum*) has diverse usage in Bangladesh and India (Bhattacharya *et al*., 1997; Chattopadhyay, 1993, 1999; Vats *et al*., 2002; Grover *et al*., 2002; Kar *et al*., 2003; Gholap and Kar, 2004; Narendhirakannan *et al*., 2006; Modak *et al*., 2007; De *et al*., 2015) [2, 4-5, 21, 8, 15, 7, 23, 20, 6]. It can influence streptozotocin-induced changes in glycogen content and carbohydrate metabolism in animals (Vats *et al*., 2004a) [32]. One report suggests that in mild to severe non-insulin dependent diabetes mellitus (NIDDM), the plant can be administered as an adjuvant to food therapy and pharmacological treatment (Agrawal *et al*., 1996) [1].

Over a month, a 1% dose of the leaf powder reduced fasting blood sugar, uronic acid, total amino acids, total cholesterol (TC), triglyceride, phospholipids, and total lipids in normal and diabetic rats. TC and triglycerides were dramatically reduced in the liver. Total lipids were dramatically decreased in the liver and kidney. A substantial decrease in TC and phospholipids was seen in the heart. All of these findings show that *O. sanctum* has a hypoglycemic and hypolipidemic effects on the experimental animals (Rai *et al*., 1997) [26]. Fresh leaf supplementation (2 g/kg, b.w. for 30 days) when compared to the control group, considerably reduced blood glucose levels and raised superoxide dismutase (SOD), reduced glutathione (GSH), and total thiol levels, while dramatically reduced peroxiodised lipid levels (Sethi *et al*., 2004) [28]. The leaves have been demonstrated to offer a wide range of potential advantages in a number of stressful situations. In one research, the leaf fixed oil was shown to exert considerable hypoglycemic, lipid lowering, and antioxidant activities in streptozotocin-induced diabetic rats. These effects might be attributed to the alpha-linolenic acid found in the oil (Suanarunsawat *et al*., 2015) [30]. The leaf extract (500 mg/kg b.w., p.o. for 15 days) shown antidyslipidemic and antioxidant activity, suggesting that it might be utilized to avoid diabetic dyslipidemia and accompanying problems (Husain *et al*., 2015) [12]. In comparison to the control group, seed oil (0.8 g/kg, b.w. /day for four weeks) significantly reduced blood cholesterol, triacylglycerol, and low-density lipoprotein and very low-density lipoprotein (LDL-+VLDL)-cholesterol in alloxan-induced diabetic rabbits (Gupta *et al*., 2006) [9].

Chloroform extract (250 and 500 mg/kg) of *O. sanctum* areal parts when compared to untreated alloxan-induced diabetic mice, dramatically reduced the raised level of blood glucose and generated a reversal of cholesterol, triglyceride, high-density lipoprotein (HDL), and LDL levels (Patil *et al*., 2011b) [25]. The administration of Tulsi to streptozocin-induced diabetic rats for 30 days significantly reduced plasma thiobarbituric acid reactive substances (TBARS) levels and improved the status of the antioxidant enzymes catalase, SOD, and glutathione peroxidase in vital organs such as the liver and kidney (Muralikrishnan *et al*., 2012) [21]. Methanolic extract of Tulsi at 500 mg/kg (p.o.) reduced diabetic manifestations/dysregulations in both non-diabetic and alloxan-induced diabetes in adult female Wistar rats (Singh *et al*., 2012) [29].

Oral treatment *O. sanctum* extract at 500 mg/kg (b.w.) reduced the glucose level in blood as well as in streptozotocin-induced diabetic mice, it prevented the generation of lipid peroxides, reactivated antioxidant enzymes, and restored GSH and metal levels (Chandra *et al*., 2008) [3]. Tetracyclic triterpenoid [16-hydroxy-4,4,10,13-tetramethyl-17-(4-methyl-pentyl)-hexadecahydro-cyclopenta[a]phenanthren-3-one] was isolated from the hydro alcoholic extract of *O. sanctum* aerial part was found to exert a significant anti-diabetic effect on the test system (Patil *et al*., 2011a) [24].

Certain minerals (e.g., Cu, Ni, Zn, K, Na, Fe, Cr, V) are linked to beneficial effects in diabetes (Narendhirakannan *et al*., 2005) [22]. Insulin resistance has been linked to zinc deficiency. Tulsi contains zinc, which may have a key role against insulin resistance in animals. Tulsi can increase activity of glucokinase, hexokinase, and phosphofructokinase. It might have a far larger role in both diabetes and other metabolic syndromes. Tulsi has been shown in studies to lower blood cholesterol and LDL levels while also lowering serum triglycerides and VLDL. Furthermore, Tulsi contains potent protective properties (e.g., anti-microbial, antioxidant, anti-inflammatory) that can prevent the abnormal oxidation and inflammatory processes in metabolic syndromes (Kapoor, 2008) [14].

Tulsi aqueous extract substantially decreased plasma glucose, HbA(1c), lipid profile, and lipid peroxidation (LPO), while increasing glutathione peroxidase (GPx), SOD, catalase (CAT), and glutathione-S-transferase (GST). Most of the measures tested, including plasma glucose levels, were reversed after 16 weeks of treatment with Tulsi and/or Vitamin E in diabetic animals (Halim and Mukhopadhyay, 2006) [10]. On the other hand, the alcoholic extract and five fractions of Tulsi leaves stimulated insulin secretion in experimental animals (Hannan *et al*., 2006) [11]. *O. sanctum* aqueous extract (200 mg/kg, p.o.) mixed with diet for eight weeks in diabetic (streptozotocin-induced) rats considerably decreased fasting blood glucose, serum lipid profile, lipid peroxidation products, and glucose tolerance. It also boosted antioxidant enzymes SOD, CAT, GPx, glutathione transferase (GT), and one antioxidant GSH in plasma and rat liver, lung, kidney, and brain (Hussain *et al*., 2001) [13]. In one research, alloxan-induced diabetic rats were fed an aqueous extract of Tulsi leaves at a dose of 200 mg/kg/day until cataracts developed. Serum glucose and body weight were measured on a regular basis, and cataracts were checked with the naked eye and a slit light 75, 100, and 115 days after alloxan administration. All three plant extracts had a positive effect on body weight and blood glucose, indicating that this plant has strong antihyperglycemic action (Vats *et al*., 2004b) [33].

The function of silver nanoparticles (AgNps) in current diabetic therapeutics and applied research is an appealing idea. Using aqueous leaf extracts of *O. sanctum*, stable AgNps with sizes ranging from 3 to 25 nm were produced. The concentration of the extract assisted in the reduction of silver nitrate, resulting in the rapid formation of AgNps at room temperature, exhibiting a faster reaction rate when compared to harsh chemical procedures and high conversion energy generally associated with the synthesis. The AgNps produced from Tulsi inhibited the *Bacillus Stearothermophilus* alpha-glucosidase enzyme model by 89.31 5.32 percent, showing an improved bio-catalytic

potential as compared to its crude extract and the control (Malapermal *et al*., 2017) [19].

Conclusion

O. sanctum has protective functions such as anti-microbial, antioxidant, and anti-inflammatory properties that may have an important role in the therapy of diabetes and metabolic disorders. Doctors should be alert of the medicinal plant's therapeutic properties and should advocate its frequent inclusion in the daily diet, particularly for diabetics and those with metabolic disorders.

Conflict of interest: None declared.

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