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Ameliorative extract *Syzygium cumini* seed extract on lipid peroxidation and antioxidant activity in alloxan induced diabetic Wistar albino rats

E. Kavitha and M. Sendhilvadivu*

Department of Zoology, Queen Mary's College, Chennai -600 004, India

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***Corresponding Author Email :** sendhilvadivu_zool@queenmaryscollege.edu.in ***ORCiD:** https://orcid.org/0000-0002-3215-3744

Abstract

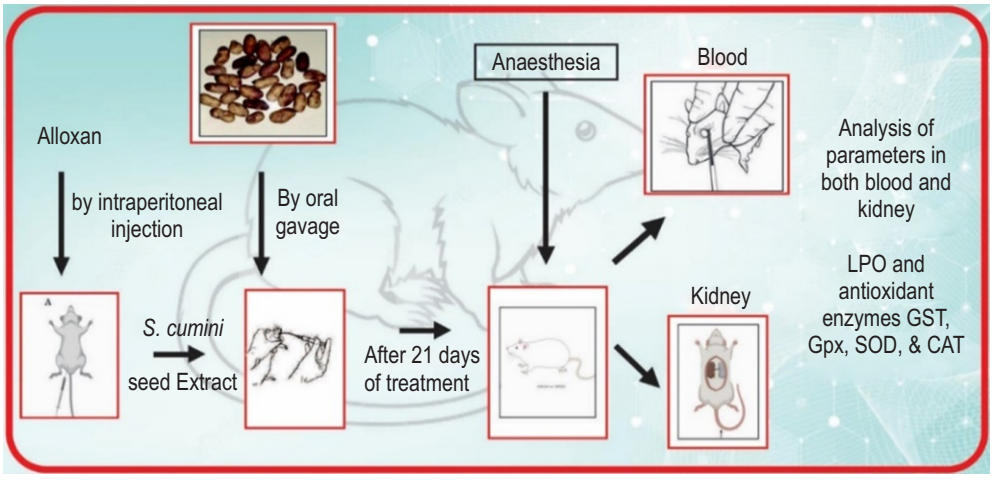
Aim: This study intends to examine the protective effects of an aqueous extract of *Syzygium cumini* seed on lipid peroxidation and antioxidant enzyme activities in alloxan-induced diabetic Wistar albino rats.

Methodology: A single intraperitoneal injection of 150 mg kg^{-1} b.wt of alloxan monohydrate was used to induce diabetes in rats. *Syzygium cumini* group rats were later administered 300 mg kg^{-1} of *Syzygium cumini* seed extract by oral gavage for 21 days. On 22nd day, the animals were given general anaesthesia, blood was drawn through the retroorbital plexus, and the kidneys were promptly removed. Lipid peroxidation levels were assessed in the blood (serum) and kidney tissues by measuring the thiobarbituric acid reactive substances, and the activities of antioxidant enzymes such as GST, GPX, SOD and CAT were examined in the blood and kidneys.

Results: The acute toxicity experiments revealed that *Syzygium cumini* did not cause any obvious toxicity indications or mortality at a dosage of 300 mg kg^{-1}, proving the safety of this extract with a broad therapeutic index. The results obtained showed that using aqueous *Syzygium cumini* seed extract for 21 days considerably ($P < 0.05$) increased the antioxidant enzyme activity for GST, GPx, SOD and CAT, while significantly ($P < 0.01$) decreasing the TBARS levels.

Interpretation: Conclusively, the seed extract of *Syzygium cumini* might be a possible treatment for controlling hyperglycemic oxidative stress complications owing to its antioxidant properties.

Key words: Albino rats, Antioxidant enzymes, Lipid peroxidation, *Syzygium cumini*, Seed extract.



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Introduction

Humans are vulnerable to a wide range of diseases due to their modern lifestyle, altered eating habits (such as eating processed food), lack of consumption of fruits and vegetables, especially those high in antioxidants. Diabetes mellitus is a group of metabolic disorders characterised by hyperglycemia. Hyperglycemia is technical term for high blood glucose level. It occurs when the pancreas does not secrete sufficient insulin or the body cannot use insulin properly. Insulin is a pancreatic hormone that permits glucose from the foods to enter the cells and change into energy required for muscle and tissue function. In diabetes, the body's ability to manage the quantity of glucose in the blood is impaired. Diabetes is the world's largest endocrine disorder with a disrupted carbohydrate, fat and protein metabolism. Uncontrolled or poorly controlled diabetes increase both short and long term complications, like micro-and macrovascular complications.

The most common complications are atherosclerosis, nerve damage, renal failure, blindness, infertility and so on. The kidney are affected by diabetes, although the exact mechanism still remains unclear. According to a recent study by the Madras Diabetic Research Foundation and the Indian Council of Medical Research (ICMR), 101 million individuals have diabetes, while 136 million have pre-diabetes (Madhu, 2023). According to the International Diabetes Foundation, diabetes killed 67 lakh individuals in 2021, and it is anticipated that 53.7 crore (1 in 10) people were living with the condition, with the figure rising to 64.3 crore in 2030 and 78.3 crore by 2045 (Behera and Sen, 2023). Alloxan is a drug used for the experimental induction of type 1 diabetes in rats (Longkumer *et al.,* 2021; Etuk, 2010). Alloxan, a β-cytotoxin, causes diabetes by destroying insulin producing β-cells in the pancreas, resulting in a reduction in insulin secretion and leading to diabetes. Alloxan is frequently used to evaluate the antidiabetic activity of both pure chemicals and plant extracts (Ighodaro *et al.,* 2018). The administration of alloxan to several animals causes islet necrosis, which has multiple associations with human diabetes (Rohilla and Alia, 2012).

Experimental animal models are utilised to investigate the aetiology of diabetes and the long-term diabetic effects reported in clinical investigations. Increasing evidence from both experimental and clinical studies suggests that oxidative stress plays an essential role in the onset and progression of diabetes mellitus and free radicals formed as a result lead to a decline in the anti-oxidant defence mechanism, resulting in increased risk and diabetes complications, all of which affect the lifespan and standard of living. Furthermore, growing data shows that oxidative stress plays an essential part in the aetiology of diabetes problems. The development of free radicals is strongly influenced by diabetic complications, which are thought to be linked to higher levels of lipid peroxidation (Abo-Elghiet *et al.,* 2023). Certain enzymatic and non-enzymatic processes cause lipid peroxidation, which is linked to mutagenesis and cell damage (Tudek *et al.,* 2017). Reactive oxygen species (ROS) are useful by-products of normal cell activity. They are important components of signalling pathways and are generated in a variety of cellular compartments. Low level of ROS that operate as redox signalling messengers required for the regular physiological functioning of cells. In contrast, overproduction of reactive oxygen species (ROS) is linked to numerous human disorders. Oxidative stress has been shown to play a part in the aetiology of several illnesses, including Alzheimer's disease (Bonda *et al.,* 2010), Parkinson's illness (Tchekalarova and Tzoneva., 2023), cardiovascular conditions such as high blood pressure, atherosclerosis (Mewborn and Stanfill, 2023), stroke (Feng *et al.,* 2023), CVDs (Steven *et al.,* 2019), diabetes type 2 (Winiarska *et al.,* 2021), and autoimmune disorders (Wójcik *et al.,* 2021). Antioxidant defence systems that protect against oxidative damage are present in all aerobic species, including humans.

Due to the fact that hyperglycemia-induced oxidative stress affects a large number of organs and tissues in diabetes patients, traditional herbs (plant extracts) are said to offer potent anti-diabetic qualities without negative side effects. The use of natural compounds with antidiabetic and antioxidant characteristics can provide many benefits. Several *in vitro* and *in vivo* studies have shown that plant extracts and their component substances (such as polyphenols and their derivatives, flavonoids, carbohydrates, glycosides, alkaloids, saponins, peptidoglycans, minerals, and vitamins) protect cells from oxidative damage directly through free radical scavenging activities (Kooti *et al.,* 2016). *Syzygium cumini*, the Java plum, belongs to the family Myrtaceae. *S. cumini* is often referred to as Indian blackberry, black plum, and jambolan elsewhere (Rashid *et al.,* 2022). The fruits, seeds, leaves, stem bark, and other parts of the plant have gained significant medicinal value (Uddin *et al.,* 2022). The seed extract has been used in a number of pharmacological and toxicological studies. Saifi *et al.* (2016) conducted a 21-day anti-diabetic trial employing 500 mg kg^{-1} hydroethanol extract of *S. cumini* seed. The treatment reduced fasting blood glucose levels and also regulated the hepatic, renal and lipid profiles. Sharma *et al.* (2017) employed aqueous *S. cumini* seed extract at 200, 300 and 400 mg kg^{-1} for 21 days in Streptozotocin-induced rats and exhibited antidyslipidemic, antioxidant and anti-inflammatory activity in their experiments. Biwas and Sen (2018) conducted a hypoglycemic trial with 200 and 400 mg ethanolic extract of *S. cumini* seed extract for three weeks, which showed *in vitro* antioxidant scavenging activity and decreased fasting blood glucose in diabetic rats. A study conducted by Amin *et al.* (2023) reported that an ethanolic extract of *S. cumini* at a dosage of 500 mg kg^{-1} exhibited a hypoglycemic effect in alloxan induced Swiss albino mice.

The fruits and seeds are used to cure pharyngitis, spleenopathy, urethrorrhea, and ringworm infection (Kumawat *et al.,* 2018). The antibacterial properties of the leaves are used to strengthen teeth and gums and are also used to treat diabetes, constipation, and other ailments (Ahmed *et al.,* 2019). The leaves also have anti-hyperglycemic and anti-inflammatory activities in alloxan-induced diabetic rats (Ajiboye *et al.,* 2018). *S. cumini*

seeds include jamboline, a glucoside, resin, albumen, and potent antioxidants tannins, monoterpenoids, flavonoids, quercetin and ellagic acid, gallic acid, caffeic acid, and ferulic acid, as well as their derivatives (Srivastava and Chandra, 2013; Kumari *et al.,* 2023). Experimental and clinical research were conducted on diabetes models. *S. cumini* has received pharmacological validation to promote this plant as a safer medicine (Ayyanar *et al.,* 2012). Jonnalagadda *et al.* (2013) revealed that *Syzygium cumini* kernel extracts help in curing ulcer symptoms. Nevertheless, the effects of this medicinal herb include cardioprotective, antipyretic, hepatoprotective, and chemopreventive properties (Das and Sarma, 2009; Syama *et al.,* 2017; Arun *et al.,* 2011; Abdulrahman and Hama, 2023; Parmar *et al.,* 2010).

A study conducted by Kumar and Kanojia (2022) discovered the protective role of an aqueous extract of *Syzygium cumini* as hepatoprotective and antioxidant activity against isoniazid-induced hepatotoxicity in female albino rats. In view of the above, the present investigation examined the effect of an aqueous extract of *S. cumini* seed on lipid peroxidation levels and antioxidant enzyme activity in the blood as well as kidney tissues.

Materials and Methods

Collection and preparation of *S. cumini* seed powder: Fruits of *S. cumini* were collected from a local market in Chennai. The mature fruits were thoroughly cleaned, and the seeds were separated. The seeds were shade dried and grounded with electric blender, pulverised and sieved to obtain a uniform powdery material. About 30g of seed powder was taken in a 500-ml flask; to this, 360 ml of distilled water was added, and kept in a sterile setting for 24 hrs. After filtering the liquid extract, it was maintained in a water bath at 80–90°C until complete dryness. The dried powder was collected and kept at 4°C for further study (Desai *et al.,* 2019).

Experimental animals: Wistar albino rats weighing 200–240 g were purchased from the Mass Biotech Animal Unit in Pulipakkam, Chengalpet. Experimental animals were kept in polypropylene rat cages placed in a hygienic setting with a 12 hr light/dark cycle, at 22°C-24°C and 30 to 70% humidity. Each animal was given conventional laboratory feed (70% carbohydrate, 25% proteins, 5% lipids) and an unlimited supply of water. The animals were acclimatized for 7days in a regular habitat before the trial began. The testing procedure was authorized by the Institutional Animal Ethics Committee (IAEC). Ethical clearance number CPCSEA Regn. No.: 2084/ PO/ RcBt/ S/19/CPCSEA.

Acute toxicity study: Five healthy adult rats were selected at random in accordance with Organisation for Economic Co-operation and Development (OECD) Guidelines 425. The aqueous extract of *S. cumini* seed (300 mg kg^{-1} b.wt) was administered to 4hr fasting rats. Initially one animal was given a test dosage. After the animals had survived for 48 hrs, test dosages of 300, 1000, 1500 and 2000 mg kg^{-1} were successively administered to other animals. To diagnose if there were any physical signs of toxicity, rats were observed for any change in fur loss, respiratory pattern, shaking hands, seizures, unusual stool (diarrhoea), fatigue, severe discomfort, stress, and sickness. The animals were monitored for the next 14 days.

Induction of diabetes and study protocol: The rats were randomly divided into following 3 groups, each group containing 6 animals (n=6). Group I (control group):The control group rats were normal rats; Group II (Diabetic group without treatment): The overnight fasted rats was induced with alloxan monohydrate @150 mg kg^{-1} b.wt by single intraperitoneal injection. The 5% glucose solution was provided to the animals to consume immediately after the injection to prevent transient hypoglycemia. After 48 hrs of alloxan induction, the diabetes in animals was confirmed by loss of body weight, polyuria, glycosuria, polydipsia and polyphagia. Group III (Treatment group): Diabetic rats were treated with 300 mg kg^{-1} b.wt of aqueous extract of S. cumini seed orally for 21 days via oral gavage.

Collection of blood and tissue sampes: On the 22nd day, the rats were anaesthetized using deep ether, and the blood was drawn from the retroorbital plexus. Animals were euthanized, and kidneys were dissected. The blood and kidney tissue samples were used to measure lipid peroxidation (TBARS) and antioxidant enzymes.

Assessment of TBARS and antioxidant enzymatic activities in the blood and kidney: The state of lipid peroxidation was examined by calculating TBARS based on the procedure of Ohkawa *et al.* (1979). Glutathione s-transferase (GST) activity was estimated by the method of Habig *et al.* (1974). Glutathione peroxidase (GPx) was determined by the method of Rotruck et al. (1973). Superoxide dismutase (SOD) activity was estimated by the method of Beauchamp and Fridovich (1973) and catalase (CAT) activity was determined by the method of Chance and Maehly (1955).

Statistics Analyses: The results are presented as mean±SD. Difference between the means were assessed by student t-test, followed by a One-way ANOVA. Differences between the groups at $p<0.05$ were considered statistically significant.

Results and Discussion

The current study was carried out to investigate the ameliorative effect of *S. cumini* seed extract against alloxan-induced diabetic rats and to examine the lipid peroxidation and antioxidant enzyme activities in the blood and kidney tissues. Diabetes mellitus is a serious health concern all over the world. The possibility of managing it through oral administration of hypoglycemic medications has received significant attention throughout the years. Though several types of oral hypoglycemic medications along with insulin are available for the treatment of diabetes mellitus, patients are increasingly demanding the use of herbal remedies with hypoglycemic action. Medicinal plants have

Table 1: Effect of *S. cumini* seed extract on GST, GPx, SOD, CAT and TBARS levels in blood

Parameters	Group 1 (Control group)	Group 2 (Diabetic group)	Group 3 (*S.cumini* treated group)
GST	0.35 ± 0.105	0.088±0.044**	0.330±0.0863##
GPx	0.433±0.139	0.066±0.027**	0.376±0.143##
SOD	0.338±0.070	0.146±0.025**	0.265±0.055#
CAT	0.815 ±0.135	0.451±0.057**	0.725±0.129##
TBARS	0.063 ±0.021	0.226 ±0.099**	0.021±0.007##

Values are presented as mean ± SD, where n = 6, and their significance level was calculated by Student t-test, followed by One-way ANOVA. The significance level is **p < 0.01 when compared to control group and #p<0.05, # #p<0.01. when compared to diabetic group. **Units:** GST: µ moles CDNB mg min^{-1}. GPx: µ moles mg min^{-1}. SOD: µ moles mg min^{-1}. CAT: µ moles H_2O_2 mg min^{-1}. TBARS: µ mole mg^{-1}.

a wide range of nutraceutical potential, containing a diverse array of bioactive chemicals that provide significant health benefits beyond basic sustenance (Singh *et al.,* 2023). As evidenced by recent research and experimentation, herbal medicines are gaining popularity due to their natural origin and minimal side effects. The World Health Organisation has documented 21,000 medicinal plants for therapeutic use seeds, berries, roots, leaves, bark and flowers contain bioactive compounds or phytocompounds that have wide clinical applications (Prasathkumar *et al.,* 2021).

Acute toxicity studies have revealed the non-toxic nature of aqueous extract of *S. cumini* up to 2000 mg kg^{-1} b.wt. Rats treated with the plant extracts were normal and showed no noticeable behavioural or neurological changes. No mortality or toxic response was reported at any of the doses administered during 14-day monitoring period. An acute toxicity test conducted by Silva *et al.* (2012) evaluated the effect of hydroalcoholic extract of *Syzygium cumini* leaves in rats and mice and reported no mortality. Prasad et al. (2016) also reported that the administration of *Syzygium cumini* bark extract showed no detectable clinical signs of toxicity or mortality during the study period of 14 days. *S. cumini* is a common plant used in traditional medicine due to its well-known medicinal properties (Chagas *et al.,* 2015).

Antioxidant enzymes are the initial phase of defence against ROS-induced oxidative harm in living organisms (Demirci-Cekic *et al.,* 2022). The principal scavenging enzymes that eliminate harmful free radicals *in vivo* are GST, GPx, SOD and CAT. Glutathione functions both as a scavenger and a substrate for glutathione peroxidase. GST and GPx are important in the catabolism of H_2O_2 as well as purification of endogenous metabolic peroxides and hydroperoxides, which initiates GSH (Ursini and Maiorino, 2020). SOD protects tissues from oxygen-free radicals. SOD is an essential defence enzyme that scavenges O_2 anion from H_2O_2 and so reduces the harmful effects caused by free radicals formed from subsequent reactions. CAT is a hemoprotein responsible for detoxifying enormous levels of H_2O_2 (Akomolafe *et al.,* 2015). The enhanced activity of catalase enzyme obtained in this study revealed that *S. cumini* seed extract has in vivo antioxidant activity and is capable of mitigating the effect of ROS in biological systems. In the present study, alloxan induction resulted elevated oxidative stress in diabetic rats, as evidenced by the decreased levels of antioxidant enzymes.

In the diabetic group rats, the antioxidant enzymes such as (GST 0.088 ± 0.044), GPx (0.066 ± 0.027), SOD (0.146 ± 0.025) and CAT (0.451 ± 0.057) were significantly (p<0.01) reduced in the blood as compared to the control group rats GST: 0.35±0.105, Gpx: 0.433±0.139, SOD: 0.338±0.070 and CAT: 0.815±0.135; (Table 1). In diabetic rats, a significant decrease was detected in antioxidant enzymes such as GST, GPx, SOD and CAT by 75%, 85%, 57% and 45%, respectively, compared to the control group in the blood samples, as shown in Fig. 1(a). Antioxidant enzymes in the diabetic group were also reduced (p<0.01) in the kidney (homogenates) (GST 0.038 ± 0.014, GPx 0.061 ± 0.021, SOD 0.041 ± 0.023, and CAT 0.345 ± 0.168) as compared to the control group (GST 0.248±0.094, GPx 0.528±0.081, SOD 0.363±0.076 and CAT 0.65±0.04) as shown in Table 2. In diabetic rats, antioxidant enzymes GST, GPx, SOD and CAT were decreased by 85%, 88%, 89% and 47% respectively compared to the control group in the kidney samples as shown in Fig. 1(b). In the current study, the reduced activities of GST, Gpx, SOD and CAT in diabetic rats were due to the inactivation induced by alloxan-generated ROS. The changes in serum and tissue antioxidant enzyme activity during diabetes in the current study are similar to previous studies. Diabetes has been documented to have an adverse effect on the activity of endogenous antioxidant enzymes and concentrations of antioxidant molecules (Adeosun *et al.*, 2020).

Subsequently, treatment with aqueous extract of *S. cumini* at a dosage of 300 mg kg^{-1} significantly (p<0.01) increased the levels of GST 0.330 ± 0.0863, GPx 0.376 ± 0.143 (p<0.01), and CAT 0.725 ± 0.129 while SOD 0.265 ± 0.055 significantly (p<0.05) increased in the blood compared as compared to the diabetic group animals (Table 1). The administration of *S. cumini* extract increased the antioxidant enzyme levels of GST, GPx, SOD and CAT by 275%, 470%, 82% and 61%, respectively compared to the diabetic group in the blood samples as shown in Fig. 1(a). The aqueous extract of *S. cumini* treatment reversed the activities of these enzymatic antioxidants, which might be due to decreased oxidative stress. *S. cumini* extract (300 mg kg^{-1}) treated rats showed (p < 0.05) notably enhanced GST 0.206 ±

Table 2: Effect of *S. cumini* seed extract on GST, GPx, SOD, CAT and TBARS levels in kidney

Parameters	Group 1 (control group)	Group 2 (Diabetic group)	Group 3 (*S. cumini* treated group)
GST	0.248±0.094	0.038±0.014 **	0.206± 0.099 #
GPx	0.528±0.081	0.061±0.021 **	0.428±0.080 ##
SOD	0.363±0.076	0.041±0.023 **	0.281±0.062 ##
CAT	0.65 ± 0.04	0.345±0.168 **	0.571±0.046 #
TBARS	0.086±0.023	0.268±0.120 **	0.07±0.023 ##

Values are given as mean ± SD, where n = 6, and their significance level was calculated by Student t-test, followed by One-way ANOVA. The significance level is **p < 0.01 when compared to control group and # p<0.05, # # p<0.01. when compared to diabetic group. **Units:** GST: µ moles CDNB mg^{-1} min^{-1}. GPx: µ moles mg min^{-1}. SOD: µ moles mg min^{-1}. CAT: µ moles H_2O_2 mg min^{-1}. TBARS: µ mole mg^{-1}.

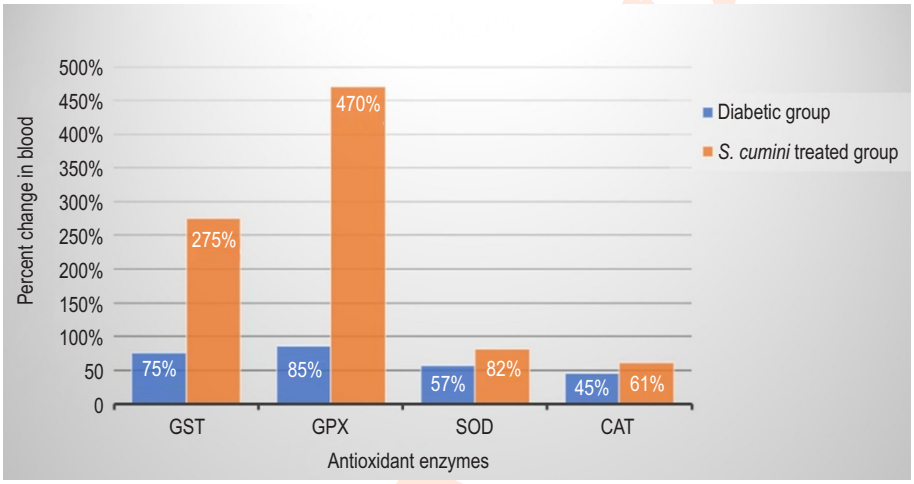

Fig. 1(a): Percentage change in antioxidant enzymes in blood

0.099, CAT 0.571 ± 0.046, activities whereas Gpx 0.428 ± 0.080 (p < 0.01) and SOD 0.281 ± 0.062 were (p<0.01) significantly increased in kidney when compared with the diabetic group as shown in Table 2. *S. cumini* extract treatment increased the percentage of antioxidant enzyme activity level GST, GPx, SOD and CAT by 442%, 601%, 585% and 66%, respectively compared to the diabetic group in the kidney samples as shown in Fig. 1(b). *S. cumini* seed extract treatment ameliorated the antioxidant enzymes activities a normal level, near to control group. The enhanced antioxidant engyme activities in diabetic rats after *S. cumini* extract treatment might be attributed to the bioactive compounds present in *S. cumini.* (Mariyam *et al.,* 2020). The plant extract possess antioxidant properties due to the presence of flavonoids. Flavonoids protect lipids against oxidative damage in various ways (Manzoor *et al.,* 2020) by inhibiting ROS generations, or chelating trace elements involved in free radical generation; scavenging ROS; or antioxidant defence upregulation or protection. Iron-chelating and iron-stabilising abilities are well recognised for quercetin in particular. According to Ulla *et al.* (2017), oral administration of an aqueous extract of *S. cumini* seed effectively reduced TBARS levels and raised antioxidant enzyme levels. Recently, Shankar *et al.* (2023) reported the efficacy of ethanol extract of *S. cumini* in mitigating arsenic-induced hepato-renal function and oxidative stress in rats. The primary process of ferroptosis is lipid peroxidation, which occurs when oxidants attack lipids. Uncontrolled lipid peroxidation causes membrane rupture and cell death by producing lipid peroxyl radicals, hydroperoxides, and other oxidative products (Ayala *et al.,* 2014). In the present study, alloxan administration significantly increased lipid peroxidation (TBARS) in the blood and kidney tissues. This statement is clear from the study that the TBARS level in the blood (0.226 ± 0.099) and kidney tissues (0.268 ± 0.120) were significantly (p<0.01) increased in alloxan-induced diabetic untreated rats in comparison to control group (0.063±0.021 and 0.086±0.023) rats (Tables 1 and 2). Due to alloxan induction, the diabetic group TBARS level in blood and kidney were decreased by 259% and 212%, respectively compared to the control group as shown in Fig.2. Hyperglycemia leads to free radical production due to glucose auto-oxidation (Farhood *et al.,* 2019). A higher level of TBARS in diabetic rats is likely related to oxidative stress and impaired antioxidant defence capacity (Olagunju, 2022), Which is

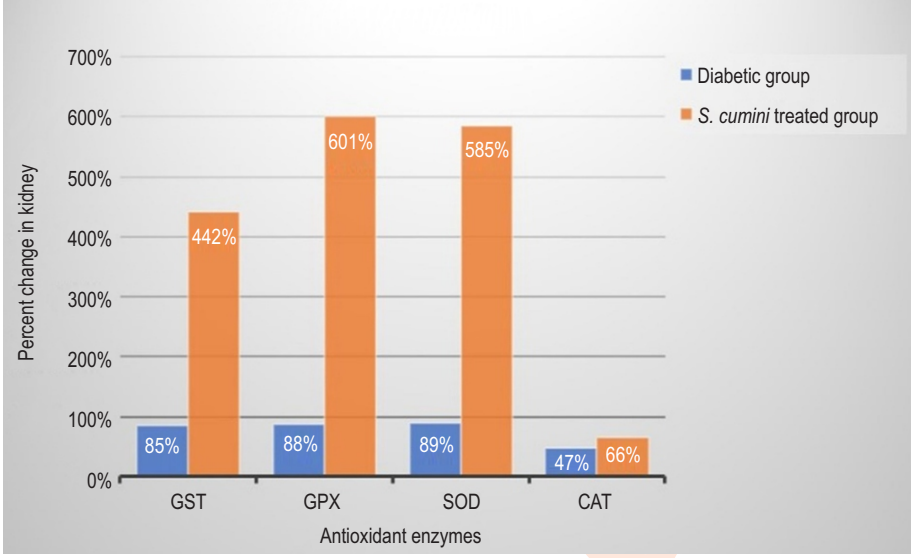

Fig. 1(b): Percentage change in antioxidant enzymes in kidney tissues.

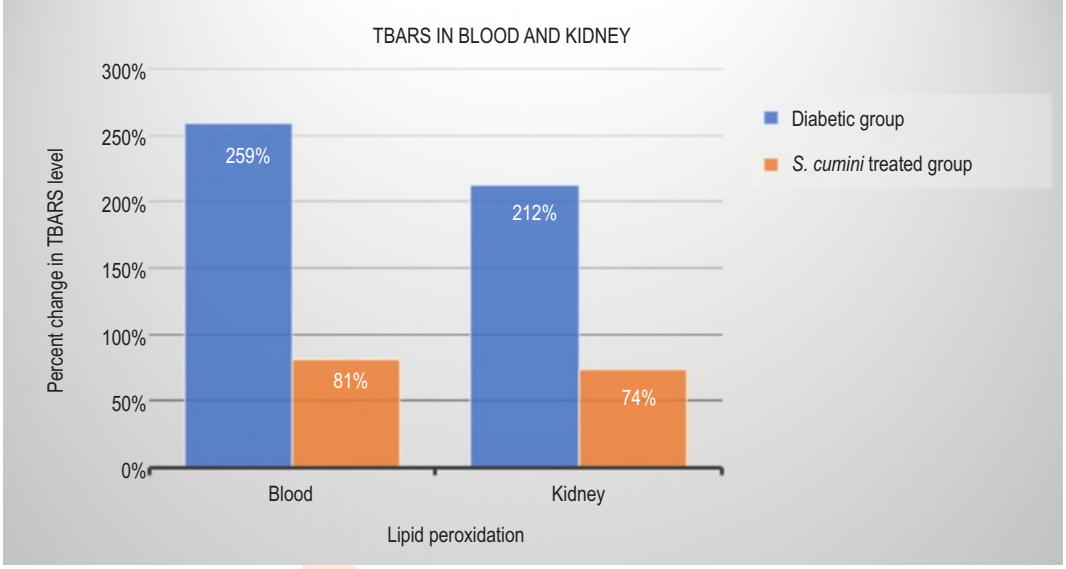

Fig. 2: Percentage change in Lipid peroxidation (TBARS) in blood and kidney.

due to damaging effects on pancreatic β cells, which produces insulin, and also fact that the tissue contains a high concentration of early peroxidizable fatty acids. This increased level of TBARS is similar to the reports of Attia *et al.* (2019) and Sanjivkumar *et al.* (2020).

Following that, treatment with 300 mg kg^{-1} *S.cumini* seed extract significantly ($p<0.01$) ameliorated the TBARS levels in the serum (0.021 ± 0.007) and kidney tissues (0.07 ± 0.023) as compared to the diabetic group rats (Table 1, 2). Administration of *S.cumini* extract reduced the TBARS level in the blood and kidney samples by 81% and 74%, respectively compared to the diabetic group as shown in Fig.2. This suggests that plant extracts minimise oxidative damage due to antiperoxidative effects of phyto components present in *Syzygium cumini* extract. The reduction in TBARS level was due to the ability of *S. cumini* seed extract to inhibit the process of lipid peroxidation in diabetic rats, which may be due to the free radical scavenging activities of its phytochemical components, (Menaka and Venkatasubramanian, 2017).

Robertson *et al.* (2005) found that antioxidants have been shown to slow the progression of diabetes in animal models by boosting beta-cell activity and strengthening antioxidant defence mechanisms in pancreatic islets, which may be a viable pharmacologic approach to diabetes management. Hossain *et al.* (2011) stated that the oral treatment of *S. cumini* extract (400 mg kg^{-1} b.wt. day) for 7 weeks dramatically reduced liver LPO levels in rats, indicating that *S. cumini* seed not only suppressed *in vitro* free radical generation and consequent oxidative stress but also inhibited their in vivo development. Baldissera *et al.* (2016) in their study, found that crude hydroalcoholic extract of *S. cumini* leaves exhibits potential protective capabilities against oxidative stress and DNA damage, most likely due to the presence of phenols and myricetin glycoside concentration, as well as antioxidant activities of these compounds. Bitencourt *et al.* (2017) found that treating diabetic rats infected with *Candida albicans* with aqueous *Syzygium cumini* extract (ASc) and nanoparticle aqueous *Syzygium cumini* (NPASc) for 21 days lowered TBARS levels in the liver, kidney, and pancreas. The antioxidant properties of the extract ameliorated oxidative stress.

In conclusion, the present findings suggest that *S. cumini* contain biomolecules that encourage insulin receptors or activate the β-cells of the Islets of Langerhans in the pancreas of alloxan-induced diabetic rats. Thus, consumption of *S. cumini* seed extract may be considered a natural antioxidant as their antihyperglycemic activity helps to reduce oxidative stress in diabetic conditions, which may play a beneficial role in managing diabetes.

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