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REVIEW

An Overview on Ethnopharmacology of Different Medicinal Plants of Odisha State of India in the Management of Diabetes Mellitus

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Diabetes mellitus, commonly known as diabetes, is a group of metabolic disorder associated with elevated blood glucose level. World health organization recommended the traditional and herbal remedies for the diabetic management. The application of herbal remedies is extremely increased worldwide in the last three decades. Most of the synthetic drugs were discovered from the plant source out of different regions of the world to meet the demand. Several medicinal plants like *Gymnema sylvestre*, *Pterocarpus marsupium*, *Catharanthus roseus*, *Trigonella foenum*, *Annona squamosa*, *Aegle marmelos*, *Withania somnifera*, *Boerhavia diffusa*, *Boerhavia erecta*, *Momordica charantia*, *Cocos nucifera*, *Ricinus communis*, *Azadira chtaindica* and *Aloe vera* have been reported to have varying level of hypoglycemic property. One of the factors involved in the evolution of diabetic convolutions is the impairment due to free radicals and hence a compound with antioxidant and antidiabetic potential would be more effective. The present review article was designed to provide an absolute data on these medicinal plant based remedies by using the traditional healers of Odisha state, India.

Keywords: Diabetes, Odisha, Herbal product, Phytochemical constituents, Ethnomedicine.

INTRODUCTION

Diabetes mellitus as a metabolic disorder of several causes indicated with chronic hyperglycemia and abnormal level of protein, fat and carbohydrate metabolism resulted from either the insufficient creation of insulin by pancreatic beta cells or the unproductive use of insulin by the body [1]. The number of people with diabetes has arises from 108 million to 420 million in between 1980 to 2014. The global prevalence of diabetes in adults above 18 years of age has been increased from 4.7% to 8.5% in between 1980 to 2014. By 2030, diabetes will become the seventh foremost cause of death worldwide as per World Health Organization. Report found that the prevalence of diabetes can be overwhelm by regular physical exercise or lifestyle changes and balanced diet along with use of pharmacological intervention [2]. Currently, there are many conventional therapy, both oral and parental existing for the management of glycaemic control in diabetes. However, these medication has some limitations in terms of overpriced or have specific adverse effects and other complication. Since from ancient times, there has been an enormous exploration of herbal medicine for the management of metabolic disorder around the world as these are rich source of medicinal properties [3]. Therefore, many traditional plants have been preferred for the management of diabetic mellitus as they are found to be safer as compared to conventional therapy and possess a remarkable antioxidant property [4,5]. These antidiabetic herbs with their dosages forms are listed in official monographs known as Indian Ayurvedic Pharmacopoeia and many of their extracted products have reported in referred journal. Tribal healers of Odisha have been using different parts of various plants like *Gymnema sylvestre*, *Pterocarpus marsupium*, *Catharanthus roseus*, *Trigonella foenum*, *Annona squamosa*, *Aegle marmelos*, *Withania somnifera*, *Boerhavia diffusa*, *Boerhavia erecta*, *Momordica charantia*, *Cocos nucifera*, *Ricinus communis*, *Azadira chtaindica*, *Aloe vera* and other unknown herbs for the management of glycemic control in diabetes. The aim of the existing study is to explore scientifically the possible mech-

anism involved with antidiabetic activity of various plants used by the traditional healers of Odisha state of India.

Medicinal plants for the management of diabetes: World health organization has notified that 80% of the world populations currently depends upon herbal drugs for leading health issues. Around 21,000 species of plants used for different medicinal benefits worldwide are listed in world health organization out of which 2500 species are in India and 150 species are extensively used commercially. India is the leading manufacturer of medicinal herbs and hence known as biological hub of the world [6,7]. Previous studies revealed that out of 800 plants employed in the diabetic management only 30% of plants used traditionally for diabetes have been biologically assayed. Diabetes mellitus alone is coincide with many other disorders affecting healthy volunteers, which can be treated by utilizing the herbal integrity of India [8]. Most of the drugs were extracted directly or indirectly from plant sources. There are around 30 species of herbal extracts used by the traditional healers of Odisha state for the management of diabetes. Out of which few potential herbs with antidiabetic property, their origin and active constituents are given in Table-1. Several studies are now emphasizing on the application of herbal medicines to avoid various adverse effects and the costs associated with the allopathic drugs.

Antidiabetic activity of various plants from Odisha state

***Gymnema sylvestre*:** *Gymnema sylvestre* is known as gurmar which means "sugar destroyer" the extracts of this herb contains gymnemic acids (Fig. 1), which interact with taste receptors to suppress the taste of sweetness. *Gymnema sylvestre*, is an important medicinal herb with anti-hyperglycemic activity, often used in patients having diabetes. It is cultivated in the southern region of Asia and easily accessible in many regions of Odisha state. The plant root and leaves of this herb possess medicinal value. The plant extracts has the ability to increase enzyme activity required for the glucose utilization and uptake. It has been found that the extract helps in reducing the blood sugar level and possesses hepato protective activities. Studies reveals that the leaf extract of *Gymnema sylvestre* exhibited hypoglycemic activity and lowered blood cholesterol level in streptozotocin-induced diabetic rats. Antidiabetic effects of gymnemic acids are shown by increase in insulin production, beta cells regeneration and utilization of glucose [9,10]. Leaf extract of *Gymnema sylvestre* produces antioxidant and anti-peroxidative activity along with the antidiabetic effect [11].

TABLE-1
DETAIL MECHANISMS AND CHEMICAL CONTENTS OF PLANT EXTRACTS

Antidiabetic plants	Phytoconstituents	Mechanism	Ref.
Gymnema sylvestre	Gymnemic acid, gymnemosides, gurmarin, betaine, choline,trimethylamine, Stigmasterol, quercitol, gymnenic acid IV	Gymnemic acid molecules constitutes a receptor on the surface of intestine, which inhibits the absorption of sugar molecules that leads to a reduction in blood glucose levels. It also helps in pancreatic β cells regeneration and secretion of insulin.	[9,10]
Cathanthrus roseus	Catharanthine, vindoline, vindolinene vinblastine, vincristine	Increase in the metabolism of glucose	[47]
Trigonella foenum graecum	Trigonelline, gentianine, galactomannan, diosgenin	Increase glucose uptake, normalization of glycosylated hemoglobin, increase glycogenesis, increase in oxidative stress	[15,16]
Aegle marmelos	Aegelin, marmelosin, marmesin	Pancreatic β-cells regeneration and insulin secretion, stimulation of glucose uptake	[25]
Aloe vera	Leucine, isoleucine, alanin, aloin, barbaloin, isobarbaloine, aloetic acid, emodin, aloe-emodin, cinnamic acid, glucomannan, crysophanic acid	Insulin secretion and its synthesis, carbohydrate digestion, activation of gluconeogenesis.	[64,67]
Pterocarpus marsupium	Catechin, epicatechin, chiorogenic acid, liquiritigenin, isoliquiritigerin	β-Cell regeneration, insulin release, increase in glycogen synthesis, insulin like activity.	[35]
Azadirachta indica	Quercetin (flavonoid) and nimbosterol (β-sitosteriol) nimbin, nimbinene, nimbosterol	Carbohydrate absorption, transformation of pancreatic β-cells and secretion of insulin.	[53]
Withania somnifera	Withanine, somnine, withaferine, withanolides	Increase glucose uptake, carbohydrate digestion and absorption	[42,43]
Momordica charantia	Terpenoide, pyridine, pyrolidine, alkaloids, charantin, polypeptide-p	Decrease blood glucose level by mimicking the action of insulin.	[79,82,83]
Boerhaavia diffusa	Punarnavine, boeravinone, hypoxanthine, ursolic acid, punarnavoside, lirodendrin, arachidic acid, α-2-sitosterol, palmitic acid, ester of β-sitosterol, tetracosanoic, β-Sitosterol, hexacosonoic, stearic, urosilic acid, triacontanol, hentriacontane	Pancreatic β-cells regeneration and insulin secretion	[51,52]
Cocos nucifera	L-Arginine, ascorbic acid, vitamin B, B_1, B_2, B_3, B_5, B_6, folic acid folic acid, plant hormones, enzymes (acid phosphatase, catalase, dehydrogenase, diastase, peroxidase, RNA polymerases) and growth-promoting factors.	Restoration of glycogen level, increase in serum insulin level, recover the action of antioxidant enzymes (superoxide dismutase and catalase levels) and decreased lipid peroxidation. Significantly reduces the generation of free radicals.	[74]
Ricinus communis	Ricinoleic, isoricinoleic, stearic, dihydroxystearic acids 26, ricinine, *n*-demethylrecinine, quercetin	Stimulant the release of insulin followed by the repair of pancreatic β-cells, antioxidant and hypoglycemic activity	[76]

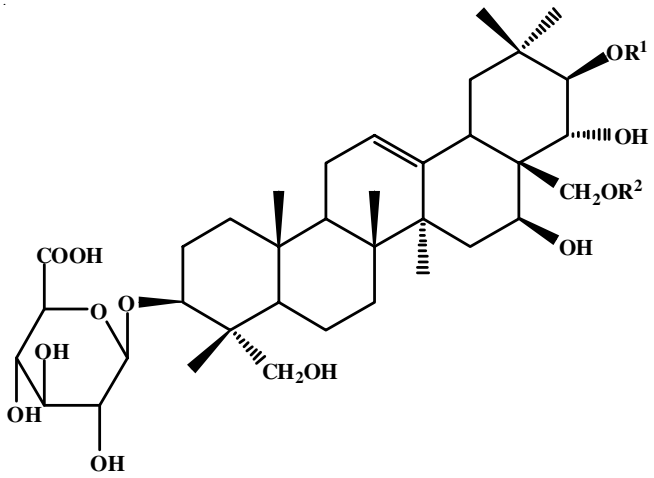

Fig. 1. Chemical structure of gymnemic acid

***Trigonella foenum-graecum*:** *Trigonella foenum-graecum* is commonly known as Fenugreek belongs to family Fabaceae. Fenugreek has been cultivated majorly in countries like North Africa, southern Europe and western Asia. Ethanolic extract of seeds of *Trigonella foenum-graecum* shows potential hypoglycemic effect. Apart from the diabetes management, it is also used in high cholesterol, gastrointestinal disorders and in inflammation. Decrease in rate of glucose absorption and delay in gastric emptying are the activities by the seed fibers of *Trigonella foenum-graecum*, which help in reducing the increased blood glucose level [12]. Amino acid, 4-hydroxy isoleucine of seed fiber also increases the insulin secretion at all level [13]. Xu *et al*. [14] elucidated the hypoglycemic and hypocholesterolemic effect of seeds of *Trigonella foenum-graecum* on type one and type two diabetes mellitus. Galactomannan is the active constituent *Trigonella foenum-graecum*, which has effective anti-hypoglycemic activity. Galactomannan increases the glucose uptake, increases the glycogen content (stimulate glycogenesis), normalize the glycosylated hemoglobin and also shows protective effect on pancreatic islet [15]. Kumar *et al*. [16] also revealed that fenugreek galactomannan helps in lowering the blood sugar level in alloxan induced animals.

***Annona squamosa*:** *Annona squamosa* Linn. derived from the family Annonaceae, commonly known as sitaphal and custard apple or sugar apple in English. It is cultivated throughout Odisha state and all parts of India. Glycosides, flavonoids, phenolic compounds, proteins, tannins are reported as the active components of this plant and out of all flavonoids possess antidiabetic activity (Fig. 3). Leaf extracts of *Annona squamosa* previously been shown to have hyperthyroidism effects [17]. Phytochemical analysis of leaves of *Annona squamosa* shows the presence of flavonoids, which have potent antidiabetic activity (Fig. 2) [18]. Hot aqueous extract of *Annona squamosa* leaves shows antidiabetic and hypoglycemic activity. Ethanolic extract of *Annona squamosa* leaves at a dose of 350 mg/kg body weight helps in reducing 6.0% of the blood glucose level within 1 h [19]. A potent antidiabetic activity showed by the aqueous extract of *Annona squamosa* through significant decrease in blood glucose level and increase in the serum insulin level. The probable mechanism of action include stimulation of insulin effect of plasma either through elevating the pancreatic insulin secretion or by its release from the bound form [20]. The consequential control of serum lipid level leads to the improvements in the insulin level by treating the diabetic rats with aqueous extract of *Annona squamosa* [21,22].

***Aegle marmelos*:** *Aegle marmelos* is one of the most important medicinal plants, which is widely used traditionally in India belongs to the family of Rutacae. It is commonly known as Bale fruit tree available throughout in all areas of Odisha state. The antidiabetic activities of *Aegle marmelos* leaf extracts in glucose-induced hyperglycemia have been reported [23]. Leaves of this plant contain alkaloids, terpinoids, flavonoids, tannins, cardiac glycosides, saponins and steroids (Fig. 3). Fruits of the plant also contains various phytochemicals such as carbohydrates, protein, calcium, phosphorus, fiber, potassium, minerals, fat, iron, vitamins (A, B_1, C & B_2), steroids, lignin, alkaloids, phenolic compounds, cardiac glycosides, terpenoids and flavonoids [24]. *Aegle marmelos* bark extracts exerts a significant hypoglycemic activity in streptozotocin induced diabetic rats by enhancing the number of β-cells [25]. Aqueous fruit extracts of *Aegle marmelos* improves the β-cells activity and recovered the partially destroyed β-cells in the islet of pancreas [26,27]. Ismail & Yaheya [28] elucidated that there is a significant changes in the postprandial blood glucose level of patients who receives the extract of *Aegle marmelos* compared to the patients who were on their regular hypoglycemic therapy. Antidiabetic activity also expressed by the flower extract of *Aegle marmelos* through stimulating the insulin secretion and by decreasing the HbA1c level in diabetic rats [29]. Aqueous seed extract of *Aegle marmelos* potentially reduce the blood sugar level to normal and also helps in normalizing the lipid profile in diabetes [30].

***Pterocarpus marsupium*:** *Pterocarpus marsupium* is a medicinal herb employed in treatment of diabetes mellitus belongs to the family of Fabaceae, located in various part of Odisha state. The origin of *Pterocarpus marsupium* is India, Sri Lanka and Nepal. The broad variety of pharmacological actions of *Pterocarpus marsupium* has been proved in various traditional system of medicine [31]. Plant extracts are extensively used to treat diabetes mellitus for over 100 decades [32]. It has been found from different studies that the extract has hypoglycemic effects in diabetes-induced rat. The extract contain two main compounds, which is responsible for antidiabetic activity are pterostilbene and (-)-epicatechin (Fig. 4). Multiple mechanisms responsible for hypoglycemic effects of *Pterocarpus marsupium* including insulin release, β-cell regeneration and insulin-like actions (Fig. 4) of compounds isolated [33,34]. The flavonoid extract of the bark of *Pterocarpus marsupium* also helps in regenerating the destroyed beta cells in alloxan induced diabetic rats [35]. Ethanolic fractions at a dose of 0.25 g/kg exhibits maximum hypoglycemic effect compared to the aqueous and hexane [36]. *Pterocarpus santalinus* wooden cups are also used in drinking purpose for diabetic management [37].

***Withania somnifera*:** *Withania somnifera* popularly called as Ashwagandha or Indian ginseng is a small shrub used as an important herb in Ayurveda since ancient times belongs to the

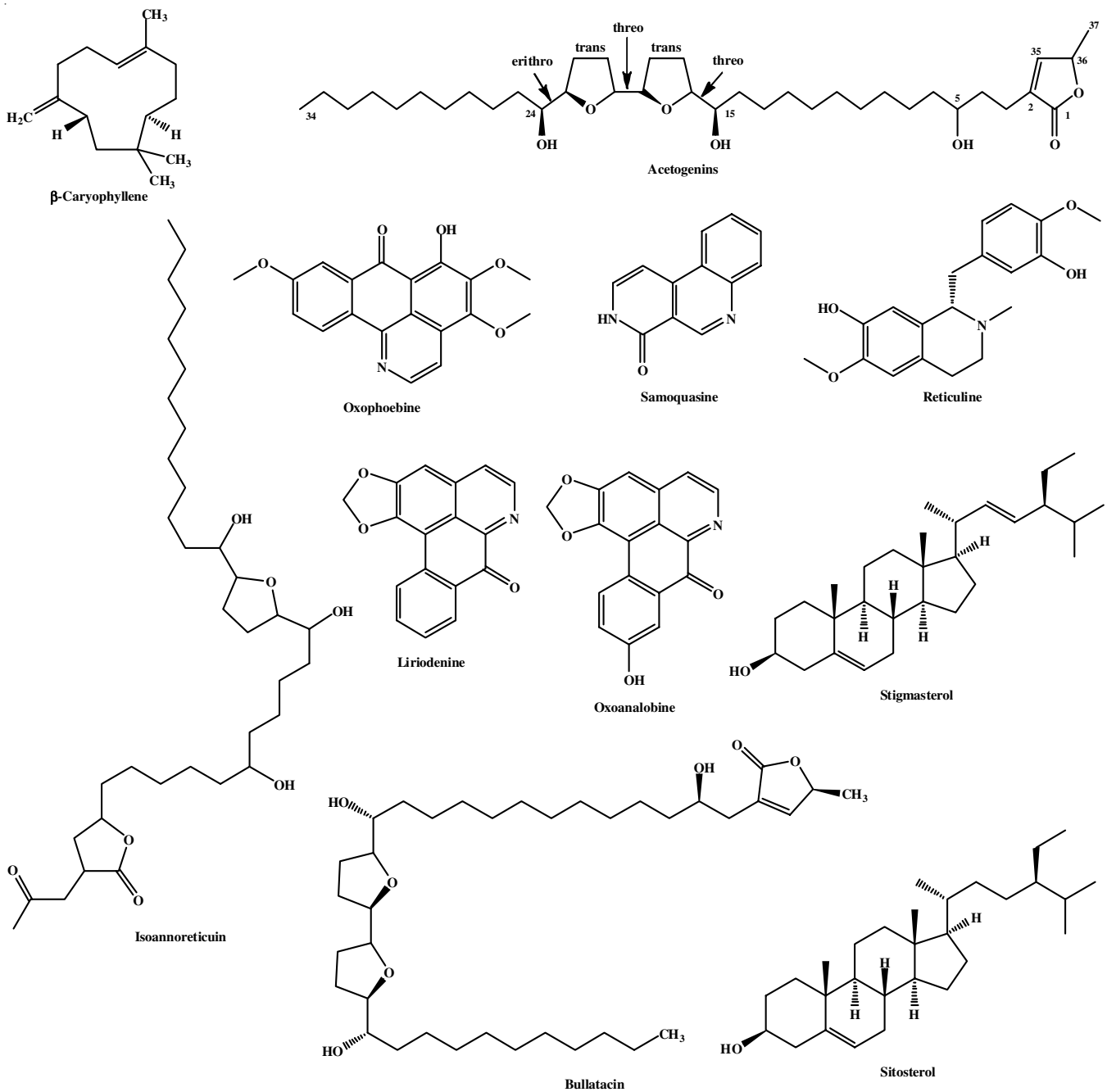

Fig. 2. Chemical structures of main phytochemical ingredients of *Annona squamosa*

family Solanaceae. The constituents like withanine, somnine, withaferine, withanolides are the major phyto-compounds of *Withania somnifera* (Fig. 5). Animal models used for hypoglycemic activity studies seem to be preferred method using cultured cells for glucose uptake. Previous studies revealed that ethanolic root extracts of *Withania somnifera* on streptozotocin induced diabetic rats for a period of three weeks helps in lowering blood glucose in type I diabetic model [38]. It has also been reported that root and leaf extract of *Withania somnifera* possess a hypoglycemic and hypolipidemic effect on alloxan generated diabetic albino rats [39,40]. Because of its antioxidant activities and presence of contents like phenolic compounds, flavonoidsit helps in preventing various diabetic complications [41]. Many active constituents comprising alkaloids, saponins, sitoindosides, steroids, tannins and flavonoids were recognized and isolated from *Withania somnifera* by phytochemical examination [42,43]. An effect of increase in glucose uptake in rat myotubes and adipocytes and also an increases in insulin secretion in pancreatic β-cell observed by administering leaf and root extracts of *Withania somnifera* [44]. Oral administration of *Withania somnifera* root powder regulates the plasma and hepatic cholesterol metabolism and antioxidant property in hypercholesteremic animals [45].

***Catharanthus roseus*:** *Catharanthus roseus* Linn. is a traditional medicinal plant used in diabetic management belongs to the family Apocynaceae. It is available in many regions of

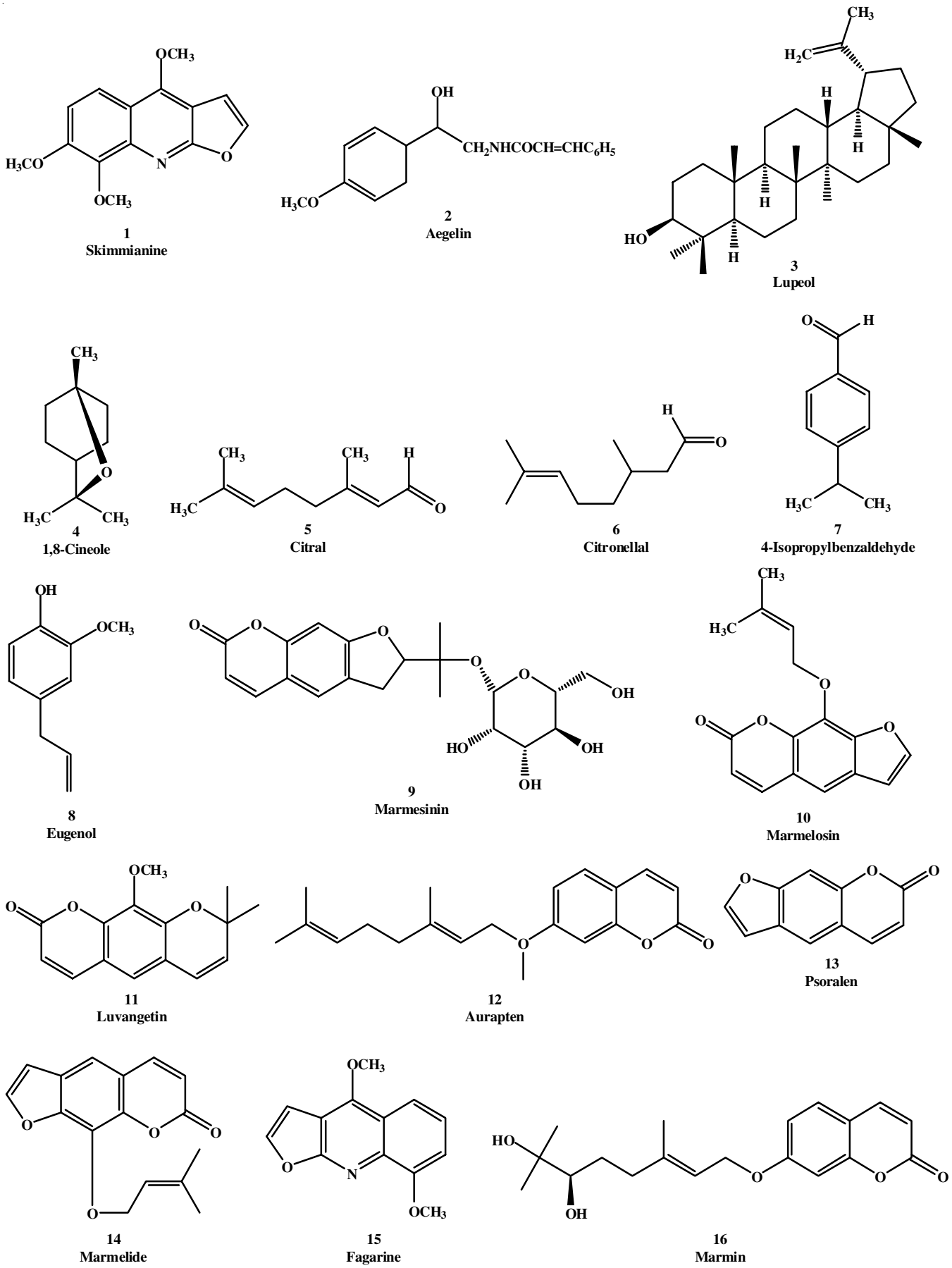

Fig. 3. Chemical structures of main phytochemical ingredients of *Aegle marmelos*

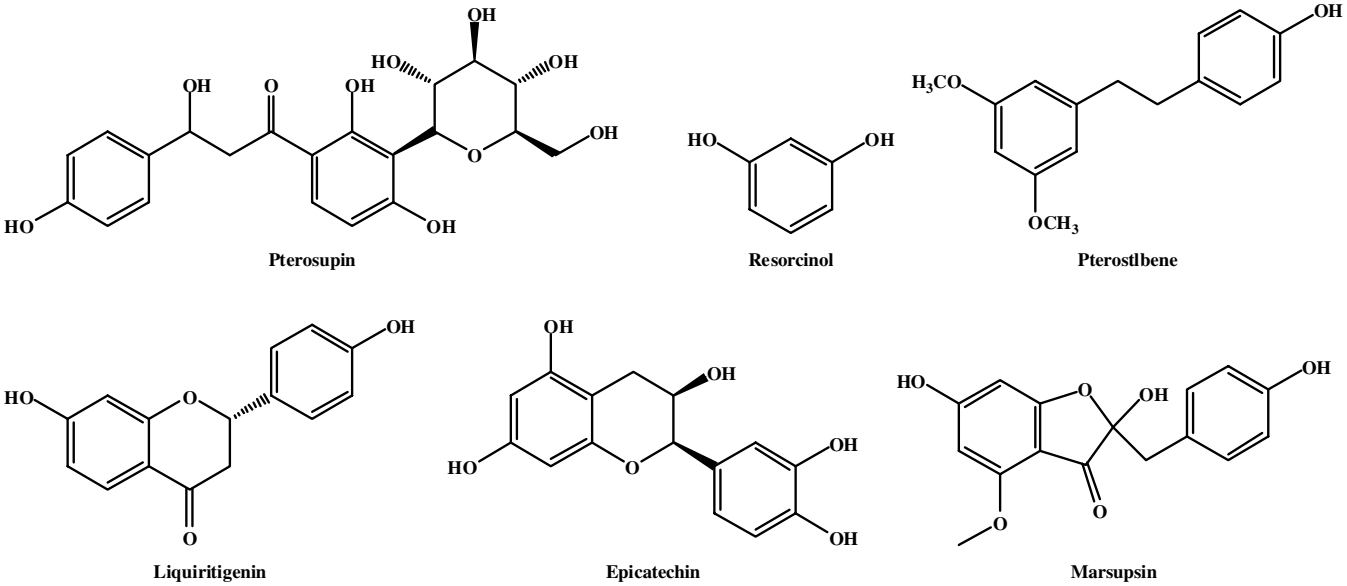

Fig. 4. Chemical structures of main phytochemical ingredients of *Pterocarpus marsupium*

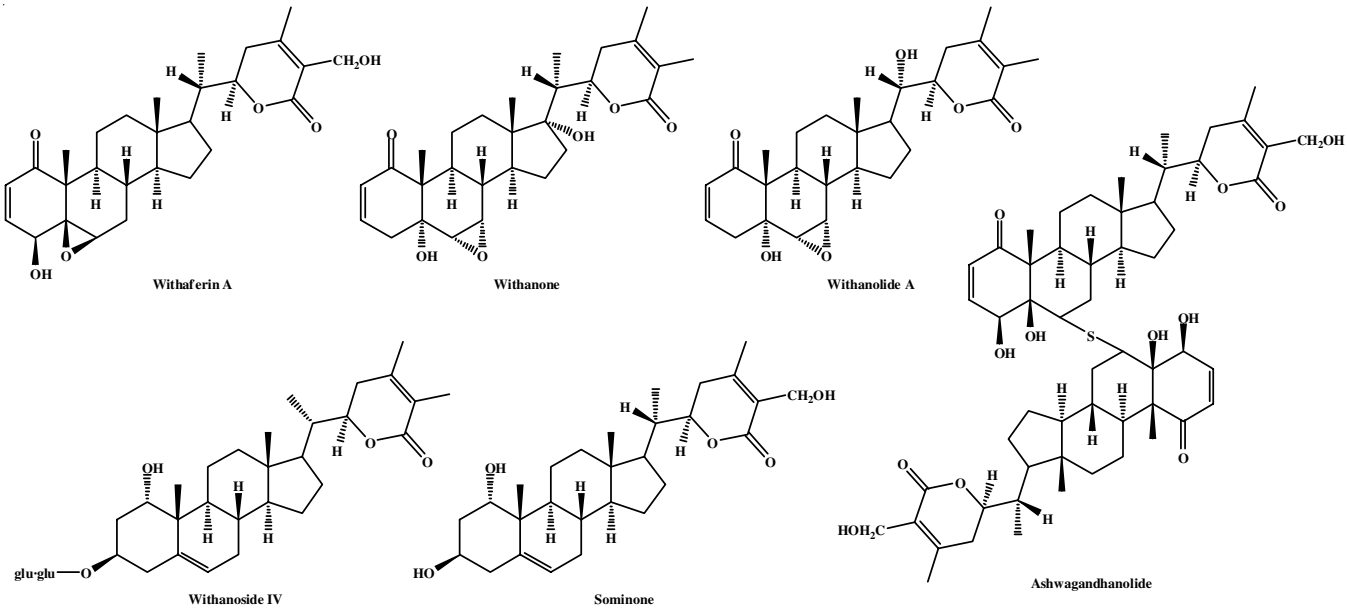

Fig. 5. Chemical structures of main phytochemical ingredients of *Withania somnifera*

Odisha state. The possible antidiabetic and hypolipidemic effects of *Catharanthus roseus* leaf powder in diabetic rats were evaluated from different studies. Earlier reports indicate that hydro alcoholic or dichloromethane-methanol extracts of leaves of *Catharanthus roseus* shows significant blood glucose lowering activity in laboratory animals. Chemical constituents that show hypoglycemic activity are vindoline, tetrahydroalstomine, catharanhtine, lochericine, leurosine, vindolinine, adenosine, β-sitosterol, quercetin, *etc*. (Fig. 6). It contain vincamine (monoterpenoid indole alkaloid) which shows antidiabetic activity [46]. Ayurvedic doctors recommend fresh leaf juice of *Catharanthus roseus* in practice in India for their various beneficial effects [47]. Vindogentianine, a new indole alkaloid together with six known alkaloids vindolinine, vindolicine, vindoline, vindolidine, serpentine and perivine were found in the leaf extract of *Catharanthus roseus*. Vindogentianine helps in reducing hyperglycemia in the β-TC6 cells of pancreas and C2C12 cells of myoblast in mouse by enhancing the glucose uptake and protein-tyrosine phosphatase 1B (PTP-1B) inhibition [48]. Vindogentianine acts as an inhibitor of PTB-1B, which is an insulin sensitizer in the management of type-2 diabetes [49]. Methanolic extracts of the leaves of *Catharanthus roseus* diminishes the diabetic complications by inhibition of alpha glucosidase and α-amylase and also causes increase in glucose utilization by increasing the enzymes activity [50].

***Boerhaavia diffusa* and *Boerhaavia erecta*:** Punarnava is a well-established drug in Ayurveda procured from the genus *Boerhaavia* L. belongs to the Family Nyctagynaceae. *B. erecta* and *B. diffusa* are the two identical species, found in India in the name of punarnava known to have important therapeutic

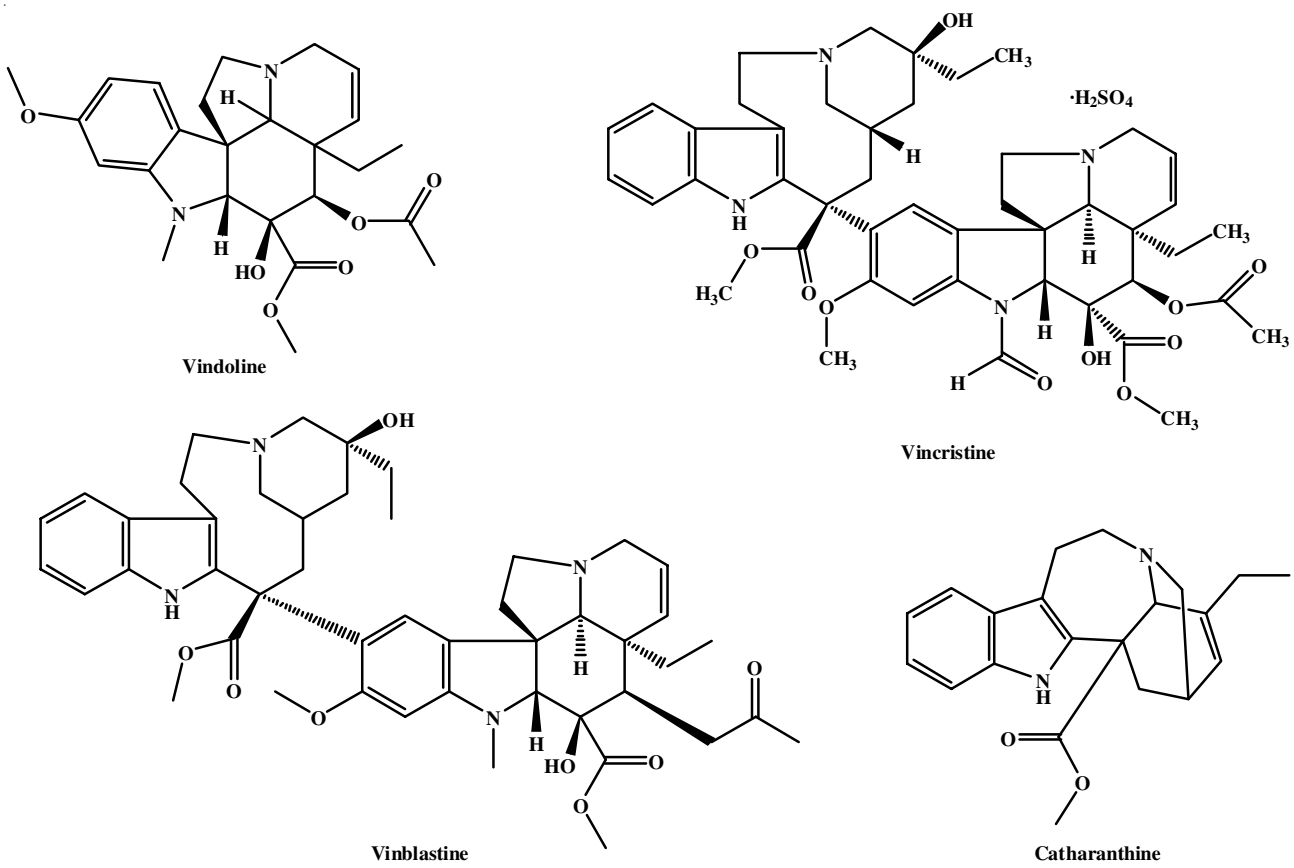

Fig. 6. Chemical structures of main phytochemical ingredients of *Catharanthus roseus*

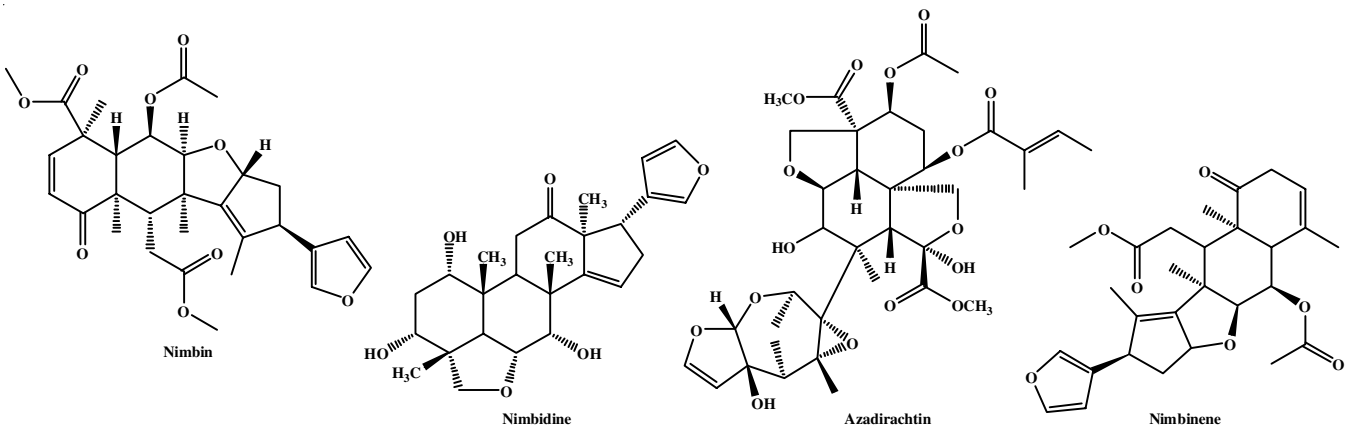

Fig. 7. Chemical structures of main phytochemical ingredients of *Azadirachta indica*

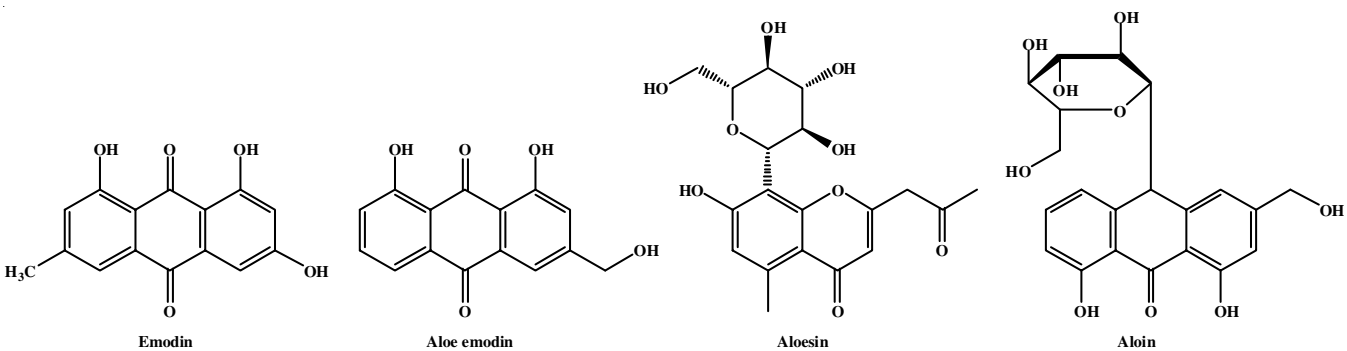

Fig. 8. Chemical structures of main phytochemical ingredients of *Aloe vera*

properties. As both species of *Boerhaavia* contains homogeneous biochemical ingredients, they may possess similar therapeutical actions. *B. erecta* is a straight, pubescent herb available in many tropical and semi-tropical region. It constitutes glycosides, flavonoids, saponins, alkaloids, steroids and more polar compounds like minerals, vitamins, sugar and proteins. Its root is employed in stomachic, diuretic, cardio tonic, hepatoprotectives, to treat gonorrhea, laxative, expectorant, jaundice, enlarged spleen and anthelmintic. Few studies [51,52] reported that the extracts of *B. diffusa* and *B. erecta* possess antidiabetic and anti-hyperlipidemic effects against streptozotocin generated diabetic rats.

***Azadirachta indica*:** *Azadirachta indica* is familiar as neem worldwide comes from the family Meliaceae. It is considered to have emerged from South Asia and grows well in tropical and sub-tropical regions, available throughout Odisha state. The tree contains a number of active constituents such as nimbidin, nimbinene and nimbin. Quercetin, nimbosterol and a number of liminoids are the main active components of leaves (Fig. 7). Nimbin, tannins, nimbinene are the chief active constituents of trunk bark while tannins and non-tannins are the primary constituents stem bark. Seed extracts contains flavonoids and nimbosterol (β-sitosterol), which is said to have antimalarial, antibacterial and potent antifungal activity. Antidiabetic effect of *Azadirachta indica* like effect of this plant sugar levels in both humans and animal models has been proved traditionally and clinically in many studies. Another β-sitosterol content, which is said to have antidiabetic activity, is *Aristolochia indica* [53]. Leaf extracts of *Azadirachta indica* regulates the insulin level by improving the expression of insulin signaling molecule and GLU4 protein [54]. Azadirachtin (azadirachtolide, azadiradione, gudunin and meliacinolin) shows a potent hypoglycemic effect by inhibition of α-glucosidase and α-amylase [55,56]. Chloroform extracts of *Azadirachta indica* exhibits a vigorous effect of β-cell regeneration and protection of islet in diabetes mellitus [57]. Ethanolic extract of leaves of *Azadirachta indica* also demonstrated the reduced effect of glucose. Presence of insulin-like substances, which affects carbohydrate absorption, blocking of insulin action, β-cell regeneration, are considered as various mechanism of action of this plant [58].

***Aloe vera*:** It mainly grows in tropical climates around the world and also cultivated in large scale for its medicinal values in Odisha state belongs to the family Asphodelaceae. Many phytoconstituents such as anthraquinones (aloe-emodin, barbaloin, isobarbaloin), phytosterols, vitamins, proteins, amino acids, carbohydrates are present in *Aloe vera* [59] (Fig. 8). Rajasekaran *et al*. [60] reported the antidiabetic effects in the diabetic patients and in alloxen, streptozotocin generated diabetic model. *Aloe vera* gel extracts significantly decreases the fasting blood sugar level as well as glycated hemoglobin (HBA1C) levels in diabetic mice [61]. Jain *et al*. [62] reported that *Aloe vera* gel at a dose of 200 mg/kg produces an antidiabetic activity in streptozotocin generated diabetic rats. Recent approaches [63-65] suggest that *Aloe vera*gel extract is responsible for scavenging activity of peroxyl and superoxide radicals. *Aloe vera* gel extracts exhibit significant hypoglycaemic effect by preventing the damage of pancreatic β-cells and partially recovering the destroyed β-cells [66]. Emodin and manose-6-phosphate content of aloe exhibits the anti-inflammatory potential by suppressing the activity of TNFα towards the insulin sensitivity [67,68]. It also exhibits hypoglycaemic effect by inhibiting pancreatic α-amylase activity [69,70].

***Cocos nucifera*:** It is commonly called as coconut belongs to the family arecaceae available in almost all parts of Odisha state. many main constituents such as phenols, flavonoids, steroids, tannins, triterpenes and alkaloids are present in coconut. It is used pharmacologically as an antibacterial, analgesic, anti-inflammatory, antifungal, antioxidant, antiparasitic, antimalarial, cardioprotective, *etc*. Methanolic extract of *Cocos nucifera* inflorescence (flower and the flower bearing stalk collectively) decreases the serum glucose level, increases the serum insulin level [71] and also possess good antioxidant as well as free radical scavenging activity [72]. It was found that the significant antidiabetic activity was showed by the flowers extract of the plant in the streptozotocin induced diabetic rats at the dose of 300 mg/kg [73]. Tyagi *et al.* [74] reported that ethanolic extract of this plant showed potent antidiabetic activity at the doses of 200 mg/kg and 400 mg/kg in the streptozotocin induced diabetic rates.

***Ricinus communis*:** This plant is a species of perennial flowering plant and widely available in Odisha state belongs to the family Euphorbiaceae. It contains several chemical constituents such as steroids, saponins, alkaloids, flavonoids and glycosides, *etc.* The seeds and fruits of this plant contain 45% of fixed oil, which contains glycosides of ricinoleic acid, stearic acid, isoricinoleic acid and dihydroxystearic acid. It is used as an anticancer, antioxidant, antiulcer, antimicrobial, antidiabetic, hepatoprotective, central analgesic, antiasthmatic, *etc.* Flavonoids are reported to have hypoglycemic effect [75]. Afolayan & Kibiti [76] reported that both aqueous and alcoholic extracts of *Ricinus* communis exerts the hypoglycemic activity because of the stimulant effect of flavonoids, saponin contents, which causes the regeneration of pancreatic β-cells and inhibits the intestinal absoption of glucose. Kumar [77] demonstrated that the root, stem and leaves of the plant showed hypoglycemic activity in the albino rats at the dose of 250 mg/kg.

***Momordica charantia*:** It is a tropical plant cultivated everywhere in Odisha state and in other parts of India as well. *Momordica charantia* is commonly used in cooking and as a natural remedy for the treatment of diabetes [78]. Because of the consequential antidiabetic and hypolipidemic activity, *Momordica charantia* can be used along with the allopathic treatment for the management of diabetes and also to decrease its complications [79]. It has also been reported that oral administration of the extracts of seeds of *Momordica charantia* shows the hypoglycemic effects in streptozotocin induced type-1 diabetes [80]. With the help of much scientific evidence the traditionally used plant *Momordica charantia* today become the most favourable plant for diabetes [81]. Methanolic extract of *Momordica charantia* helps in significantly lowering the blood glucose level by inhibiting the α-glucosidase activity. It is found to contain charantin (tritorpenoid), polypeptide-p which are used to control diabetes naturally [82]. Polypeptide-n reduces the blood glucose level by performing similar action as of insulin. Therefore it is used by the patients with type-1 diabetes as plant based insulin replacement [83]. A dose of 20

mg/kg body weight of aqueous extract of the whole fruit of *Momordica charantia* signifies an effect of narrowing the blood glucose level by 48% [84]. The hypoglycemic prospective of *Momordica charantia* comprises of β-cell regeneration [85], recovery of partially destroyed β-cells and stimulation of pancreatic insulin stimulation [86].

Conclusion

People of Odisha state used their indigenous plants to overcome the metabolic disorder, it suggest that they used traditional plants based on ethnobotany. Based on traditional use, 13 herbal medicines were selected and explore the important bioactive compounds, which are used for the management of diabetic mellitus. In this review article, the main chemical constituents of the studied 13 herbal medicines were explored, which is responsible for exhibiting hyperglycaemic effect either by inhibiting pancreatic amylase enzyme or by regulating the insulin-signaling molecules. This study provides the scope for the readers to further explore the active constituents of these antidiabetic plants and their possible mechanism of actions for future research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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