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A Review on Fruits Having Anti-Diabetic Potential

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ABSTRACT

Diabetes mellitus is a metabolic disorder of the endocrine system. The disease occurs worldwide and its incidence is increasing rapidly in most parts of the world. Moreover, continuous use of the synthetic anti-diabetic drugs causes side effects and toxicity. Therefore, seeking natural and non-toxic anti-diabetic drugs is necessary for diabetic therapy. Medicinal fruits play an important role in the development of potent therapeutic agents. The present paper reviews the data reported on pharmacologically active phytoconstituents obtained from fruits involved in anti-diabetic activity along with pharmacological status which have been experimentally studied for hypoglycaemic activity. This work stimulates the researchers for further research on the potential use of medicinal fruits having anti-diabetic potential.

Keywords: Fruits, diabetes, plants, alloxan, streptozotocin.

INTRODUCTION

Diabetes mellitus is a metabolic disorder which is emerging as a severe problem and is currently affecting around 143 million people[1] and by 2030 it is predicted to reach 366 million population worldwide[2]. Since ancient times natural products of plant origin and numerous dietary constituents have been known. About 800 plant species have been reported to possess anti-diabetic properties. Several plant species have been used for prevention or management of diabetes by the Native Americans, Chinese, South Americans and Asian Indians[1]. Diabetes is a chronic problem affecting carbohydrate, protein and fat metabolism. It has a significant impact on the health, quality of life and life expectancy of patients, as well as on the health care system. Exercise, diet and weight control continued to be essential and effective means of improving glucose homeostasis. In addition to adverse effects, drug treatments are not always satisfactory in maintaining euglycemia and avoiding late stage diabetic complications. Medicinal herbs with antihyperglycemic activities are increasingly sought as an alternative approach by diabetic patients and health care professionals[3].

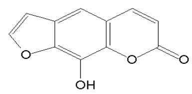
Many traditional plant treatments exist as a hidden wealth of potentially useful natural products for diabetes control. Despite recommendations by the World Health Organization in 1980 few traditional anti-diabetic plants have received scientific or medical scrutiny[4]. Currently number of natural products exists that demonstrate hypoglycemic activity. Indeed, depending upon the source that one might use, there are approximately 800 to 1200 plants that exhibit hypoglycemic activity. While research and development efforts in this particular area thus far are largely restricted to traditional medicine uses, future research may well identify a potent anti-diabetic agent[5].

Fruits as a potential source of drug

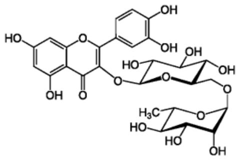
The ovules of the flowers after fertilization are converted into seeds, whereas the ovary wall develops further to form the protective covering of the seeds, which is known as fruit. In botany this particular coating is called pericarp which consists of three different layers epicarp, mesocarp and endocarp[6].

Medicinally important phytoconstituents obtained from fruits exerted a wide range of pharmacological action on body for instance antimalarial activity exerted by fruits of *Tetrapleura tetraptera*[7]; cardioprotective activity exerted by fruits of *Raphanus sativus*[8], *Lagenaria siceraria*[9], *Punica granatum*[10]; immunomodulating activity from *Cucumis melo*[11], *Terminalia chebula*[12] fruit; anti-anxiety, hepatoprotective, anti-ulcer, anti-asthmatic from *Artocarpus lacucha*[13], *Feronia elephantum*[14], *Garcinia cambogia*[15], *Scindapsus officinalis*[16] fruits respectively. A brief description of phytoconstituents, dose and pharamacology of various extracts obtained from anti-diabetic fruits have been discussed in **table 1** given below.

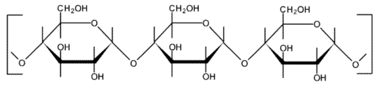
The increase in demand for the use of plant based medicines to treat diabetes may be due to the side effects associated with the use of orthodox drugs such as insulin and oral hypoglycemic agents[17]. Effective control of blood glucose level is a key step in preventing or reversing diabetic complications and improving the quality of life in both type 1 and type 2 diabetic patients[18]. Many kinds of natural products, such as triterpenes (*Morinda citrifolia*, *Momordica dioica*, *Momordica balsamina*, *Cucumis trigonus*, *Coccinia indica*, *Citrullus colocynthis*); flavonoids (*Aegle marmelos*, *Carica papaya*, *Morinda citrifolia*, *Feronia elephantum*); sterols (*Abelmoschus esculentus*, *Diospyros peregrine*), coumarins (*Aegle marmelos*); saponins (*Panax ginseng*, *Artocarpus heterophyllus)*, phenolics (*Vaccinium angustifolium*, *Terminalia catappa*, *Punica granatum*, *Phyllanthus emblica*, *Luffa tuberose*, *Mangifera indica*, *Helicteres isora*, *Syzygium jambolanum*)*;* polysaccharides (*Artemisia sphaerocephala*, *Ganoderma lucidum*, *Grifola frondosa*, *Tamarindus indica*, *Physalis alkekengi*, *Lyophyllum decastes*, *Lodoicea sechellarum*, *Limonia acidissima*); alkaloids (*Murraya koenigii*, *Withania coagulans*) *etc*. as shown in **figure 1** exerted anti-diabetic potential and have been reported as beneficial for treatment of type 2 diabetes[19-70].



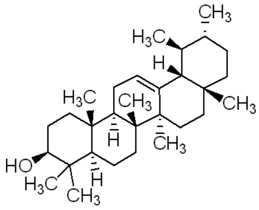
Xanthotoxol



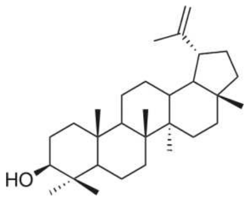
Rutin



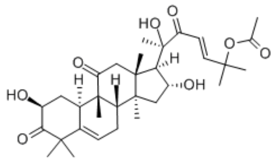
Polysaccharide



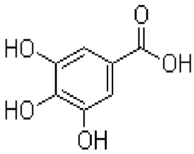
β-amyrin



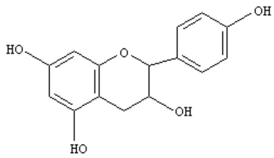
Lupeol



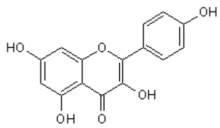
Cucurbitacin B



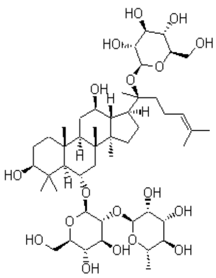
Gallic acid



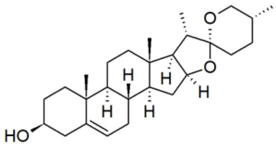
Anthocyanins



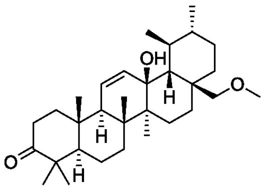
Kaempferol



Ginsenosides



Diosgenin



Momordicin

Figure 1: Chemical structures of various phytoconstituents reported from fruits

Table 1: Brief description of anti-diabetic fruits[19-70]

Sr. no.	Plant/family name	Common name	Chemical constituents	Extract	Dose mg/kg	*In vitro*/*In vivo* model
1	*Aegle marmelos*, Rutaceae	Bengal Quince	Coumarins (including xanthotoxol and alloimperatorin methyl ether), flavonoids (including rutin and marmesin), alkaloids	Aqueous	1.0 g/kg	Streptozotocin induced diabetic rabbits
2	*Artemisia sphaerocephala*, Asteraceae	Worm wood	Polysaccharide	Aqueous	200	Alloxan-induced diabetic rats
3	*Artocarpus heterophyllus*, Moraceae	Jackfruit	Sapogenins	Aqueous	250, 500	Alloxan-induced diabetic rats
4	*Butea monosperma*, Fabaceae	Bastard teak	Butrin, butein, palasonin, stigmasterol-3 β-D-glucopyranoside	Aqueous	1 or 2 g	Type II diabetic patients
5	*Carica papaya*, Caricaceae	Papaya	Saponins, tannins, alkaloids, flavonoids, anthraquinones, glycosides and reducing sugars	Aqueous	100, 200, 400	Wistar rats having diabetes type II
6	*Thespesia populnea*, Malvaceae	Portia tree	Populnetin, herbacetin, populneol, quercetin	Alcoholic	100, 200, 300	Alloxan-induced diabetic rats
7	*Citrus reticulate*, Rutaceae	Mandarin	Essential oil	Essential oil	500,1000, 1500,2000	Alloxan-induced diabetic rats
8	*Coccinia indica*, Cucurbitaceae	Ivy-Gourd	β-amyrin and its acetate, lupeol and cucurbitacin B	Alcoholic	150	Alloxan-induced diabetic rats
9	*Cucumis metuliferus*, Cucurbitaceae	Jelly melon	β-carotene, fatty acids	Fruit extract	1000,1500	Alloxan-induced diabetic rats
10	*Diospyros peregrine*, Ebenaceae	Gaub Persimmon	Lupeol, betulin, gallic acid, betulinic acid, hexacosane, hexacosanol, sitosterol, β-D-glucoside of sitosterol and a triterpene ketone	Aqueous	50, 100	Streptozotocin–nicotinamide induced type II diabetic rats
11	*Feronia elephantum*, Rutaceae	Wood Apple	Bioflavonoid, triterpenoids, stigma sterol, bergapten	Aqueous	500	Alloxan-induced diabetic rats
12	*Ganoderma lucidum*, Ganodermataceae	Reishi mushroom	Polysaccharides	Polysaccharide fraction	25, 50, 100	Streptozotocin induced diabetic mice
13	*Grifola frondosa*, Meripilaceae	Maitake	Disaccharide	Diethyl ether-ethyl alcohol soluble fraction	20% Maitake extract	Glucose tolerance test in KK-A diabetic mice
14	*Helicteres isora*, Sterculiaceae	East Indian Screw tree	Steroids, terpenoids, alkaloids, carbohydrate and phenolic compounds such as tannins and flavonoid	Aqueous	500 µg/ml	Glucose tolerance test in diabetic rats
15	*Terminalia chebula*, Combretaceae	Chebulic Myrobalan	Shikimic, gallic, triacontanoic and palmitic acids, β-sitosterol, daucosterol, triethyl ester of chebulic acid and ethyl ester of gallic acid	Aqueous	200	Streptozotocin induced diabetic mice
16	*Zizyphus spina-christi*, Rhamnaceae	Christ thorn	Fatty acids	Hydroalcoholic	500	Alloxan-induced diabetic dogs

17	*Withania coagulans*, Solanaceae	Vegetable Rennet	Milk-coagulating enzyme, esterases, free amino acids, fatty oil, an essential oil and alkaloids	Ethanolic	750	Streptozotocin induced diabetic rats
18	*Vaccinium angustifolium*, Ericaceae	Wild Blueberry	Phenolics	Ethanolic	12.5 mg/ml	Adipocyte differentiation assay, insulin secretion assay, β- cell proliferation assay
19	*Terminalia catappa*, Combretaceae	Indian Almond	Phenolics	Petroleum ether, methanolic, aqueous	68, 40, 42	Alloxan-induced diabetic rats
20	*Tamarindus indica*, Fabaceae	Tamarind tree	Polysaccharides	Methanolic	200	Streptozotocin induced diabetic rats
21	*Syzygium jambolanum*, Myrtaceae	Jambolan	Anthocyanins, citric, malic and gallic acids	Methanolic	100 ng mL^-1	Assessment of cell cytotoxicity, measurement of 2-deoxy-d-^{3}[H] glucose
22	*Lodoicea sechellarum*, Palmae	Sea coconut	Carbohydrates	Fruit extract	2, 3, 4 g	Type II diabetic patients
23	*Rhus coriaria* Anacardiaceae	Sicilian Sumach	Limonene, nonanal and dec-2 (Z)-enal	Ethanolic	400	Alloxan-induced diabetic wistar rats
24	*Punica granatum*, Punicaceae	Pomegranate	Tannins	Ethanolic	200	Alloxan-induced diabetic mice
25	*Psidium guajava*, Myrtaceae	Guava	Polysaccharides	Methanolic	100, 200, 400	Streptozotocin induced diabetic rats
26	*Phyllanthus emblica; P. acidus* Euphorbiaceae	Indian gooseberry; Country Gooseberry	Tannins	Aqueous	350	Alloxan-induced diabetic rats
27	*Persea americana*, Lauraceae	Avocado	Fat, protein; manganese, phosphorus, iron, potassium, vitamin E, vitamin C, β-carotene, thiamine, riboflavin, nicotinic acid and foliate	Aqueous	450, 900	Alloxan-induced diabetic rats
28	*Panax ginseng*, Araliaceae	Ginseng	Saponins isolated include ginsenosides	Berry extract	150	Obese diabetic C57BL/6J *ob*/*ob* mice, Glucose tolerance test in diabetic mice
29	*Opuntia dillenii*, Cactaceae	Prickly Pear	Polysaccharides	Polysaccharide extract	100, 200, 400	Streptozotocin induced diabetic rats
30	*Murraya koenigii*, Rutaceae	Curry-Leaf tree	Carbazole alkaloids	Fruit juice	2.5, 5.0 ml/kg	Alloxan-induced diabetic mice
31	*Morinda citrifolia*, Rubiaceae	Indian Mulberry	Saponins, triterpenes, steroids, flavonoids, and cardiac glycosides	Fruit juice	2 ml/kg	Streptozotocin induced diabetic rats
32	*Momordica cymbalaria*, Cucurbitaceae	Kaarali-Kanda	Steroidal glycosides or phenolic compounds	Aqueous	0.5g/kg	Streptozotocin induced diabetic rats
33	*Momordica charantia* Cucurbitaceae	Bitter Gourd	Nonbitter and bitter momordicosides, hydroxytryptamine,charantin (a steroidal glucoside), diosgenin, cholesterol, lanosterol and β-sitosterol, cucurbitacin glycosides	Water-chloroform	10, 20	Alloxan-induced diabetic rabbits

34	*Momordica balsamina*, Cucurbitaceae	Balsam apple	Momordicin, vitamin C, resin acids, fixed oil, carotene, aromatic volatile oil, alkaloids, cucurbitacins and saponins	Methanolic	250, 500	Streptozotocin induced diabetic rats
35	*Momordica dioica*, Cucurbitaceae	Small Bitter Gourd	Steroids, tritepenoids	Ethyl acetate, ethanol	200	Alloxan-induced diabetic rats
36	*Mangifera indica*, Anacardiaceae	Mango	Phenolic compounds (m-digallic acid, gallotannin, phloroglucinol, protocatechuic acid); flavonoids (tetrahydroxy benzene, kaempferol and myricetin)	Alcoholic	100, 200	Alloxan-induced diabetic rats
37	*Lycium barbarum*, Solanaceae	Chirchata	Polysaccharide	Crude polysaccharide extracts; fruit water decoction	10; 250	Alloxan-induced diabetic rabbits
38	*Luffa acutangula*, Cucurbitaceae	Ridge gourd	Flavonoids	Petroleum ether, alcoholic, aqueous	1500, 3000, 6000	Alloxan-induced diabetic mice
39	*Limonia acidissima*, Rutaceae	Wood Apple	Polysaccharide	Methanolic	200, 400	Alloxan-induced diabetic rats
40	*Citrullus colocynthis*, Cucurbitaceae	Colocynth Bitter Apple	Cucurbitacins include cucurbitacin E-, J-, L-glucosides	Methanolic	250, 500	Streptozotocin induced diabetic rats
41	*Melia dubia*, Meliaceae	African Mahogany	Liminoid	Alcoholic	300	Streptozotocin induced diabetic mice
42	*Abelmoschus esculentus*, Malvaceae	Gumbo	Carbohydrate, gums and mucilages, proteins, phytosterols, flavonoids, tannins, phenolic compounds and volatile oil	Ethanolic	300	Alloxan-induced diabetic mice
43	*Cucumis trigonus*, Cucurbitaceae	Indravaaruni	Steroid and triterpenoid compounds, cucurbitacin B and proteolytic enzymes	Aqueous	500	Streptozotocin induced diabetic rats
44	*Musa paradisiaca*, Musaceae	Banana	Dietary fibre, pectin	Methanolic	100-800	Streptozotocin induced diabetic mice
45	*Lyophyllum decastes*, Lyophyllaceae	Fried chicken mushroom	Polysaccharide	Aqueous	500	KK-Ay diabetic mice (genetically type II diabetes mice model)
46	*Diospyros lotus*, Ebenaceae	Date plum	Phenolics	Aqueous	500, 750, 1000,150	Streptozotocin induced diabetic rats
47	*Viburnum opulus*, Caprifoliaceae	Cranberry bush	Tannins	Aqueous	100	Alloxan-induced diabetic mice
48	*Physalis alkekengi*, Solanaceae	Strawberry tomato	Polysaccharide	Aqueous	50, 100	Alloxan-induced diabetic mice
49	*Butea monosperma* Papilionaceae	Flame of the forest	Flavonoids	Aqueous	3 g	Type II diabetic patients
50	*Luffa tuberosa*, Cucurbitaceae	Wild luffa	Phenolics	Aqueous	250, 500	Streptozotocin induced diabetic rats

CONCLUSION

This paper has presented 50 anti-diabetic fruits which shows hypoglycemic activity. The most commonly studied plant families are Cucurbitaceae, Rutaceae, Solanaceae. Various secondary metabolites from fruits like triterpenes, flavonoids, sterols, coumarins, saponins, tannins, polysaccharides *etc*. have been exerting wide range of anti-diabetic activity. Thus successful results have been achieved by following an appropriate screening approach. More investigations must be carried out to evaluate the mechanism of action of medicinal plants with anti-diabetic effect.

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