

2. REVIEW OF LITERATURE

The literature pertaining to the present study entitled “**Efficacy of a Software “Nutra Glyx” on Nutraceutical Recipes Incorporated with Selected Medicinal Plants for Diabetes Mellitus**” is reviewed under the following headings:

- 2.1. Prevalence of Diabetes Mellitus – The Current Scenario
- 2.2. Medicinal Plants and their Nutraceutical Effects
- 2.3. Nutraceutical Properties of Guava Leaf (*Psidium guajava L.*)
- 2.4. Nutraceutical properties of Long Pepper (*Piper longum L.*)
- 2.5. Nutraceutical properties of Sirukurinjan Leaf
(*Gymnema sylvestre R.Br.*)
- 2.6. Nutraceutical Properties of Naval Seed (*Syzygium cumini L.*)
- 2.7. Nutraceutical Properties of Kandankathiri (*Solanum virginianum L.*)
- 2.8. Information Technology and Software in the Management of Diabetes Mellitus

2.1. Prevalence of Diabetes Mellitus - The Current Scenario

Diabetes is the fifth leading cause of mortality accounting for over 3.8 million deaths annually (Yoon *et al.*, 2013). Individuals with diabetes have an increased risk of all-cause for mortality and morbidity related to CVD compared with individuals without diabetes (Ballotari *et al.*, 2013). Diabetes mellitus is one of the commonest non-communicable diseases (Ramachandran and Snehalatha, 2014). In 2013, The International Diabetes Foundation estimated the global prevalence of diabetes to be 382 million (Guariguata *et al.*, 2014). Eight percent of these individuals were thought to be in the low- and middle-income countries. India is home to the second largest number of people with diabetes (Anjana *et al.*, 2011). With rampant urbanization and a drastic change in lifestyle, the prevalence of Type II diabetes (the most common form of diabetes in India) (Mohan *et al.*, 2007), is expected to increase from 51 million in 2010 to 100 million by 2030 (Whiting *et al.*, 2011).

Diabetes is one of the largest global health emergencies of the 21st century. According to the International Diabetes Federation, (IDF, 2015) reports, the world has 415 million diabetics with 215 males and 199.5 females, besides 318 million with impaired glucose tolerance. India has 69.2 million diabetics, at the prevalence rate of 8.7, second largest after China. Also, reviews indicate that nearly 60% of diabetics have never been screened or diagnosed due to a lack of awareness (IDF, 2015).

Various factors such as increased life expectancy, urbanization lifestyle changes, and stress are the contributing factors of diabetes. Early identification of at-risk persons using simple screening and appropriate lifestyle intervention would greatly help in preventing / postponing the onset of diabetes (Singh and Dixit, 2014).

It was estimated that in 2017 there are 451 million (age 18–99 years) people with diabetes worldwide. These figures were expected to increase to 693 million) by 2045. It was estimated that almost half of all people (49.7%) living with diabetes are undiagnosed. Moreover, there were an estimated 374 million people with impaired glucose tolerance (IGT), and it was projected that almost 21.3 million live births to women were affected by some form of hyperglycemia in pregnancy. In 2017, approximately 5 million deaths worldwide were attributable to diabetes in the 20–99 years age range. The global healthcare expenditure on people with diabetes was estimated to be USD 850 billion in 2017 (Cho *et al.*, 2017).

According to Kaiser *et al.* (2018) there are more than 500 million prevalent cases of type 2 diabetes worldwide and the prevalence is comparable between high- and low-income countries.

2.2. Medicinal Plants and their Nutraceutical Effects

Medicinal herbs or plants have been known to be an important potential source of therapeutics or curative aids. The use of medicinal plants has attained a commanding role in the health system all over the world. This involves the use of medicinal plants not only for the treatment of diseases but also as potential material for maintaining good health and conditions. Many countries in the world,

that is, two-third of the world's population depends on herbal medicine for primary health care. The reasons for this is because of their better cultural acceptability, better compatibility and adaptability with the human body and pose lesser side effects. From records, most of the used drugs contain plant extracts. Some contain active ingredients (bioactive components or substances) obtained from plants. Through recent researches, plant-derived drugs were discovered from the study of curative, therapeutic, traditional cures and most especially the folk knowledge of indigenous people and some of these claims and beliefs of people are irreplaceable despite the recent advancement in science and technology. Some of the drugs believed to be obtained from plants are aspirin, atropine, artemisinin, colchicine, digoxin, ephedrine, morphine, physostigmine, pilocarpine, quinine, quinidine, reserpine, taxol, tubocurarine, vincristine and vinblastine (Oladeji O, 2016).

As per the words of Kala (2006), the traditional medical systems of India, Ayurveda is part of a time-tested culture and honored by people still today. These traditions have successfully set an example of natural resource use in curing many complex diseases for more than 3,000 years. Many advantages of such eco-friendly traditions exist. The plants used for various therapies are readily available, are easy to transport, and have a relatively long shelf life. The most important advantage of herbal medicine is the minimal side effects, and relatively low cost compared to synthetic medicines. The success of medicinal plants sector mainly depends on the awareness and interest of the farmers as well as its other stakeholders, supportive government policies, availability of assured markets, profitable price levels, and access to simple and appropriate agro-techniques. The successful establishments of medicinal plants sector may help in raising rural employment, boost commerce around the world, and contribute to the health of millions.

Selvaraj and Periyasamy (2016) rightly pointed out that diabetes has become the most common disorder in both developing and developed countries, and the metabolic disorder is rapidly widespread in most parts of the world. Also, the WHO has predicted that diabetes would be the seventh leading cause of death by the year 2030. Recently, it has also been reported that around 30% of diabetic patients use some form of complementary and alternative medicine.

Complementary and alternative medicines are the use of medicinal plants and other dietary supplements, which are used as alternatives to mainstream Western medical treatment. Various medicinal plants have been explored for the treatment and control of diabetes.

The findings from the study carried out by Boadu and Asase (2017) suggest that traditional healers are consulted for herbal medicines for the treatment and management of both common and specialized diseases and ailments. The extent to which the people living in the area consult the healers is unknown, but it is essential to understand this to determine the proper role of herbal medicine in the health care system of the people. It is also essential to scientifically evaluate the specific uses of the medicinal plants reported in the current study using plant materials from the area through pharmacological, toxicological, and clinical studies to ensure the safety of the people consuming the medicines and for possible drug development. The results of the study have also confirmed that factors of time and place are given considerations during the harvesting of plant materials by healers.

2.3. Nutraceutical Properties of Guava Leaf (*Psidium guajava* L.)

Guava (*Psidium guajava* Linn.) Family Myrtaceae is an important plant used traditionally for medicinal purposes. Guava is rich in antioxidants compounds and contains a high level of ascorbic acid. The pharmacological actions and the medicinal uses of aqueous extracts of guava leaves in folk medicine include the treatment of various type of gastrointestinal disturbances such as vomiting, diarrhea, inhibition of the peristaltic reflex, gastroenteritis, spasmolytic activity, dysentery, abdominal distention, flatulence, and gastric pain. The important active constituents are essential oils, flavonoids, carotenoids, polyphenolic compounds, pentacyclic triterpenoids, esters, and aldehydes, etc. This paper explains the Evidence-based information regarding the phytochemistry and pharmacological activity of this plant (Mittal *et al.*, 2010).

According to Joseph and Priya (2011) *Psidium guajava* (Linn.) is popularly known as 'poor man's apple of the tropics,' and has a long history of traditional use for a wide range of diseases. The fruit, as well as its juice, is freely

consumed for its great taste and nutritional benefits. Much of the traditional uses have been validated by scientific research. Toxicity studies in mice and other animal models, as well as controlled human studies, show both leaf and fruit are safe without any side effects. Some chemicals isolated from plants like quercetin, guaijaverin, flavonoids, and galactose-specific lecithins have demonstrated promising activity in many human trials. The plant has been extensively studied in terms of the pharmacological activity of its major components, and the results indicate potent anti-diarrheal, antihypertensive, hepatoprotective, antioxidant, antimicrobial, hypoglycemic and anti-mutagenic activities. In recent years, the emphasis of research has been on utilizing traditional medicines that have along and prove the history of treating various ailments

Guava Leaves, seeds, and peels of fruits have significant proportions of bioactive compounds with beneficial physiological and metabolic properties. Its antioxidants can control body weight and biochemical variables like glycemia, dyslipidemia, hypertension and other risks of cardiovascular diseases and it is traditionally used in herbal medicines, and they exhibit many therapeutic effects including amebicide, analgesic, vermifuge, anti-malarial, anti-bacterial, colic-relief, anti-spasmodic, astringent, anti-ulcerous, hypotensive, anti-inflammatory, anti-hyperglycaemic and anti-diarrhoeal properties, as well as acting as a gastrotonic cough suppressant and combating some psychic diseases (Bontempo, *et al.*, 2011 check spelling).

A study conducted by Thanigaivelan and Muthukumaran (2010), concluded that *Psidium guajava leaves* extract exhibited anti-diabetic activity by enhancing the peripheral utilization of glucose by correcting the impaired liver and kidney glycolysis and by limiting its gluconeogenic formation similar to insulin. This effect may be due to the presence of tannin, saponin, flavonoids, phenol triterpenes, and other constituents' presence in the leaves, which could act synergistically or independently in enhancing the activity of glycolytic and gluconeogenic enzymes.

As chronic suppression of postprandial blood glucose elevation is important in preventing type II diabetes mellitus. Guava Leaf Tea was found to have inhibited the alpha-glycosidase enzymes in in-vitro condition and has

helped in the reduction of postprandial blood glucose level (Deguchi and Miyazaki, 2010).

According to Radwan *et al.* (2018), 500mg of guava leaf extract possesses a more potent anti-hyperglycemic effect in comparison to glibenclamide, the well-established anti-diabetic agent. This effect was indicated from the ability of the extract to restore the increase in serum glucose level to normal values. The potent anti-hyperglycemic effect of guava leaf extract could be due to its ability to promote glucose uptake by liver and other peripheral tissues together with the inhibition of intestinal glucose absorption induced by guava leaf extract. Also, the antioxidant effect of guava leaf extract may have a role in preserving the β -cells and preventing further losses and inhibiting the pathogenesis of diabetic complications arising from free radical production. The present data also showed that guava leaf extract could minimize the impairment in hepatic and renal functions associated with diabetes.

Banu *et al.* (2013) opined that *Psidium guajava leaf* extract had marked hypoglycaemic as well as hypolipidemic effect in alloxan-induced diabetes. This extract, therefore, could be used for lowering glucose, TC, TG, LDL and VLDL levels and reducing thereby the risk of CVD by increasing HDL cholesterol level. Thus 500 mg ethanolic leaf extract of *Psidium guajava leaf* treated rats showed lower the blood glucose level significantly.

In a study conducted by Wang *et al.* (2010), seven major active components, quercetin, myricetin, avicularin, gallic acid, kaempferol, hyperin and gallic acid, were isolated from extracts of guava leaves. The major active components of these extracts were glycosides of quercetin and there is an obvious relationship between the structure and activity in these isolated active compounds, a mixture of two components could confer an obvious synergistic effect to inhibitory activity against α -glucosidase, but not against α -amylase, which is found for the first time in this study on anti-diabetic activity of isolated compounds from guava leaves. The results give scientific support for the proper use of guava leaves in folk medicine for the treatment of diabetes, and this work could help to develop medicinal preparations or nutraceutical and functional foods for diabetes and related conditions.

According to Subramanian *et al.* (2009), the presence of tannins, triterpenes and three types of flavonoids such as quercetin, avicularin, guaijaverin in *Psidium guajava leaf* may be partially responsible for its anti-diabetogenic properties. Therefore, supplementing a balanced diet with *Psidium guajava leaf* extract may provide health-promoting effects. In conclusion, treatment with *Psidium guajava leaf* exhibits a beneficial effect on blood glucose homeostasis as well as a protective effect against streptozotocin-induced diabetes and thus provides a rationale for the use of this plant leaves in Ayurvedic medical treatment.

2.4. Nutraceutical properties of Long Pepper (Piper longum L.)

Piper longum (Piperaceae family) is used in Indian traditional medicine as a remedy for various disorders including diabetes mellitus. It grows all over India, in evergreen forests and is cultivated in Assam, Tamil Nadu, and Andhra Pradesh. It is a small shrub with a large woody root and numerous creeping, jointed stems, thickened at the nodes. *Piper longum* Linn is especially helpful in preventing hyperglycemia, cardiovascular, hepatic and renal diseases.

Piper longum Linn. (Pippalimoola) is found in Ayurvedic literature right from the time of Charak up to the latest nighantus prove its utility in therapeutics, especially in gastrointestinal and respiratory system diseases. Further nutraceutical researches have proved its anticancer, antioxidant, hepatoprotective, anti-microbial, antiplatelet, analgesic, anti-amoebic, anti-fertility, anti-diabetic due to the presence main chemical constituents are piperine, pipartine, triacontane, dihydro-stigmasterol, sesamin; methyl 3,4,5, trimethoxycinnamate, two alkaloids piperlongumine and piperlonguminine, etc. The drug is easily available, inexpensive, backed by years of therapeutic use (Gopani *et al.*, 2017).

Piper longum (commonly called as Pippali (fruit) or Piplamul (root) in Hindi) which is highly valued for its medicinal benefits. Pharmacological profile shows that the plant exhibits anti-diabetic and anti-hyperlipidemic, hepatoprotective, neuroprotective, cardioprotective, anti-bacterial, aphrodisiac, relieves respiratory disorders and can also be used as a digestive agent. Many

scientific investigations have proved that plant-derived herbal extracts as an effective alternative for disease management, therefore, may be considered as one of the potential sources for isolation of new therapeutic agents with relatively less or no side effects as compared to other therapeutic agents (Srivastava, 2014).

According to Singh and Navneet (2017), the fruits of the *Piper longum Linn* are used as a stomachic, liver tonic, abortifacient, pungent, aphrodisiac, stomachic, laxative, anti-diarrheal, anti-dysenteric, anti-asthmatic, anti-bronchitis, abdominal complaints, in urinary discharges, tumors, diseases of the spleen, pains, inflammation, leprosy, insomnia and jaundice. The roots of *Piper longum Linn* are used for the treatment of heart diseases. An infusion of the root is used for parturition, to help in the eviction of the placenta. *Piper longum Linn* possesses several pharmacological properties like antibacterial, antifungal, insecticidal, antiulcer, antiplatelet, anti-amoebic, hepato-protective, anti-obesity, larvicidal, antidepressant, anticancer, anti-asthmatic, etc. *Piper longum Linn* contains piperine as the major and active constituent; the piperine content is 3-5%. The fruits of *P. longum* possess starch, protein and alkaloids, volatile oils, saponins, carbohydrates, and amygdalin.

A study conducted by Punitha, (2006) showed a significant decrease in the level of blood glucose and glucose-6-phosphatase activity and a significant increase in the plasma insulin level and hexokinase activity at the end of the experimental period in diabetic rats treated with *Piper longum* aqueous extract (300mg/kg orally). *Piper longum* aqueous extract also significantly reduced the thiobarbituric acid-reactive substances (TBARS) level and enhanced the antioxidants status in induced diabetic rats after 45 days of treatment. *Piper longum* aqueous extract showed anti-hyperglycemic and anti-lipid peroxidative effects like that of the reference drug glibenclamide in alloxan-induced diabetic rats.

Patel (2016) claims that fruit of *Piper longum Linn* contains, this plant includes volatile oil, alkaloids, and saponins, starch. Important chemical compounds such as are Piperine and Piplatin are found to be useful in many ways especially for antimicrobial, anti-inflammatory, antibacterial, anti-asthmatic, anti-diabetic.

Studies have undoubtedly provided scientific confirmation and evidence for the safe use of the roots of *Piper longum* by traditional healers in the treatment of diabetes (Shaik *et al.*, 2013). *Piper longum* revealed the presence of various important bioactive compounds viz. alkaloid, flavonoids, glycosides, tannin, phenol, and sterol (Esha *et al.*, 2013). *Piper longum* has potent anti-hyperglycemic and anti-lipid peroxidative effects in alloxan-induced diabetic rats. Further studies are warranted to isolate and characterize the bioactive anti-diabetic principles from the dried fruits of *Piper longum*, which can, therefore, be used as an alternative remedy for the treatment of diabetes mellitus and oxidative stress associated diabetic complications.

2.5. Nutraceutical properties of Sirukurinjan leaf (*Gymnema sylvestre* R.Br.)

Gymnema sylvestre R.Br. is an imperative remedial woody climber belonging to family Asclepiadaceae- 'The Milk Weed Family'. One special name of this plant species is 'Miracle fruit'. The name 'Gymnema' probably derives from the Latin word meaning 'naked' and *sylvestre* means 'from the forest'. The leaves of *Gymnema* are reported to be bitter, astringent and acid. They temporarily paralyze the sensory perception of sweet and for this amazing property it is known as "GUDMAR". It is also known as 'Sugar Destroyer'. *Gymnema* leaves have a mixture of bioactive constituent's tri-terpenes and saponins viz. Gymnemic acids, Gymnemagenin, and Gurmarin due to them this plant represents the anti-diabetic property. The first scientific confirmation of *G. sylvestre* use in human diabetics came almost a century back when it was demonstrated that the leaves of *G. sylvestre* reduce urine glucose in diabetics (Paliwal *et al.*, 2009).

In an animal study, conducted by Paliwal *et al.* (2009) leaf powder extract of *G. sylvestre* had positive and encouraging effects over blood glucose levels. No harmful effect was observed on the health status of the subjects, and thus it can be concluded that *G. sylvestre* powder is effective in lowering the fasting as well as postprandial blood glucose levels. Moreover, Pankaj Kishor Mishra *et al.* have investigated the anti-diabetic and hypolipidaemic activity in Alloxan-induced diabetic rats by using aqueous leaf extract at the variable dosage (Mall *et al.*, 2009). Similarly Mary Sujin *et al.* (2008) also checked the effect of *G.sylvestre* powder in rats and investigated the anti-hyperglycemic

action of a crude saponin fraction and five triterpene glycosides derived from the methanol extracts of *G. sylvestre*. The medicinal plant *Gymnema sylvestre* is found to possess significant phyto constituents especially alkaloids, tannins, saponins, phenols, glycosides, flavonoids, etc. (Vijaya Kumar and Jafar Ahamed, 2017).

Gymnema sylvestre is used for lowering serum cholesterol, triglycerides and blood glucose level (hypoglycemic or anti-hyperglycemic), hypo-lipidaemic, weight loss, stomach ailments, constipation, water retention and liver diseases, either high or low blood pressure, tachycardia or arrhythmias, and used as aperitive, purgative, in eye troubles, anti-inflammatory, smooth muscle relaxant, prevention of dental caries, cataract and as anticancer-cytotoxic agent. Its flowers, leaves, and fruits contains alkaloids, flavones, saponins, sapogenins, anthraquinones, hentri-acontane, pentatriacontane, α and β -chlorophylls, phytin, resins, d-quercitol, tartaric acid, formic acid, butyric acid, lupeol, β -amyrin related glycosides and stigmasterol having main principle bioactive compounds viz. gymnemic acids, gymnemasides, gymnemagenin, gurmarin, gymnemosides, gymnemanol, gymnemasins, gypenoside, and conduritol which act as therapeutic agent and play vital role in many therapeutic applications. Gymnemic acids are thought to be responsible for its anti-diabetic activity, and it is the major component of an extract shown to stimulate insulin release from the pancreas. Another anti-sweet agent gumarin is utilized as a pharmacological tool in the study of sweet-taste transduction (Thakur *et al.*, 2012).

The leaves of *G. sylvestre* contain triterpene saponins belonging to oleanane and dammarene classes. Oleanane saponins are gymnemic acids and *Gymnema* saponins, while dammarene saponins are gymnemsides,. The leaves also contain resins, albumin, chlorophyll, carbohydrates, tartaric acid, formic acid, butyric acid, anthraquinone derivatives, inositol alkaloids, organic acid (5.5%), paraben, calcium oxalate (7.3%) lignin (4.8%), and cellulose (22%). It possesses hypoglycemic and hypolipidemic activity in long term treatment and is also capable of regenerating β -cells and hence it could be used as a drug for treating diabetes mellitus (Vijayakumar and Prabhu, 2014).

The water extract of *Gymnema sylvestre* R.Br leaf was tested for hypoglycemic activity in normal and alloxan induced diabetic rats by

Sathya, *et al.* (2008). Grated amount (2ml/kg) of the water extract of *Gymnema sylvestre* leaf was given to both normal and alloxan-induced diabetic rats. A significant reduction of glucose concentration was noticed in normal rats; blood glucose level was significantly reduced in diabetic rats. Protein level was also decreased in diabetic rats. Urea, uric acid, and creatinine levels were increased in diabetic condition.

In another study conducted by Aralelimath, and Bhise (2012) active extract of *Gymnema sylvestre* with the dose of 200 and 400mg/kg was administered orally to streptozotocin induced diabetic rats for 40 days for the assessment of plasma glucose, insulin, glycosylated hemoglobin (HbA1c), tissue and liver glycogen, lipid parameters such as triglycerides, total cholesterol, LDL-cholesterol, and HDL-cholesterol in normal as well as streptozotocin diabetic rats. These results indicate that *Gymnema sylvestre* extract shows a significant change in the all above said biochemical parameters when compared to the control group. The histopathological study shows the significant recovery of damaged β -cells in diabetic *Gymnema sylvestre* treated rats when compared to diabetic control ones. In conclusion, these results indicate that *Gymnema sylvestre* extract, possessed hypoglycemic and hypolipidemic activity in long-term treatment and is also capable of regenerating β -cells and hence it could be used as a drug for treating diabetes mellitus. Because it has the regenerating ability of β -cells, at least the people in the earliest stages of the disease could be treated to delay or prevent full-blown clinical diabetes.

A study carried out by Yogalakshmi *et al.* (2014), on the methanolic extract of *Gymnema sylvestre* leaves indicated, that *Gymnema sylvestre* extract significantly ($P < 0.01$) reduced the blood sugar level. The oral administration of methanolic extracts at doses of 300 mg/kg lead to a significant blood glucose reduction. This may lay the foundation to study the active compounds of such anti-diabetic plants that are responsible for the hypoglycemic activities.

Shirisha *et al.* (2017), studied the antidiabetic and anti-lipidemic activity of 800mg/kg of Sirukurinjan extract (*Gymnema sylvestre* R.Br.) and found that antidiabetic effect of leaf extract of *Gymnema sylvestre* was excellent and equally effective when compared with Glibenclamide. There was significant hypolipidemic effect observed with leaf extract of *Gymnema sylvestre*. Hence it

is a promising anti-diabetic agent for the development of a phytomedicine for diabetes mellitus

Mellitus. Kushwah and Kayande (2014), claims that The anti-diabetic activity of *Gymnema sylvestre* extracts may not be due to through the insulin secretion by pancreatic beta cells. It may be due to the increased entry of glucose into the peripheral tissues and organs like the liver. Since *Gymnema sylvestre* extracts increased the activity of glycogen synthase in the liver, it may increase the storage of glucose in hepatocytes. It also may be decreased the activity of phosphorylase in the liver; thereby it may prevent the release of glucose into the blood. These observations strongly suggest that *Gymnema sylvestre* extracts may not act like sulfonylureas, but like other oral anti-hyperglycemic drugs. This study indicates that treatment with *Gymnema sylvestre* extracts may be an alternative to some of the presently available drugs, which have some adverse effects.

2.6. Nutraceutical Properties of Naval Seed (*Syzygium cumini* L.)

The *Syzygium cumini* (or *Eugenia jambolana*) tree belongs to the Myrtaceae family also called as Jamun, Jambul and Jambol in India and Malaya, is a common traditional medicinal plant, whose parts have been pharmacologically proven to possess hypoglycemic, antibacterial activities. Different parts of the plant, such as bark, leaves, fruit, and seeds have been used in various traditional systems of medicine. The widespread therapeutic use of *S.cumini* in traditional medicine warrants chemical analysis to elucidate the role of the active principles in different plant parts. The phytochemicals like maleic acid, oxalic acid, gallic acid, tannins, cyanidin glycoside, oleanolic acid, flavonoids, essential oils, betulinic acid, friedelin have been reported for anti anaemic, gingivitis, antidiarrhoeal, antipyretic, antibacterial, antineoplastic, anti-inflammatory, hypoglycemic, gastroprotective and hypolipidemic properties.

According to (Ramya, 2012). *S.cumini* seeds possess phytochemicals such as alkaloids, flavonoids, glycosides, steroids, cardiac glycosides, saponins, resins, phenols, tannins, and terpenoids, etc., which are of high therapeutic value. The infrared characterization revealed the presence of aliphatic as well as aromatic compounds. This study also demonstrated that the extract has potent

α -amylase inhibitor with a higher degree of inhibition. The results suggested that the *S.cumini* seeds possess significant anti-diabetic activity and help to determine the regional pharmaceutical value of *S.cumini* seeds as a traditional medicinal utilization for the management of diabetes. The therapeutic value of *Syzygium cumini* has been recognized in a different system of traditional medication for the treatment of different diseases and ailments of human beings. It contains several phytoconstituents belonging to the category of alkaloids, glycosides, flavonoids and volatile oil. In the literature, it has been reported as a digestive, astringent, blood purifier and anthelmintic, antibacterial, analgesic, anti-inflammatory, antioxidant, ulcers, diabetes as well as gastro protective agents. Several studies using modern techniques have authenticated its use in diabetes and shown promising results (Pepato *et al.*, 2005).

Syzygium cumini is one of the widely used medicinal plants in the treatment of diabetes and several other diseases and is an important medicinal plant of India. The plant is rich in compounds containing anthocyanins, glucoside, ellagic acid, isoquercetin, kaempferol, myricetin, and hydrolyzable tannins (1-0-galloyl castalagin and casuarinin). The seeds also contain alkaloid jambosine and glycoside jamboline, which slows down the diastatic conversion of starch into sugar (Ayyanar and Subash, 2012).

A study conducted by Raza *et al.* (2017) depicted that both seed and fruit extracts of naval seed reduce the blood glucose level significantly and also regulate the insulin levels in hyperglycemic rats. It was noted that Jamun fruit extract attenuated serum glucose levels to 5.35% and 12.29% in normal and hyperglycemic rats, respectively; while insulin levels were improved by 2.82% and 6.19%, correspondingly. Whereas, Jamun seed extract reduced glucose to 7.04% and 14.36% and showed 3.56% and 7.24% higher insulin levels in normal and hyperglycemic rats, respectively. Also, diet based regimen was tailored using Jamun fruit/seed and their extracts to alleviate hyperglycemia. Jamun fruit and seed hold nutraceutical worth to address various diet-related malfunctions especially hyperglycemia. In the current research, Jamun seed and fruit extracts proved effectual in the regulation of blood glucose and insulin parameters. Likewise, hyperglycemia and hyperinsulinemia were also managed by the

provision of Jamun seed extracts. Results exhibited that fruit has a lower potential than seed in reducing the sugar levels of diabetic rats. It can be concluded that jamun is a potential source of naturally occurring bioactive components, thus regulating the blood glucose profile and may be used as curing therapy in diabetes.

The extract of *Syzygium cumini* seeds isolated at 20°C shows maximum inhibition of glucoamylase (50%). The possible mechanism by which extracts of *Syzygium cumini* seeds bring about its hypoglycemic action may be by affecting the activity of glucoamylase or by increasing the glycogen biosynthesis. Thus, the significant inhibition of glucoamylase suggests that the active hypoglycaemic compound present in ethanolic extracts of Jamun seeds does not necessarily require the presence of functioning of β -cells for its favorable action seen in type-I. It means the ethanol extracts of *Syzygium cumini* seeds may act in a variety of diabetic conditions with or without functioning of pancreatic β -cells (Meshram *et al.*, 2011). Also, *Syzygium cumini* (Linn.) has been documented to elicit hypoglycemic activity. Herbal preparations of *Syzygium cumini* have been considered as safe, effective and economical for various ailments in Indian traditional system of medicine. Its seed extract is used for the treatment of diabetes.

A study was undertaken by Saifi *et al.* (2016) to evaluate the hypoglycemic potential and effect on various biochemical parameters of 70% v/v hydro-alcoholic extract of seeds of *Syzygium cumini* (SCE) in alloxan-induced diabetic rats. Diabetes was induced by injecting alloxan (120mg/kg, i.p.). Rats were divided into different groups for the study. Group I served as normal control, Group II served as diabetic control, Group III served as standard control and treated by Tolbutamide at a dose of 100 mg/kg p.o. Group IV served as diabetic rats treated with the hydro-alcoholic extract of seeds of *Syzygium cumini* at a dosage of 500 mg/kg body weight. All the treatments were given for 21 days. At the end of the study on 21, days over night fasted rats were sacrificed, and blood was collected to determine fasting blood glucose and biochemical findings. Diabetic rats treated with *Syzygium cumini* (Linn.) Extracts at a dose of 500 mg/kg significantly ($P < 0.01$) reduced fasting blood glucose and

normalized the lipid profile, renal profile and hepatic profile. Improvement in the histopathology of pancreas and liver of *Syzygium cumini* (Linn.) extracts treated rats confirmed its protective role in diabetes.

An investigation conducted by Bansode *et al.* (2017), that tannins, saponins, and flavonoids isolated from targeted *Syzygium cumini* seed demonstrated a significant decrease of serum sugar level and an apparent improvement in glucose tolerance in the single administration study. Hence, it was clear that these compounds could give a hypoglycemic effect in people with diabetes, especially in case of high postprandial glucose level. *Syzygium cumini* seed extract was administered to diabetic rats with the dose of 100 mg/kg, per oral (PO) and the effect of the fractions on body weight, liver glycogen, and serum glucose was studied up to 15 days. Results: The results have indicated that diabetic rats treated with fractions showed a statistically significant ($P < 0.05$) decrease in serum glucose and an increase in body weight and liver glycogen.

2.7. Nutraceutical Properties of Kandankathiri (*Solanum virginianum* L.)

Solanum virginianum L. (Syn.: -*Solanum Virgininum* Schrad. and H. Wendl.), commonly known as wild eggplant or nightshade plant, is a prickly herb found in most of the parts of the Asia and Australia of the world and has much therapeutic application in the traditional system of medicine especially Ayurveda. It belongs to family Solanaceae, has spines throughout the plant. Fruits are globular and edible, flowers appear in cymes or sometimes solitary and are blue, leaves are elliptical or ovate and are full of spines, stems appear green when young and brownish when matured. Various phytoconstituents have been found; the major constituents is alkaloid. It has a vital role in various traditional as well as medicinal uses for curing internal and external physiological disorders (Rane, 2014).

Solanum virginianum L. is a plant with many therapeutic applications in traditional systems of medicine especially Ayurveda. *Solanum virginianum* is a well-known medicinal plant in the traditional medicinal system, and recent scientific studies have emphasized the possible use of *Solanum Virgininum* in modern medicine. *Solanum virginianum* L. plant contains alkaloids, sterols, saponins, flavonoids, and their glycosides and also carbohydrates, fatty acids,

amino acids, etc. The Anti-hyperglycemic activity was associated with an increase in plasma insulin. Though the exact mechanism of action is not known, it could be due to increased pancreatic secretion of insulin from existing β -cells. It is known that certain alkaloids and flavonoids present in *Solanum virginianum* L. exhibit hypoglycemic activity and is also known for their ability of beta cell regeneration of pancreas. The plant is widely studied for the various pharmacological activities like anti-asthmatic, hepatoprotective, cardiovascular, hypoglycemic and mosquito repellent properties (Reddy and Rajasekhar, 2014).

Solanum virgininum is a plant with great potential in the treatment of type II diabetes mellitus as its aerial parts were found to possess good anti-hyperglycemic activity. The activities may be attributed to the constituents found in the leaves stem and fruit of the plant that may act as insulin secretors. The active principles like flavonoids, sterols, terpenoids and phenolic may contribute to the anti-hyperglycemic (Anitha and Christin, 2014).

Solanum virgininum were found to contain alkaloids, tannins and anthracenosides were also detected. Hypoglycemic activity of *Solanum Virgininum* extracts was determined by postprandial glucose test after administration of extracts at 10mg/100g body weight to adult albino rats. Postprandial plasma glucose level was measured at 30 minutes intervals for 2 hours. The result of this study showed that *Solanum Virgininum* extracts had hypoglycemic activity. Thus, the plant may be effective in the management of hyperglycemia may be attributed to the phytochemicals present in the plants (Egwim *et al.*, 2014).

The extensive survey of literature revealed that *Solanum virgininum* is an important source of many pharmacologically and medicinally important chemicals, especially steroidal hormone solasodine and other chemicals like solasonine, campesterol, campeferol, diosgenin and various useful alkaloids. The plant is extensively studied for the various pharmacological activities like anti-asthmatic, hepatoprotective, cardiovascular, hypoglycemic and mosquito repellent properties. Various traditional claims like immunomodulation, hypolipidemic, antibacterial, sexual behavior, tolerance, and dependence is not studied till the date and needs attention in this area to explore further medicinal values of this plant (Ravindra and Aakanksha, 2018).

According to Poojari and Bhalerao (2018), in recent years *Solanum Virgininum* Schrad and Wendel has been investigated for the presence of a wide range of phytochemicals viz. alkaloids, sterols, saponins, flavonoids and their glycosides and also carbohydrates, fatty acids, amino acids etc. Various traditional claims like anti-fertility, anti-inflammatory, anti-allergic, anti-hyperlipidemic, and anti-filarial activity.

Solanum Virgininum, contains steroidal glycoalkaloid solasodine (about 0.2%), steroidal saponine, solamargine, β -solamargine, solasonine, solacarpidine, sterol, viz, cycloartenol, nor carpesterol, cholesterol and their derivatives (Gangwar *et al.*, 2013).

In a study conducted by Gupta (2009), the anti-diabetic and anti-hyperlipidemic effects of aqueous-methanol (40:60) extract of *Solanum virgininum* whole plant (Sx) were investigated in normoglycemic, glucose fed, and alloxan-induced diabetic rats. In normoglycemic rats, the powdered extract of *Solanum virgininum*, administered at doses of 200 mg/kg and 400 mg/kg b.w x 1 p.o. resulted in the reduction of blood glucose level by 10.55% and 12.83% respectively. In glucose fed diabetic rats, the reduction of blood glucose level was also achieved dose-dependently and significantly compared to the vehicle control group. In another experiment, powdered *Solanum Virgininum* extract was administered daily at doses of 200 mg/kg and 400 mg/kg p.o., for seven days, after alloxan administration (150 mg/kg i.p.). The treatment showed a significant dose-dependent percentage of blood glucose lowering in diabetic rats. This effect of *Solanum virgininum* was comparable to that of a reference standard drug, glibenclamide (10 mg/kg b.w p.o. x 7). Additionally, the *Solanum virgininum* plant extract also had potent anti-hyperlipidaemic activity and was found to improve the lipid levels of alloxan-induced diabetic rats at the end of the treatment period. Phytochemical screening of the *Solanum virgininum* total plant extract showed the presence of spirosta-steroidal saponins, amino acids, phytosterols, flavonoids, glycoalkaloids, tannins, and terpenoids, many of which were previously unreported and now contributed to the bioactivity of *Solanum Virgininum*.

2.8. Information Technology and Software in the Management of Diabetes Mellitus

Diabetes is a complex and burdensome disease that requires the person with diabetes to make numerous daily decisions regarding food, physical activity, and medications. It also necessitates that the person is proficient in some self-management skills. For people to learn the skills necessary to be effective self-managers, Diabetes self-management is critical in laying the foundation with ongoing support to maintain gains made during education. Despite proven benefits and general acceptance, the numbers of patients who are referred to and receive Diabetes self-management are disappointingly small. This position statement and algorithm provide evidence and strategies for the provision of education and support services to all adults living with type II diabetes. It is imperative that the health care community, responsible for delivering quality care, mobilizes efforts to address the barriers and explores resources for Diabetes self-management to meet the needs of adults living with and managing type II diabetes (Powers *et al.*, 2017).

Health information technology (HIT) provides the umbrella framework to describe the comprehensive management of health information and its secure exchange between consumers, providers, government and quality entities and insurers. Its role in public health is unmatched because it plays a vital role in early detection of infectious disease outbreaks around the country, improved tracking of chronic disease management, monitoring healthcare programs and coverage, evaluation of health care utilization, and in making transparent and evidence-based decisions for health system interventions. Population-based information includes a wide range of community and health facility-based information, such as socio-demographic, health status, resources, infrastructure, financing, healthcare utilization, coverage and many more. Collecting, transmitting, processing, analyzing and presenting this information is always challenging for healthcare managers and administrators. Health information technology, in general, is increasingly viewed as the most promising tool for improving the overall quality, safety and efficiency of the health delivery system (Sinha, 2010).

There is no doubt that health information technology is an important tool for improving healthcare quality and safety. Healthcare organizations need to be selective in which technology to invest in, as literature shows that some technologies have limited evidence in improving patient safety outcomes (Alotaibi and Federico, 2017).

Technology, in general, empower patients and care givers by giving them more control over their health and making them less dependent on HCPs for health information. They use digital technology to research information online, share experiences and identify treatment options. Its use in providing access to information and education is an important driver of patient engagement. The most widely available health apps and software's are commonly based on fitness, medical reference, and wellness apps. While these software systems provide information, many currently lack the functionality to do more about health (Taylor, 2015).

Information Technology has been used to provide support to patients to enhance changes in healthcare delivery and provide clinicians with access to expertise and timely, useful data about individual patients and populations. Use of Information Technology has been associated with a corresponding improvement in measures of various lifestyle disorders such as cardiovascular disease, obesity, cancer, renal diseases, and diabetes mellitus. Information Technology can be used to improve diabetes care by promoting a productive and informative interaction between the patient and the care team (Adaji, 2008).

In all, modern technology enabled devices and applications for the treatment of diabetes is well received by patients as a supplement to usual therapy. Patients value easy-to-use devices and applications that facilitate support from health-care providers or peers. These results provide insight into strategies that health-care providers and developers of such technologies might use to further help patients with diabetes in self-care. Devices that encouraged or facilitated inter-action between patients and either health-care professionals or peers were valued and produced higher patient satisfaction for increasing support (Kaufman *et al.*, 2016).

Type II diabetes is one of the nation's leading drivers of disability and health care utilization, with elevated prevalence among individuals with lower education, income, and racial/ethnic minorities. Health information technology (HIT) holds vast potential for helping patients, providers, and payers to address T2D and the skyrocketing rates of chronic illness and associated health care costs. Patient portals to electronic health records (EHRs) serve as a gateway to consumer use of HIT. Little progress has been made in addressing identified barriers to technology adoption, especially among populations with an elevated risk of Type II diabetes. Patients often lack literacy skills and continuous connectivity and fear loss of the relationship with providers. Providers may experience structural disincentives to promoting patient use of HIT and apply hidden biases that inhibit portal use (Sheon, 2017).

Currently computerized reminder and decision support systems intended to improve diabetes care have had a limited effect on clinical outcomes. Increasing pressures on health care networks to meet standards of diabetes care have created an environment where information technology systems for diabetes management are often created under duress, appended to existing clinical systems, and poorly integrated into the existing workflow. After defining the components of diabetes disease management, the authors present an eight-step conceptual framework to guide the development of more effective diabetes information technology systems for translating clinical information into clinical action (Lester *et al.*, 2008).

The study conducted Bu *et al.* (2007), found that Information Technology for diabetes mellitus improves processes of care, prevents the development of diabetes complications and generates the cost of care savings. Although currently, self-management appears to offer the least benefit, future empirical studies may demonstrate greater benefit. Integrated systems would more closely realize the full intent of disease management and would have the greatest potential for benefit. These benefits must be weighed against implementation costs. Information Technology for Diabetes Mellitus improves the synthesis of information, delivery of knowledge, and efficiency of communication. These improvements allow coordination of care across delivery teams help to ensure that patients receive recommended care and provide tools and information that

empower patients to be more effective in their self-care. Registry-enabled diabetes management was the most effective Information Technology for Diabetes Mellitus (ITDM) approach. This may be due to its ability to influence behavior at three locations, at the health care system level through provider report cards, at the point of care through reminders, and at the patient's home through telephonic or email-based reminders Bu *et al.*, 2007).