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Study The Effect of Rice & Psyllium Husks and Their Extracts on Diabetic Rats

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Abstract

Diabetes mellitus is one of a serious of metabolic disorders with different pathophysiological mechanisms ended by hyperglycemia. This study evaluated the effect of rice and psyllium husks and their extracts on diabetic rats. Thirty-six mature male albino rats were divided into two main groups as follows: Group (1): fed on basal diet only and kept as a negative control group (n =6). Group (2): Diabetes mellitus group (n =30) were fasted overnight and then given a single intraperitoneal injection of 60mg/kg streptozotocin (STZ) dissolved in 10 mm citrate buffer (pH 4.5). After that, the rats were divided into five equal groups (6 rats each) as follows: Group (1): left as a positive control and fed on a basal diet only. Group (2): received psyllium husk extract at doses of 100mg per kg of body weight. Group (3): received a basal diet supplemented with 5% psyllium husk (50g/ kg diet). Group (4): received rice husk extract at doses of 100 mg per kg body weight. Group (5): received basal diet supplemented with 5% rice husk (50g/ kg diet). The doses were given for 28 consecutive days. At the end of the experiment, feed intake (FI), body weight gain (BWG%) and feed efficiency ratio (FER) were calculated. Serum levels of glucose, total cholesterol (TC), triglycerides (TG) , high-density lipoprotein cholesterol (HDL-c), and Low density lipoprotein cholesterol (LDL-c), as well as the activities of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP), in addition to concentrations of urea, uric acid and creatinine were measured . A histological examination of the pancreas, kidneys, and liver Was performed. Results showed that these treatments improved serum sugar levels, serum lipids, kidney and liver functions. Therefore, consuming psyllium , rice husks and their extracts may be beneficial for improving blood sugar.

Key words: Streptozotocin, psyllium husk, rice husk, serum glucose, liver functions, kidney functions, and lipid profile.

1. INTRODUCTION

Diabetes is a chronic disease that significantly effect on the lives of people around the world (**García, 2017)**. The population is expected to be 578 million people who will develop diabetes in 2030 and the number will increase by 51% (700 million) in 2045 **(Elhassaneen *et al*., 2021).** The disease's heterogeneity is reflected in its classification into several categories, mainly type 1, type 2, gestational, and several rare forms **(Yameny, 2025).**

Streptozotocin (STZ) is used as a diabetogenic drug to induce type 1 and type 2 diabetes in experimental rats **(Ghasemi and Jeddi, 2023).** The mechanism of STZ is the production free radicals, which can harm beta cells of the pancreas and interfere with the generation of insulin **(Munjiati, 2021)**

Some plants have the ability to maintain β-cells performance and decrease glucose levels in the blood. They are less affordable and have fewer side effects compared to synthetic drugs, and are more effective in treatment of diabetes mellitus **(Kooti *et al*., 2016)**.

One of the main organic waste products of the rice milling process is husk. It has antioxidant activity, and contains many phytochemicals, so reduces oxidative stress that causes diseases (**Wongmekiat *et al*., 2021**). Rice husk is composed of 11% hemicellulose with xylan being the main sugar subunit. Xylan is the most abundant carbohydrate in lignocellulosic biomass the precursor of Xylooligosaccharides (XOS), used as prebiotics. Toxic products and activity of pathogenic bacteria are decreased by xylooligosaccharides which enables the growth of probiotic bacteria **(Palwasha *et al*.,2025).**

Psyllium (*Plantago ovate*), is rich in soluble fiber, Its nutritional profile has been extensively studied for its functional benefits, including enhancing digestive health, regulating blood glucose levels, and lowering cholesterol **(Geremew *et al* .,2024).** Clinical studies indicated improved glycemic control, with reductions in postprandial glucose and HbA1c through slowed carbohydrate absorption and enhanced insulin sensitivity **(Biesiada *et al*., 2025)**. Psyllium husk ethanolic extract can reduce lipid peroxidation and increase the hormones, leptin, and adiponectin associated with hyperlipidemia (**Hashem *et al*., 2021**). "Accordingly, this study was conducted to evaluate the potential therapeutic effects of rice husk and psyllium husk on glycemic control and related biochemical parameters in experimentally induced diabetic rats."

2. Material and Methods

Materials

Psyllium and rice husks were obtained from Harraz Co. for Agricultural Seeds, Spices and Medicinal plants, Cairo, Egypt. Streptozotocin and kits were bought from El-Gomhoria Company for Trading Drug Chemicals and Medicals, Cairo, Egypt. Other chemicals were bought from Morgan Chemicals Co. Cairo, Egypt. A total of 36 adult male albino rats of the Sprague Dawley strain weighing 200±10g were bought from the Vaccine and Immunity Organization, Ministry of Health, Helwan Farm, Cairo, Egypt.

Methods

Preparation of husks extracts

The husks of *Plantago ovata* and *Oryza Sativa* were ground to fine powder, and extracted according to **Nofal *et al.* (2016).** The crude extract was stored in a deep freezer till further analysis.

Chemical analysis

Chemical composition (protein, fat, moisture, ash and carbohydrates) determined according to **A.O.A.C (2010).**

Phenolic profile identification of husks:

Phenolic compounds of the husks were identified and determined by high-performance liquid chromatography (HPLC) according to **Kim *et al.* (2006).**

Total phenolics in the husks were measured based on the method adopted by **Tarola *et al.* (2013)** and expressed as gallic acid equivalents (GAE).

Basal diet

Basal diet was prepared from fine ingredients per 100g according to **(Reeves *et al.*,1993),** and water supply was given ad-libitum and checked daily.

Induction of diabetes

Thirty rats were be fasted overnight and then administrated a single intraperitoneal injections of 60mg/kg streptozotocin dissolved in 10 mM citrate buffer (pH 4.5) **(Lu *et al.*, 2015).** Seventy two hours after STZ administration, Fasting Blood Glucose were be determined in a tail vein sample by blood glucose meter.

Experimental design:

Rats were being kept in clean wire cages under hygienic conditions. Feed and water were introduced (*ad libitum*) to the rats and checked daily. Adaptation was continued for one week. After that, rats were being divided into two main groups as follows: Group (1): was fed

on a basal diet only and kept as a negative control group (n =6). Group (2): Diabetes mellitus group thirty rats were fasted overnight and then given a single intraperitoneal injection of 60mg/kg STZ dissolved in 10 mm citrate buffer (pH 4.5) **(Lu *et al.*, 2015).**
After that, the rats were divided into five equal groups (6 rats each) as follows:

The animals were divided into five experimental groups as follows: Group (1) served as the positive control and was fed a basal diet only. Group (2) received psyllium husk (Plantago ovata) extract at a dose of 100 mg/kg body weight. Group (3) was fed a basal diet supplemented with 5% psyllium husk (50 g/kg diet). Group (4) received rice husk (Oryza sativa) extract at a dose of 100 mg/kg body weight. Group (5) was fed a basal diet supplemented with 5% rice husk (50 g/kg diet).

At the end of experiment (28 days), rats were deprived of feed and water overnight before being sacrificed. Blood samples were being collected in dry centrifuge tubes from hepatic portal veins. Serum samples were separated by centrifugation at 300 rpm for 10 minutes and kept in plastic vial at -20 till analysis.

Biological evaluation

At the time of the experiment (28days), feed intake was recorded every day and body weight was recorded every week. Biological evaluation of the different diets was carried out by calculating of body weight gain % (BWG %) and feed efficiency ratio (FER) according to **Chapman *et al.* (1959).**

Biochemical Analysis

Serum glucose was estimated according to **Trinder (1969).** Total cholesterol، triglyceride (TG) and high-density lipoprotein (HDL-c) were determined by using the methods of **Thomas (1992), Fassati** and **Prencipe (1982)** ; **Fredewaid (1972)** respectively. Lipoprotein fractions were being calculated according to **Lee and Nieman (1996)** as the following equation: LDL-c = Total cholesterol-(HDL-c + TG/5), VLDL-c = TG/5.

Serum alanine aminotransferase (ALT), aspartate amino transferase (AST) and alkaline phosphatase (ALP) were determined according to the methods described by **Reitman and Frankel (1975); Hafkenscheid (1979)** and **Moss (1982)** respectively. Urea, uric acid and creatinine were determined according to the methods of **Patton and Crouch (1977), Barham and Trinder (1972),** and **Henry, (1974)** respectively.

Histopathological Examination

Pancreas, liver and kidney of the scarified rats were washed in slain solution and kept in10% formalin solution for histopathological examination according to method mentioned by **Bancroft *et al.* (1996).**

Statistical Analysis

The mean ± SD was used to express the results. One-way analysis of variance (ANOVA) was used to examine the data for comparisons between various variables. For the comparison of significance between groups, Duncan's test was used as a post hoc test according to the statistical package program **(Artimage and Berry, 1987).**

3. Results and Discussion

Chemical composition of psyllium and rice husks:

The chemical composition of psyllium and rice husks was examined to determine their chemical composition which included ash, moisture, protein, carbs, fat and crude fiber. The results obtained on a dry weight basis are displayed in Table (1). It could be noticed that the available carbohydrate, ash, and crude fat content in rice husk recorded a higher percentage than psyllium husk, with values of 28.03, 18.39, and 3.96 compared to 5.07, 3.84, and 0.21, respectively. While crude fiber content (81.76) was higher in psyllium husk compared to rice husk, which reached 37.84.

These results are in relatively agreement with **Waleed *et al.* (2022**) found that the proximate composition of psyllium seed husk including moisture, ash, crude fat, crude protein, and crude fibers were 4.9 ± 0.01, 4.1 ± 0.01, 1.2 ± 0.01, 3.9 ± 0.05 and 20.23 ± 0.4 g/100 g, respectively. Furthermore, the proximate analysis of the rice husk samples showed the presence of carbohydrates (37.04%), crude fat (3.76%), moisture (7.93%), crude protein (1.85%), fiber (25.74%), and ash content (23.39%), according to **Nnadiukwu *et al.*(2023b).**

Table (1): Chemical composition of psyllium and rice husks

Samples / Compositions (g / 100g)	**Psyllium husk**	**Rice husk**
Moisture	6.94	8.93
Crude fiber	81.76	37.84
Crude fat	0.21	3.96
Crude protein	2.18	2.85
Ash	3.84	18.39
Available carbohydrates	5.07	28.03

Total phenolics in psyllium and rice husks:

Table (2) shows that the total phenolic content of psyllium husk was 241.8(mg Gallic Acid Equivalent / 100 g), which was higher than that of rice husk, which were 134.6(mg Gallic Acid Equivalent / 100 g). These findings are in relatively agreement with **Souza *et al.* (2020)** observed that psyllium has several antioxidant components (phenolics, flavonoids and antioxidant activity) that are very desirable in food products. Also, **Khan *et al*. (2021)** indicated that the psyllium husk plant has specific flavonoids that prevent the formation of cancer cells. Similar results were reported by **Wisetkomolmat *et al*. (2023)** clarified that rice husk contains bioactive substances having biological activity, including polysaccharides, flavonoids, tocopherols, and phenolic acids. The phenolic components, total flavonoid content, and antioxidant activities of the ethanolic rice husk extract were assessed total phenolic content as 29.90 mmol/(L•g) gallic acid and total flavonoid content as 12.16 mg/g catechin equivalent**.** Also**, Kaur and Ubeyitogullari (2023)** pointed out that rice husk is rich in bioactive substances, specifically flavonoids and phenolic acids. These substances, which are secondary metabolites found in the husk, have a variety of biological effects, including antioxidant properties that may aid in the prevention of lipid oxidations and illnesses.

Table (2): Total phenolics in psyllium and rice husks:

Total phenolics	**Psyllium husk**	**Rice husk**
Total phenolics (mg Gallic Acid Equivalent / 100 g)	**241.8**	**134.6**

Phenolic compounds of psyllium and rice husk (ppm) by HPLC analysis

Samples of psyllium and rice husks were analyzed by high-performance liquid chromatography (HPLC) for their phenolic compounds. The results obtained are shown in Table (3) and figs. (1,2). The psyllium husk sample recorded varying content of all analyzed phenolic compounds compared to the rice husk sample, as the psyllium husk sample contained a higher amount of caffeic acid and rutin compared to the rice husk sample, while naringenin was not found in the psyllium husk sample and was found in the rice husk sample. The current results are consistent with those of **Karimi *et al*. (2014)** reported that HPLC analysis revealed gallic acid, pyrogallol, apigenin, and rutin to be the main phenolic and flavonoid compounds in all rice husk varieties. Similarly, **Rahman *et al*. (2014)** stated that paddy husks are by-products of the rice milling industry and are usually discarded or burned. However, these husks are rich in compounds such as ferulic, vanillic, and p-coumaric acids, which possess strong antioxidant capacities. **Wisetkomolmat *et al*. (2023)** indicated that the non-glutinous and wetland ecotypes of rice husk samples exhibited the highest antioxidant activity and polyphenol content, as determined by principal component analysis. The glutinous rice husk showed higher antioxidant activity than the others. Interestingly, quercetin was identified as a key phenolic compound that positively correlated with the overall antioxidant activity of rice husk.

Table (3): Phenolic compounds of psyllium and rice husks by HPLC (ppm) analysis

Phenolic compounds (ppm)	Samples	
	Psyllium husk	Rice husk
Gallic acid	17.57	51.78
Chlorogenic acid	0.00	0.00
Catechin	18.56	16.89
Methyl gallate	0.00	1.18
Caffeic acid	108.51	3.29
Syringic acid	9.44	4.88
Rutin	50.72	3.11
Ellagic acid	4.70	0.00
Coumaric acid	0.90	15.00
Vanillin	9.53	3.56
Ferulic acid	2.78	10.69
Naringenin	0.00	3.66
Rosmarinic acid	5.54	2.90
Daidzein	2.72	2.76
Querectin	3.09	0.00
Cinnamic acid	0.25	1.37
Kaempferol	1.86	7.02
Hesperetin	1.17	3.79

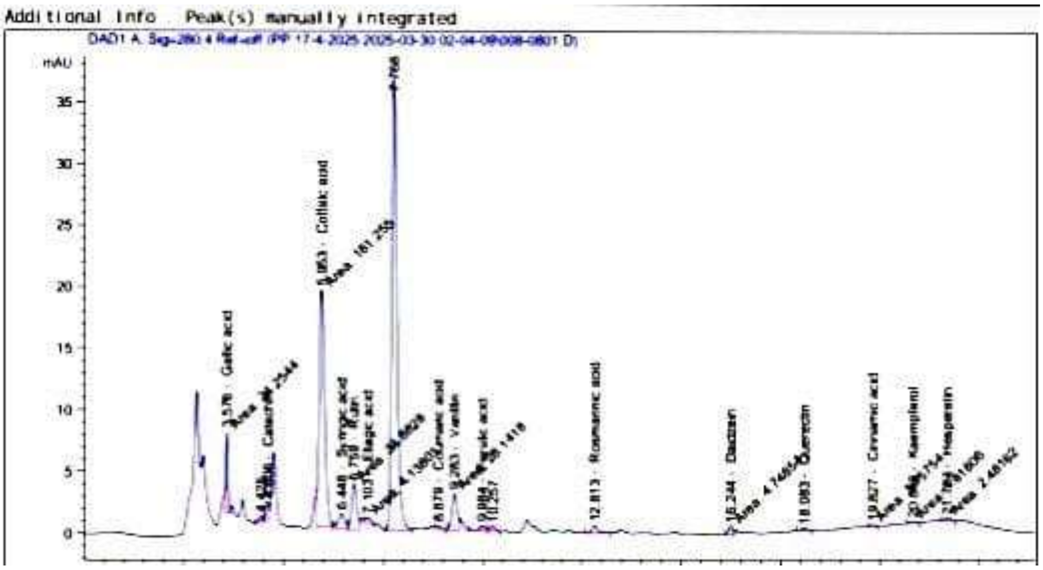

Fig . (1) HPLC analysis of phenolic compounds in psyllium husk

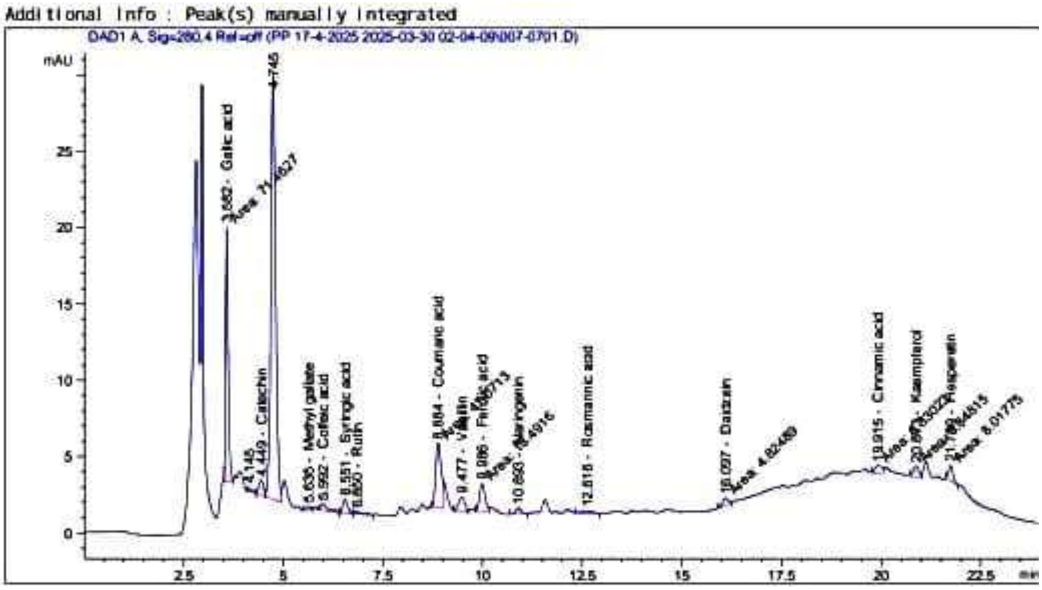

Fig . (2): HPLC analysis of phenolic compounds in rice husk

Biological effects

Effect of rice and psyllium husks and their extracts on feed intake (FI), body weight gain (BWG%) and feed efficiency ratio (FER) of diabetic rats.

Results shown in table 4 and figs. 3 to 5 indicated that the level of FI was increased nonsignificantly in the positive control group compared with the negative control group. In contrast , the mean values of BWG% and FER were significantly decreased. While diabetic rats treated with psyllium and rice husks and their extracts recorded a reduction in BWG and FER as compared to negative control group. STZ-induced diabetes resulted in specific clinical signs of diabetes, including a loss of body weight **(Guo *et al.*, 2014 and Silvares *et al.*, 2016).** Also, **(Gilani *et al.*,**

2021) who showed that after receiving STZ, experimental groups underwent a gradual decrease in body weight. The fundamental clinical correlation for weight loss was thought to be insulin deficiency, which causes protein and fat catabolism **(Guo *et al.*, 2014).** The present results were in agreement with **Mostafa (2017**), who revealed that the addition of psyllium husk to toast bread caused a significant decrease ($p<0.05$) in body weight gain. As mentioned by **Ismael (2017)**, animals fed on diets containing psyllium husk seed powder at levels of 10 and 20% recorded reduced body weight gain as compared to the negative control group. The reduction in BWG% in diabetic rats treated with psyllium and rice husk and their extracts may be due to high fiber content. These results agreed also with the recorded data of **Xing *et al*. (2017)** reported psyllium is a great source of fiber and has many other therapeutic impacts such as hypolipidemia and antihyperglycemia, antidiarrhoeal, and laxative effects, promoting energy, hemorrhoid remedy, reducing inflammation and weight loss. It is also proved that psyllium husk significantly decreased the body weight and overcome issue of obesity among children and teenage **(Akram *et al*., 2019).**

Table (4): Effect of rice and psyllium husks and their extracts on feed intake (FI), body weight gain (BWG%) and feed efficiency ratio (FER) of diabetic rats

Parameters / Groups	FI (g/day)	BWG %	FER
Negative Control	$24.59^{d} \pm 0.30$	$27.75^{a} \pm 5.25$	$0.1133^{a} \pm 0.0021$
Positive Control	$24.60^{d} \pm 0.20$	$-7.99^{d} \pm 4.00$	$-0.0032^{d} \pm 0.0016$
Psyllium husk Ex.	$28.90^{a} \pm 0.60$	$15.63^{b} \pm 5.19$	$0.0054^{b} \pm 0.0018$
Psyllium husk	$26.70^{c} \pm 0.40$	$8.83^{bc} \pm 5.09$	$0.0032^{bc} \pm 0.0017$
Rice husk Ex.	$27.60^{b} \pm 0.50$	$11.19^{bc} \pm 6.62$	$0.0042^{bc} \pm 0.0025$
Rice husk	$25.45^{d} \pm 0.70$	$6.17^{c} \pm 4.44$	$0.0026^{c} \pm 0.0018$

- Data were expressed as mean ±SD.
- Values that have different letters in each column differ significantly, while the difference among those with similar letters is not significant ($p<0.05$).

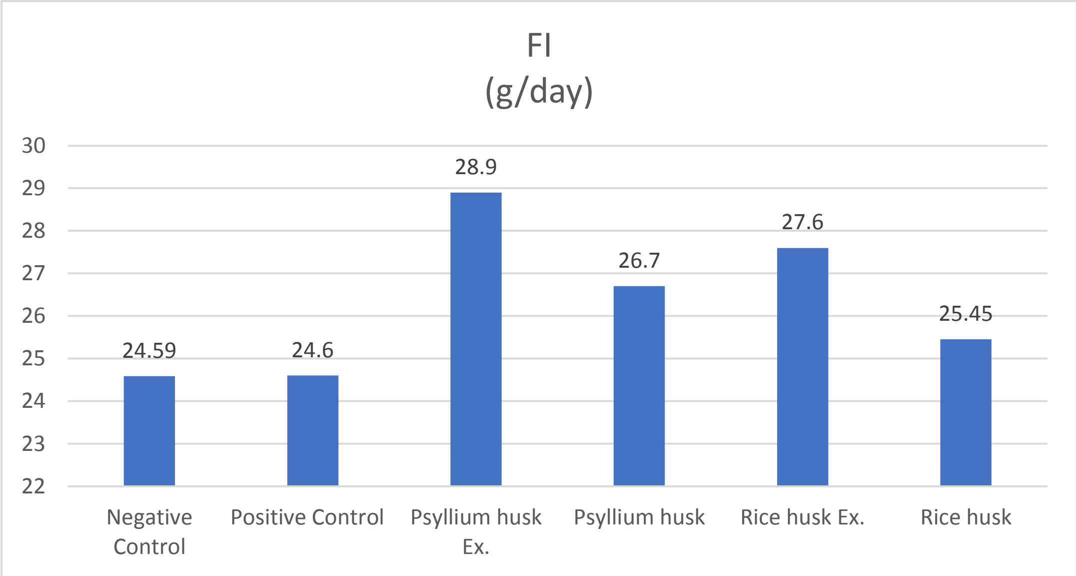

Fig.(3): Effect of rice and psyllium husks and their extracts on feed intake (FI) (g/day) of diabetic rats

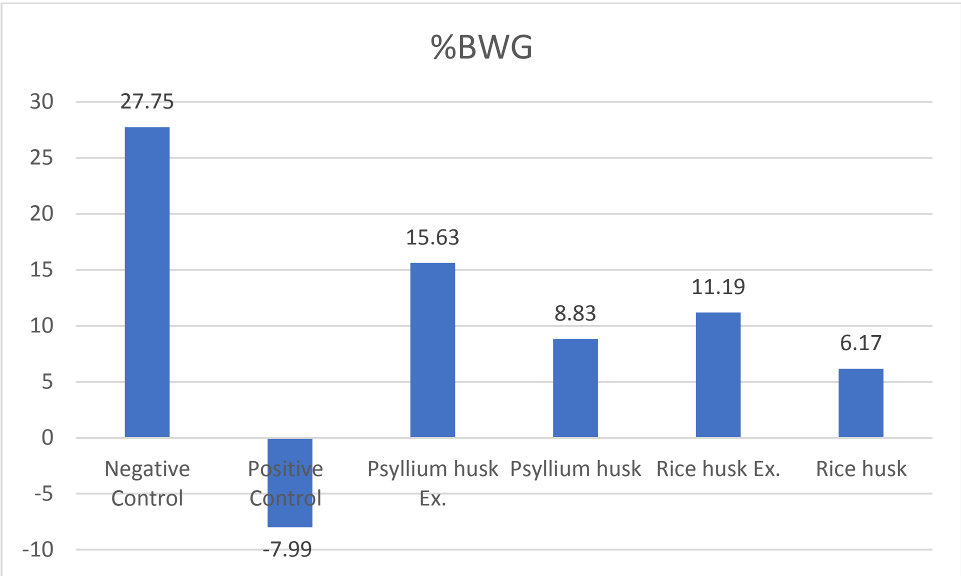

Fig.(4): Effect of rice and psyllium husks and their extracts on body weight gain (BWG%) of diabetic rats

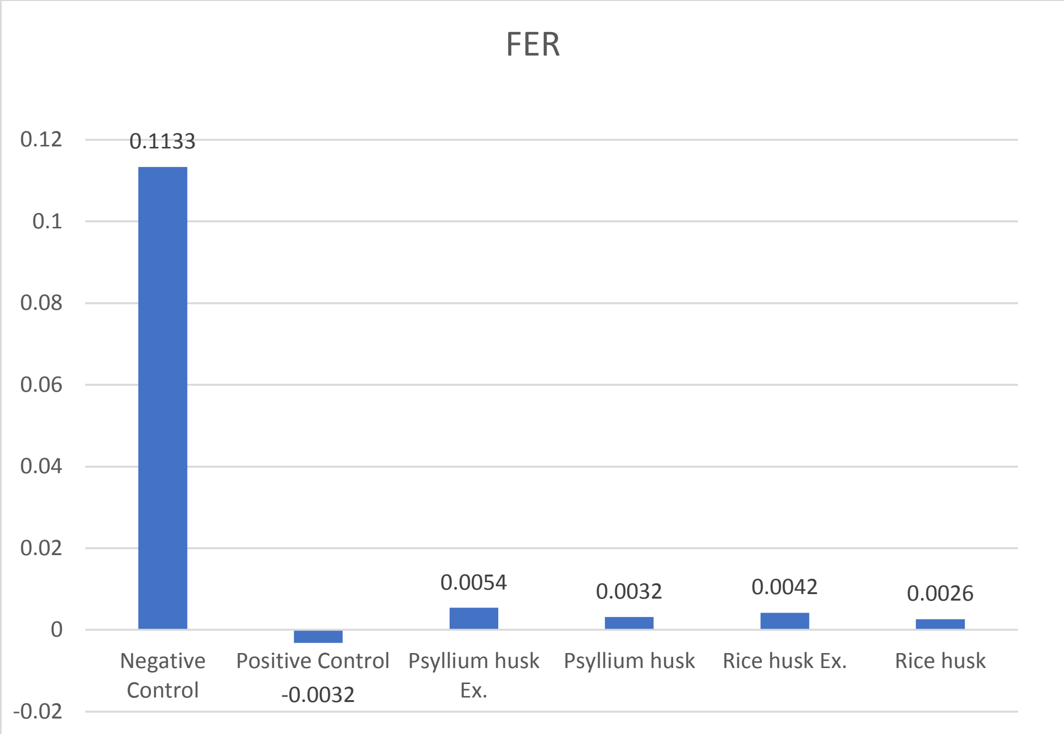

Fig.(5): Effect of rice and psyllium husks and their extracts on feed efficiency ratio (FER) of diabetic rats

Biochemical parameters of the biological experiment

Serum glucose:

Effect of rice and psyllium husks and their extracts on serum glucose of diabetic rats.

The effect of psyllium and rice husks and their extracts on serum glucose is shown in table (5) and fig.(6). When compared to the negative control group, the results indicated a significant increase in the positive control group. While diabetic rats treated with psyllium and rice husks and their extracts improved serum glucose levels in diabetic rats compared with positive control. Moreover, the best serum glucose was recorded for diabetic rats treated with psyllium husk extract. Streptozotocin is well-known as a diabetogenic chemical agent to induce diabetes mellitus in experimental animal models by specific cytotoxicity action on pancreatic β-cells, leading to affecting endogenous insulin discharge/action or both, resulting in an increase in the fasting blood glucose level **(Nastaran, 2011).** The hypoglycemic effect of psyllium and rice husks and their extracts, in the present study, was in agreement with **Rahman *et al*. (2014),** who mentioned that the various extracts of paddy husk can be used for lowering of blood glucose. Psyllium is a great source of fiber and has many other therapeutic effects, including decreasing cholesterol and preventing diabetes, according **to Xing *et al.*(2017)**. Likewise, **Akram *et al.*(2019)** discovered that its fiber is useful in diet therapy to treat diabetes patients because it binds with excess blood glucose and lowers blood sugar levels. Furthermore, **Elhassaneen *et al.* (2021)** demonstrated that psyllium seeds and husk supplementation had a hypoglycemic impact. As stated by **Bacha *et al.* (2022)**, psyllium husk fiber and lifestyle changes have a major impact on fasting blood glucose levels and lower the HOMA-IR value. Likewise, as mentioned by **Geremew *et al.* (2024)**, psyllium husk has nutritional, functional, and health benefits, making it a versatile ingredient in the food industry and an effective agent in waste treatment. Its high soluble fiber content supports digestive health, aids in cholesterol and blood sugar management, and enhances food product quality.

Table (5): Effect of rice and psyllium husks and their extracts on Serum glucose of diabetic rats

Groups / Parameters	Glucose (mg /dl)
Negative Control	$84.17^{e} \pm 8.28$
Positive Control	$353.20^{a} \pm 27.32$
Psyllium husk Ex.	$111.20^{d} \pm 8.70$
Psyllium husk	$193.40^{b} \pm 13.87$
Rice husk Ex.	$140.20^{c} \pm 13.65$
Rice husk	$194.20^{b} \pm 6.68$

- Values that have different letters in each column differ significantly, while the difference among those with similar letters is not significant ($p<0.05$).

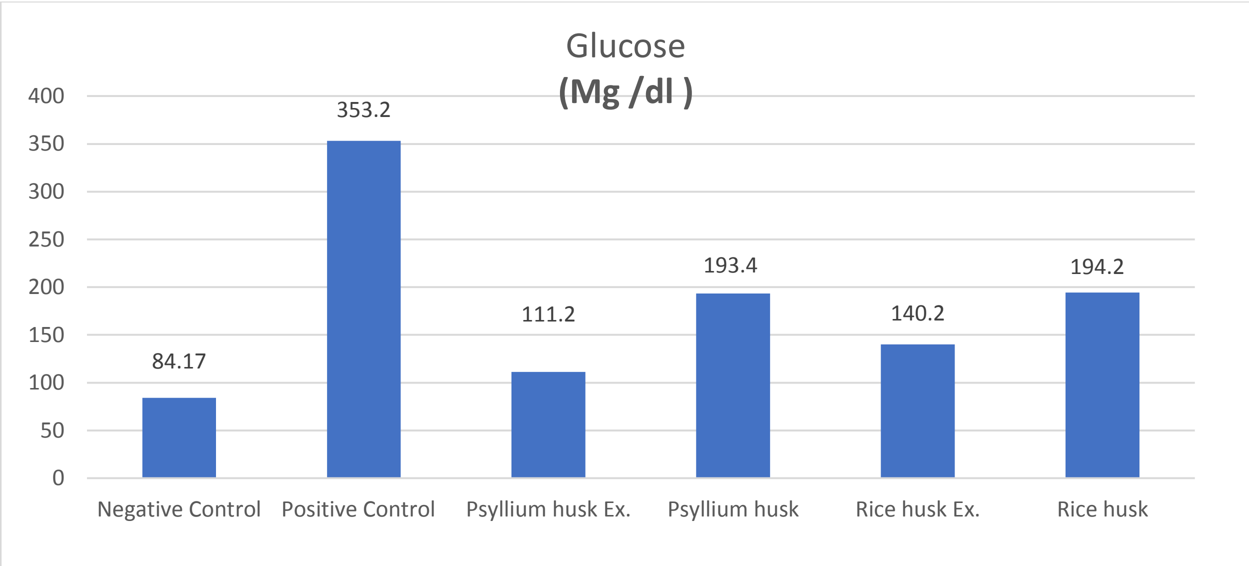

Fig.(6): Effect of rice and psyllium husks and their extracts on serum glucose (mg /dl) of diabetic rats

Liver function

Effect of rice and psyllium husks and their extracts on ALT, AST and ALP of diabetic rats.

Transaminase (ALT, AST, and ALP) activities were significantly higher in the serum of the positive control group than in the negative control group. The treated groups showed a significant reduction in ALT, AST and ALP activities compared with the positive control group. The best result was recorded for the group treated with psyllium husk extract followed by the group treated with rice husk extract as shown in table (6) and figs. 7 to 9. As the diabetes is a metabolic disorder, leads to cause harm to hepatocytes. Due to hepatic cells injury, directly linked with the discharge of intracellular elements into the systemic circulation. Hepatic cells damage can be scientifically diagnosed or a valuable clue may be easily provided by the measurement of serum concentrations of hepatic enzymes. The increased levels of hepatic enzymes may be due to discharge of enzymes from the hepatic tissue in the plasma in STZ-induced type 2 diabetes **(Rehman *et al.*, 2023).** Our results are in agreement with **Wahid *et al* . (2020)** revealed that psyllium husk mucilage (PHM) possesses substantial in vivo liver protective potency that could be attributed to its antioxidant activity. Additionally, **Chen *et al*. (2022)** reported that rice-husk silica liquid (RHSL) not only ameliorated liver tissue damage and enhanced glucose tolerance and serum insulin levels, but also reversed the expression of markers linked to glucose metabolism in a STZ-induced diabetic mouse model. Likewise **El-kholie *et al*. (2023)** showed that quinoa seeds, psyllium husk along with their mixes as powdered enhance serum glucose, renal functions, liver functions, and lipid fractions, particularly with 10% mixture quinoa seeds and psyllium husk powder, which could be used in our bakery products and daily dishes in addition to its many health benefits.

Table (6): Effect of rice and psyllium husks and their extracts on ALT, AST and ALP of diabetic rats

Parameters / Groups	ALT (U/L)	AST (U/L)	ALP (U/L)
Negative Control	33.00^{e} ± 3.22	105.33^{e} ± 10.44	220.50^{d} ± 17.76
Positive Control	69.20^{a} ± 4.44	281.40^{a} ± 12 .05	398.00^{a} ± 11.47
Psyllium husk Ex.	40.20^{d} ± 2.86	144.40^{d} ± 11.67	248.00^{c} ± 21.01
Psyllium husk	51.40 ^{b} ± 5.07	219.00^{b} ± 21.49	337.80^{b} ± 20.63
Rice husk Ex.	45.40^{c} ± 2.30	172.40^{c} ± 15.21	269.20^{c} ± 19.58
Rice husk	54.40^{b} ± 4.82	226.40^{b} ± 17.84	350.60^{b} ± 12.50

- Data were expressed as mean ±SD.
- Values that have different letters in each column differ significantly, while the difference among those with similar letters is not significant (p<0.05).

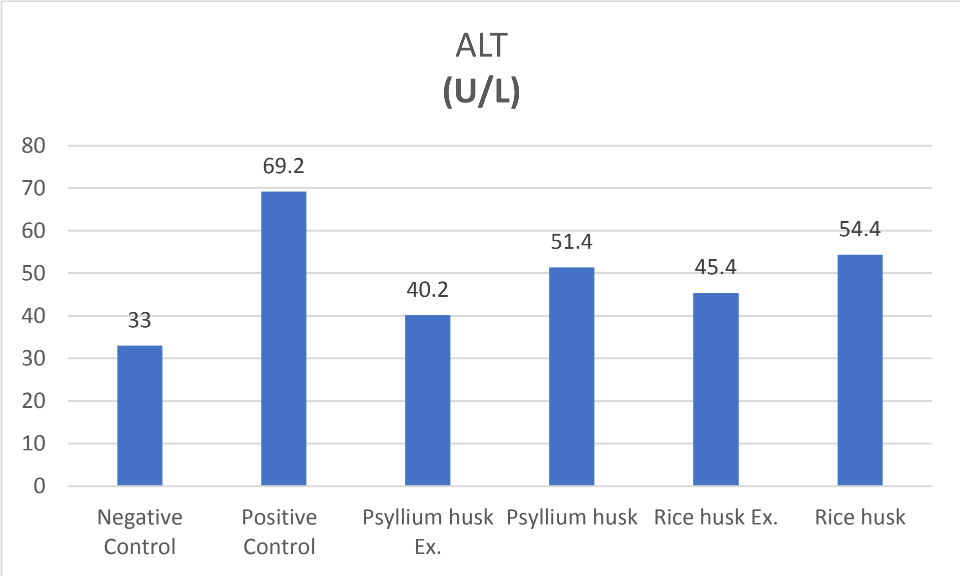

Fig.(7): Effect of rice and psyllium husk ,and their extracts on ALT (U/l) of diabetic rats

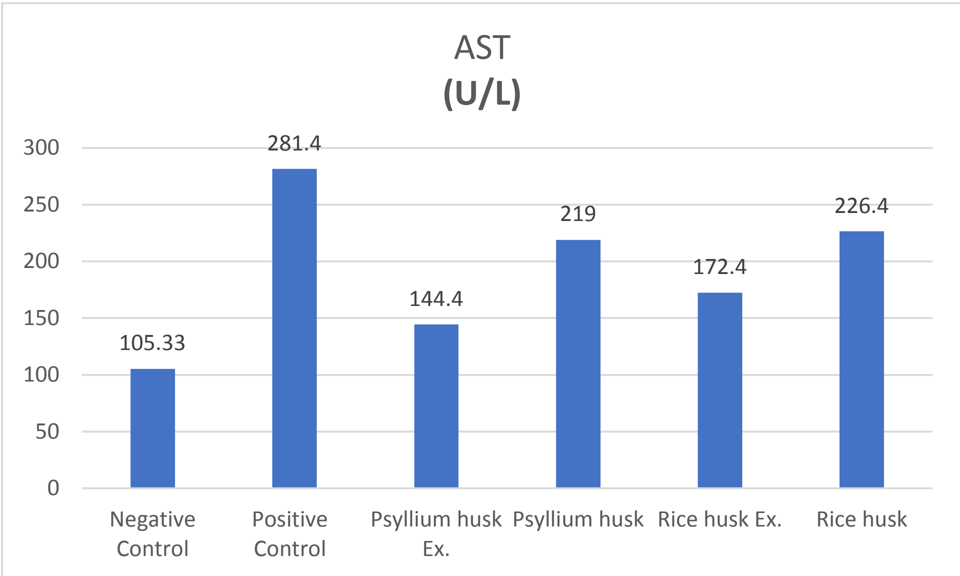

Fig.(8): Effect of rice and psyllium husks and their extracts on AST (U/l) of diabetic rats

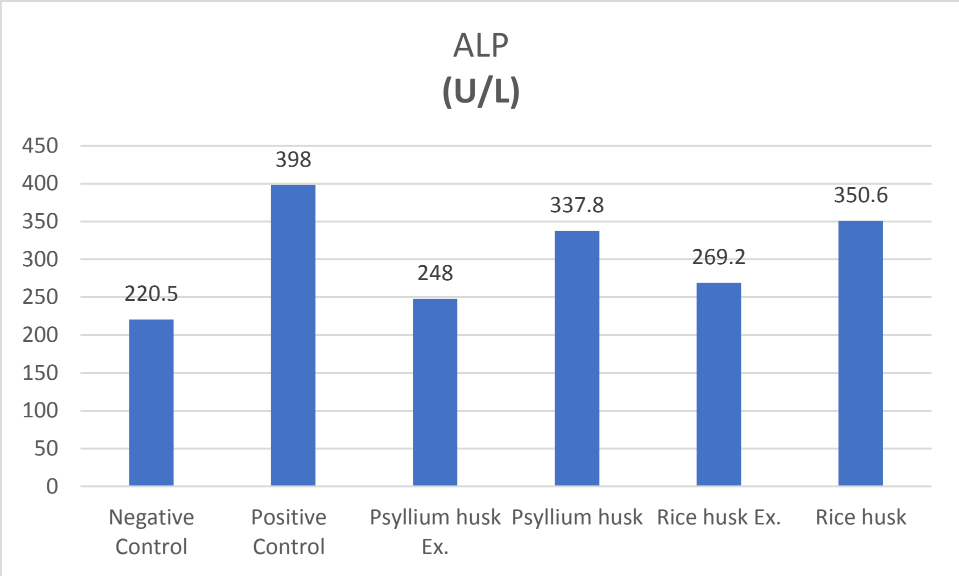

Fig.(9): Effect of rice and psyllium husks and their extracts on ALP (U/l) of diabetic rats

lipid profile

Effect of rice and psyllium husks and their extracts on lipid profile of diabetic rats.

The effect of rice and psyllium husks and their extracts on lipid fractions is shown in table (7) and figs.10 to 13. A significant increase was observed in the concentrations of (TCH, TG and LDL) in blood serum, with the exception of HDL which recorded a significant decrease in the positive group compared to the negative control group. The groups that were treated displayed a significant decrease in the activities of (Total cholesterol (TCH), triglyceride (TG), Low density lipoprotein cholesterol (LDL)) compared to the positive control group, while (high-density lipoprotein cholesterol (HDL) recorded a significant increase compared to the positive group. This dyslipidemia was in line with **Barakat *et al.* (2023)**,who discovered that development of diabetes caused a large increase in blood TG, TC, LDL-c, and a considerable drop in HDL-c. This marked hyperlipidaemia that characterizes the diabetic state may be regarded as a consequence of the uninhibited release of fat depots from adipose tissue and the liver in response to energy demands of cells already deprived of glucose due to insulin deficiency or resistance, which identifies diabetes. Insulin deficiency results in activation of hormonesensitive lipase (HSL) and consequently enhanced release of free fatty acids from adipose tissue. Thus, excess fatty acids in the plasma produced by the STZ-induced diabetes promote the conversion of excess fatty acids into phospholipids and cholesterol in the liver. These two substances, along with excess triacylglycerol formed in the liver, may be discharged into the blood in the form of lipoproteins. resulting in hyperlipidemia (**Ugbaja, 2016)**. The current results were consistent with the results of **(Khatudomkiri *et al.*, 2020)** showed that daily consumption of rice husk derived xylooligosaccharides (RH-XOS) at a dose of 500 mg/kg BW for 12 weeks exhibited the beneficial effects of lowering serum glucose level and normalizing LDL-C levels, cholesterol and triglyceride in diabetic rats, which indicated its hypolipidemia and antihyperglycemia effects. The hypolipidemic effect of psyllium husk extract observed in the present results was consistent with **Hashem *et al* .(2021)** demonstrated that the ethanolic extraction from psyllium husk has strong effects against oxidative stress, hyperglycemia and hyperlipidemia because of its high biologically active components detected by GCMS. The ethanolic extract from psyllium husk can raise GSH and CAT activity, decrease lipid peroxidation, and raise the hormones, adiponectin and leptin linked with hyperlipidemia. As mentioned by **Qaisrani *et al*. (2016)**, the active component of psyllium husk, arabinoxylans, has vital physiological roles as a laxative, manages serum lipid profile in hypercholesterolemic people, decreases serum glucose and Hb A1c levels in patients with T2MD. Also, **El-Dreny *et al*. (2023)** concluded that adding chia and psyllium powder (5%) to the diet for obese rats, led to an increase in HDL-C, and a decrease in serum glucose, TCH, TG, LDL-C and v-LDL cholesterol compared to the positive control group. And **Ahmad *et al*. (2025)** confirmed that rich in dietary fiber, psyllium husk has a long history of positive health effects, including the prevention or resistance of several prevalent disorders including obesity, diabetes, hyperlipemia and Cardiovascular diseases (CVD) .

Table (7): Effect of rice and psyllium husks and their extracts on lipid profile of diabetic rats

Parameters / Groups	TCH (mg /dl)	TG (mg /dl)	LDL (mg /dl)	HDL (mg /dl)
Negative Control	$75.17^{e} \pm 5.19$	$77.67^{d} \pm 6.50$	$6.33^{d} \pm .52$	$53.50^{a} \pm 3.94$
Positive Control	$111.20^{a} \pm 8.49$	$135.60^{a} \pm 11.95$	$35.40^{a} \pm 1.82$	$46.20^{b} \pm 2.18$
Psyllium husk Ex.	$81.80^{d} \pm 4.49$	$87.20^{cd} \pm 5.54$	$10.20^{c} \pm 0.84$	$55.00^{a} \pm 2.24$
Psyllium husk	$92.40^{bc} \pm 3.65$	$110.80^{b} \pm 9.52$	$18.00^{b} \pm .1.22$	$53.00^{a} \pm 2.92$
Rice husk Ex.	$86.40^{cd} \pm 4.56$	$96.20^{c} \pm 8.70$	$11.20^{c} \pm .84$	$55.00^{a} \pm 2.55$
Rice husk	$94.60^{b} \pm 2.41$	$115.60^{b} \pm 3.05$	$19.60^{b} \pm 1.14$	$51.00^{b} \pm 3.32$

- Data were expressed as mean ±SD.
- Values that have different letters in each column differ significantly, while the difference among those with similar letters is not significant ($p<0.05$).

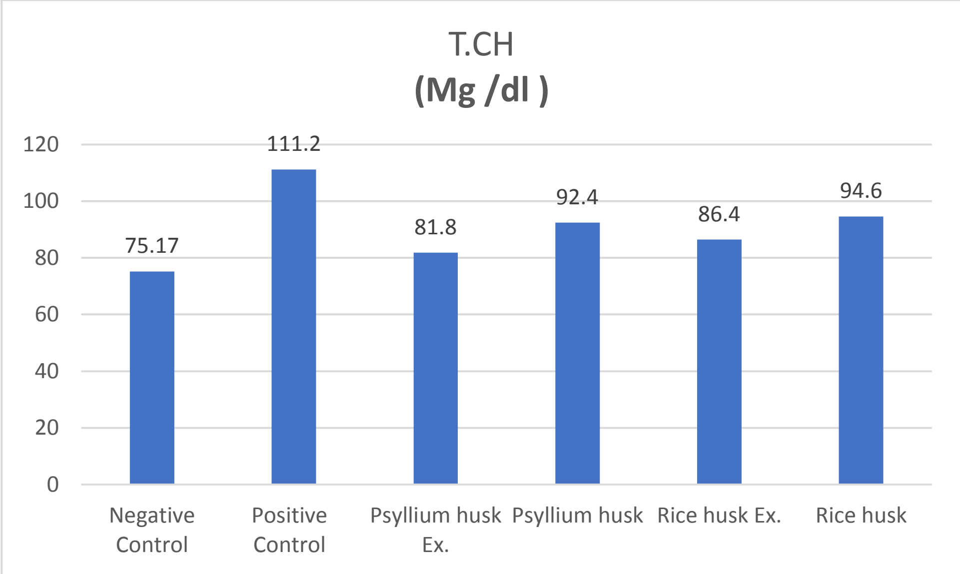

Fig.(10): Effect of rice and psyllium husksand their extracts on T.CH (mg/dl) of diabetic rats

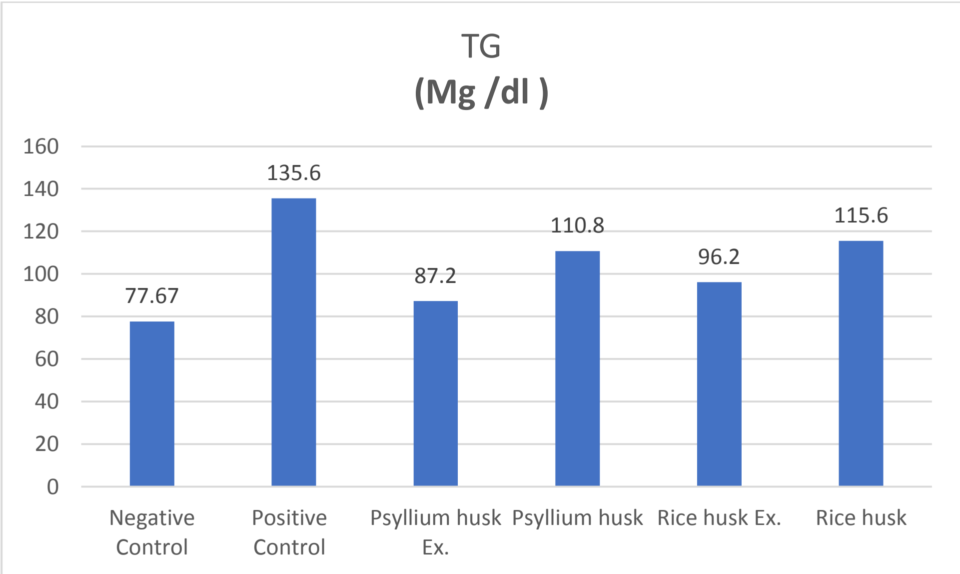

Fig.(11): Effect of rice and psyllium husks and their extracts on TG(mg/dl) of diabetic rats

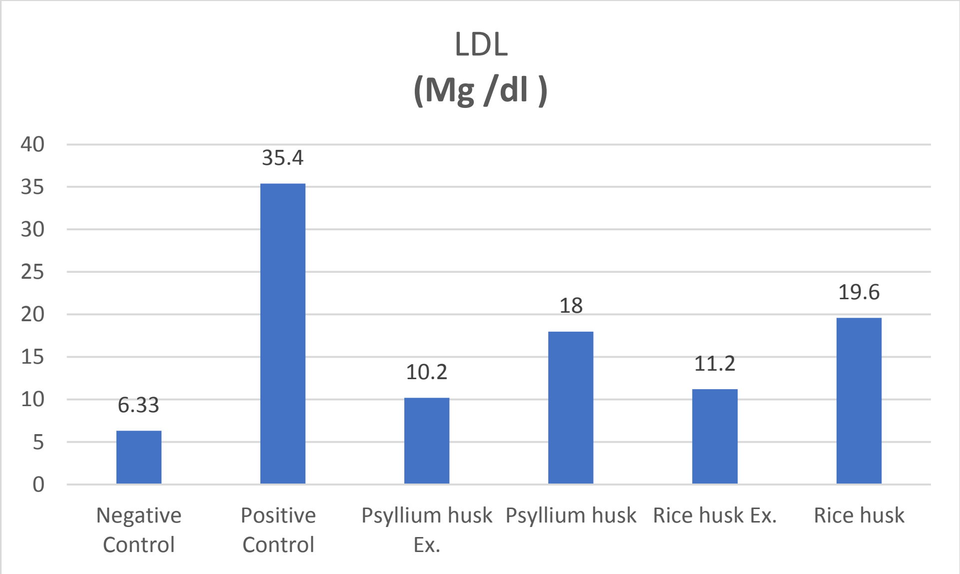

Fig.(12): Effect of rice and psyllium husks and their extracts on LDL (mg/dl) of diabetic rats

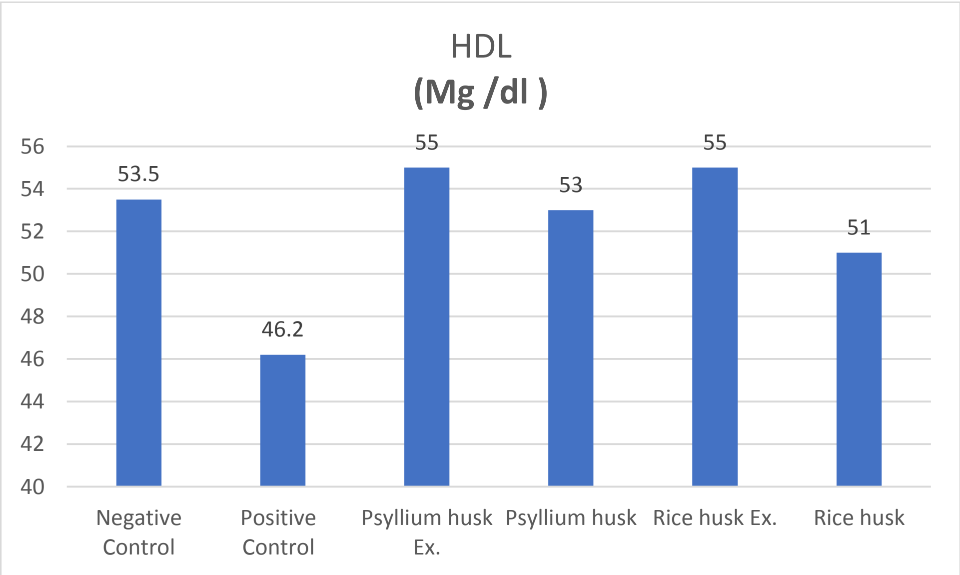

Fig.(13): Effect of rice and psyllium husks and their extracts on HDL(mg/dl) of diabetic rats

Kidney functions:

Effect of rice and psyllium husks , their extracts on Kidney functions of diabetic rats .

Results shown in table 8 and figs. 14 to 16 indicated that the levels of creatinine, urea and uric acid were increased significantly in the serum of the positive control group compared with the negative control group. The treated groups had a significant decrease as compared to the positive control group. The best result was recorded for the group treated with psyllium husk extract followed by the group treated with rice husk extract as shown in table (8). An imbalance of nitrogen coupled with reduced protein synthesis starts the generation of non-protein nitrogenous compounds, including creatinine and BUN, during diabetic nephropathy conditions **(Navale and Paranjape, 2018).** The increased level of uric acid, BUN, and creatinine in the serum of diabetic rats specifies progressive renal injury, an index of altered GFR in diabetic nephropathy **(Guo *et al.*, 2021).** Similar findings were obtained by **Rehman *et al.* (2023),** who found that the induction of type 2 diabetes mellitus with STZ directed a statistically significant ($p < 0.001$) increase in the kidney profile activity of serum blood urea and uric acid. whereas **El-Dreny *et al.* (2023)** demonstrated that adding psyllium and chia powder (5%) to the basal diet for obese rats, led to improved liver and kidney functions. As mentioned by **Hu *et al.* (2023)**, by targeting the gut–kidney axis, psyllium husk supplementation may ultimately lead to a paradigm shift in the treatment of chronic kidney disease (CKD) that includes a role for dietary fiber, such as psyllium seed husk (PSH). Regarding the effective role of rice husk extract, the current results were consistent with **Nnadiukwu *et al*. (2023a)**, who revealed that rice husk extract (RHE) contains vitamins and phytochemicals with antioxidant and anti-inflammatory properties against codeine-induced hepatorenal organ damage in rats.

Table (8): Effect of rice and psyllium husks and their extracts on Kidney functions of diabetic rats

Parameters / Groups	Creatinine (mg /dl)	Blood Urea (mg /dl)	Uric acid (mg /dl)
Negative Control	$0.57^{e} \pm 0.04$	$16.42^{e} \pm 1.25$	$1.60^{d} \pm 0.11$
Positive Control	$1.47^{a} \pm 0.13$	$67.54^{a} \pm 4.87$	$2.98^{a} \pm 0.18$
Psyllium husk Ex.	$0.73^{d} \pm 0.05$	$22.64^{d} \pm 2.17$	$1.81^{d} \pm 0.17$
Psyllium husk	$1.16^{b} \pm 0.09$	$43.64^{b} \pm 3.94$	$2.49^{b} \pm 0.17$
Rice husk Ex.	$0.84^{c} \pm 0.06$	$30.62^{c} \pm 1.69$	$2.22^{c} \pm 0.19$
Rice husk	$1.19^{b} \pm 0.09$	$47.36^{b} \pm 4.66$	$2.52^{b} \pm 0.23$

- Data were expressed as mean ±SD.
- Values that have different letters in each column differ significantly, while the difference among those with similar letters is not significant ($p<0.05$).

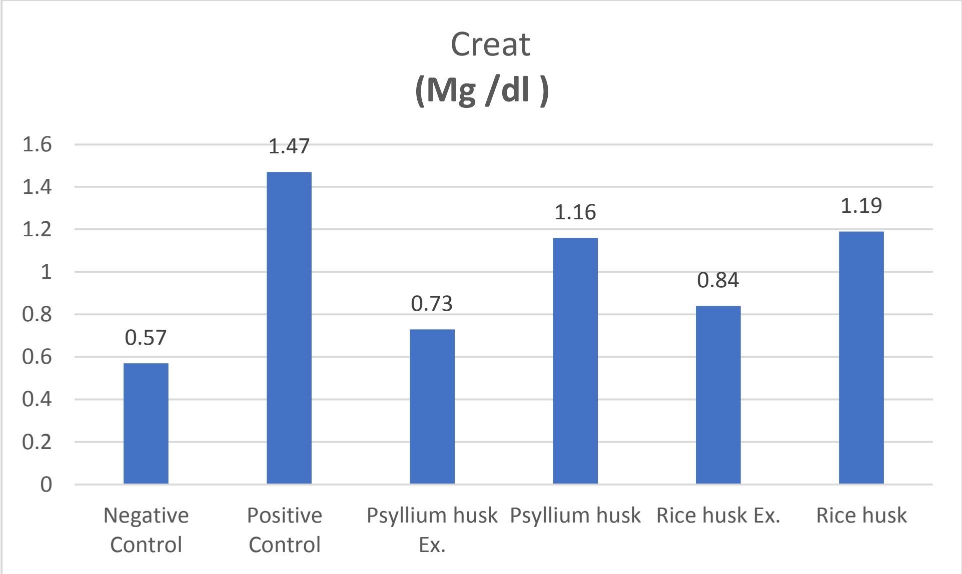

Fig.(14): Effect of rice and psyllium husks and their extracts on creatinine (mg/dl) of diabetic rats

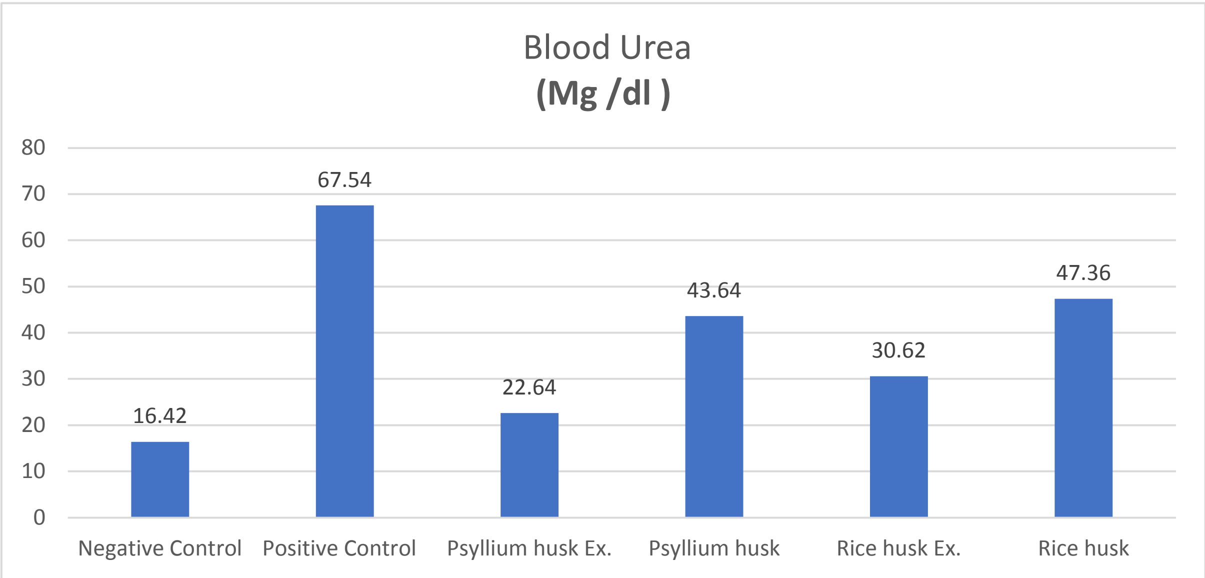

Fig.(15): Effect of rice and psyllium husks and their extracts on blood urea (mg/dl) of diabetic rats

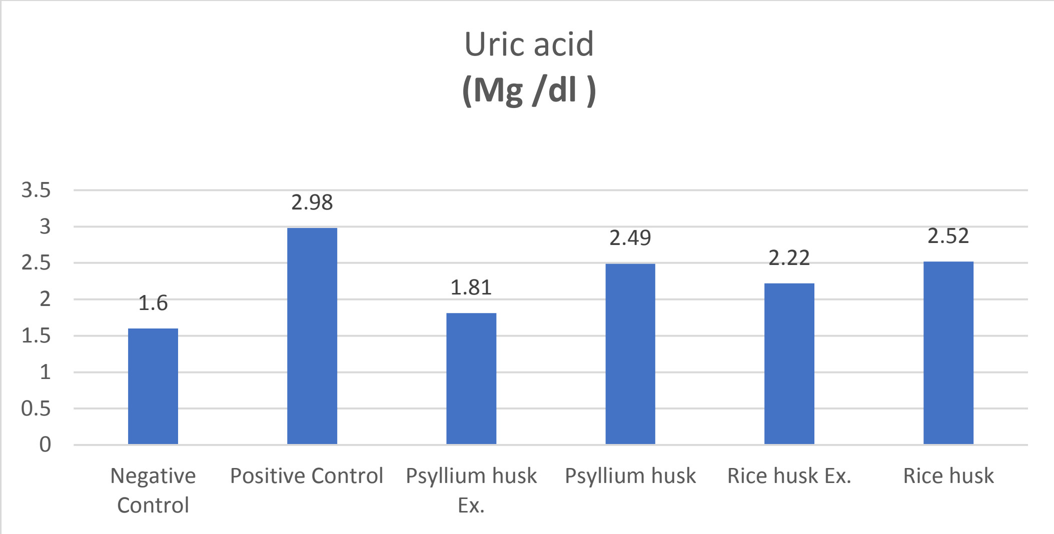

Fig.(16): Effect of rice and psyllium husks and their extracts on uric acid (mg/dl) of diabetic rats

Histological examination results:

The results of the histological examination are shown in the following figures :

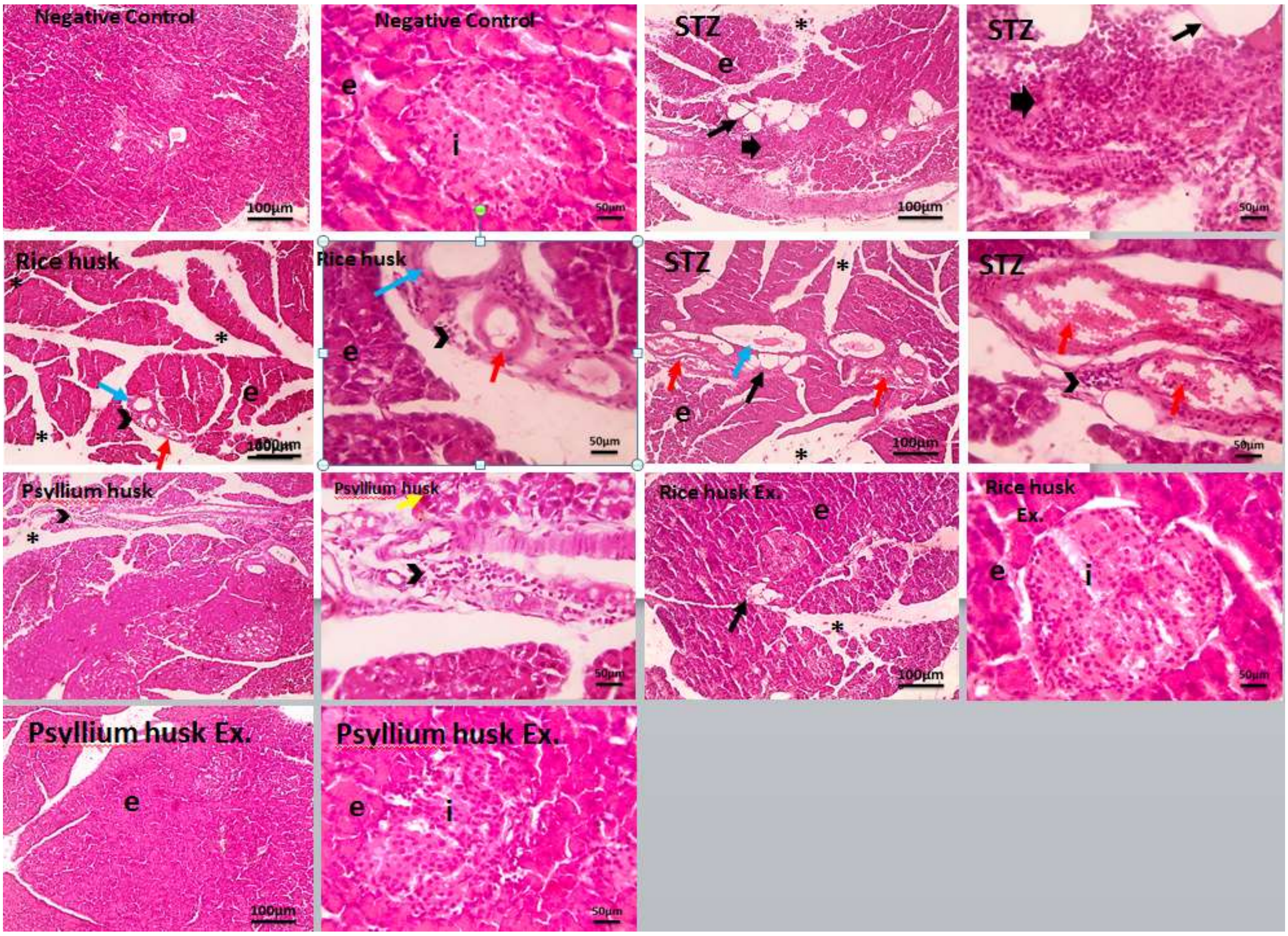

Fig.17: The microscopic H&E stained pancreatic tissue sections showing normal exocrine pancreas (e) and islet of Langerhans (i) in negative control group. Meanwhile, pancreatic tissue sections from STZ group showing shrinkage of exocrine pancreas (e) associated with interstitial edema (*), severe inflammation (thick black arrow), congested blood vessels (red arrow), dilated pancreatic ducts (thin blue arrow), deposition of fat cells (thin black arrow). Pancreatic tissue sections from rice husk group showing shrinkage of exocrine pancreas (e) associated with interstitial edema (*), few perivascular leukocytic cells infiltration (thick black arrow), mildly dilated blood vessels (red arrow), mildly dilated pancreatic ducts (thin blue arrow). Pancreatic tissue sections from psyllium husk group showing interstitial edema (*), few perivascular leukocytic cells infiltration (thick black arrow), mild vacuolar degeneration in acinar cells (yellow arrow) of exocrine pancreas (e). Pancreatic tissue sections from rice husk extract group showing interstitial edema (*), deposition of fat cells (thin black arrow) among acini of exocrine pancreas (e). Pancreatic tissue sections from psyllium husk extract group showing normal appearance of exocrine pancreas (e) and islet of Langerhans (i). Low magnification X: 100 bar 100 and high magnification X: 400 bar 50

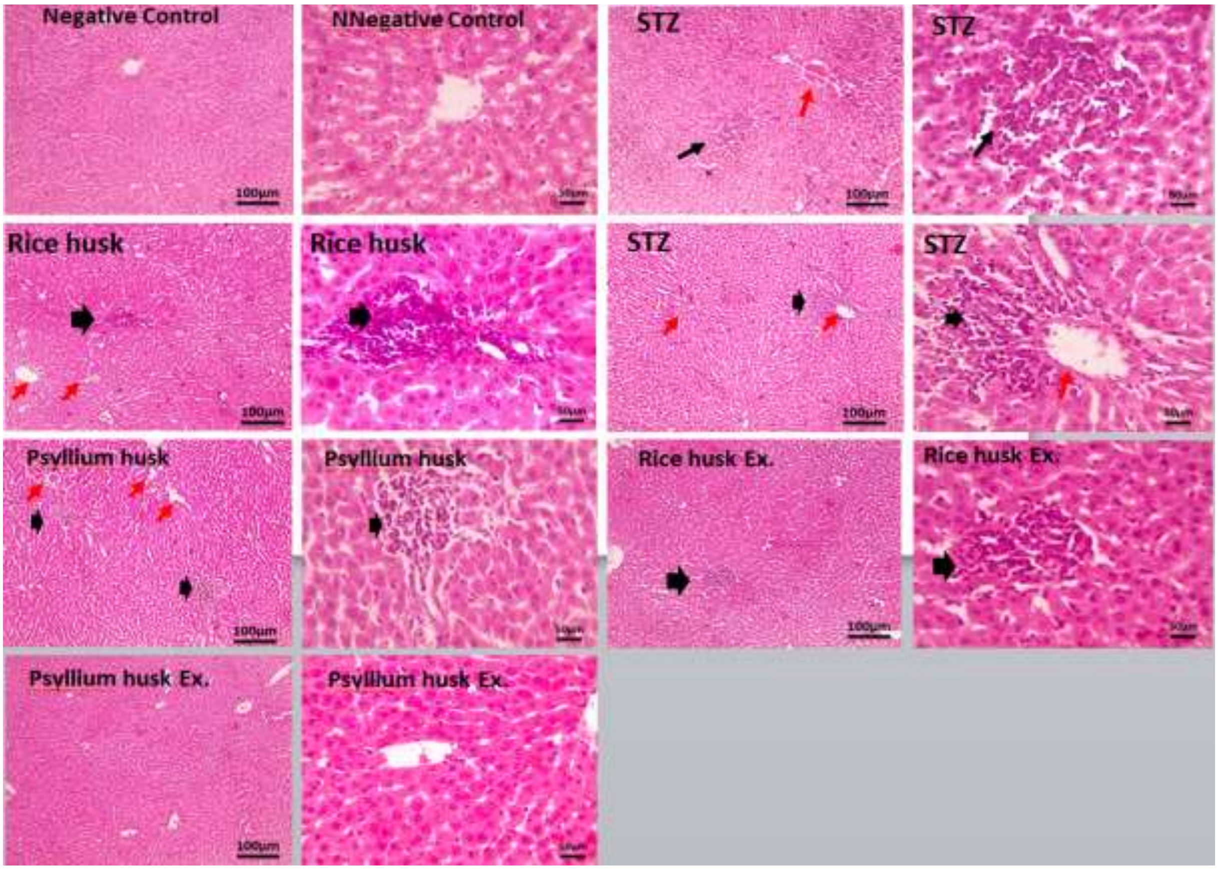

Fig.18: The microscopic H&E stained hepatic tissue sections showing normal hepatocytes in radially arranged cords around central veins with normal portal areas and sinusoids in negative control group. Meanwhile, hepatic tissue sections from STZ group showing congested portal blood vessels (red arrow), lobular (thin black arrow) and portal inflammation (thick black arrow). Hepatic tissue sections from psyllium husk group showing portal inflammation (thick black arrow) and dilated blood vessels (red arrow). Hepatic tissue sections from rice husk group showing milder portal inflammation (thick black arrow) than in Se group with dilated blood vessels (red arrow). Hepatic tissue sections from rice extract group showing milder portal inflammation (thick black arrow) than in psyllium and rice husk groups. Hepatic tissue sections from psyllium husk extract group showing normal appearance of hepatocytes, portal areas and sinusoids. Low magnification X: 100 bar 100 and high magnification X: 400 bar 50

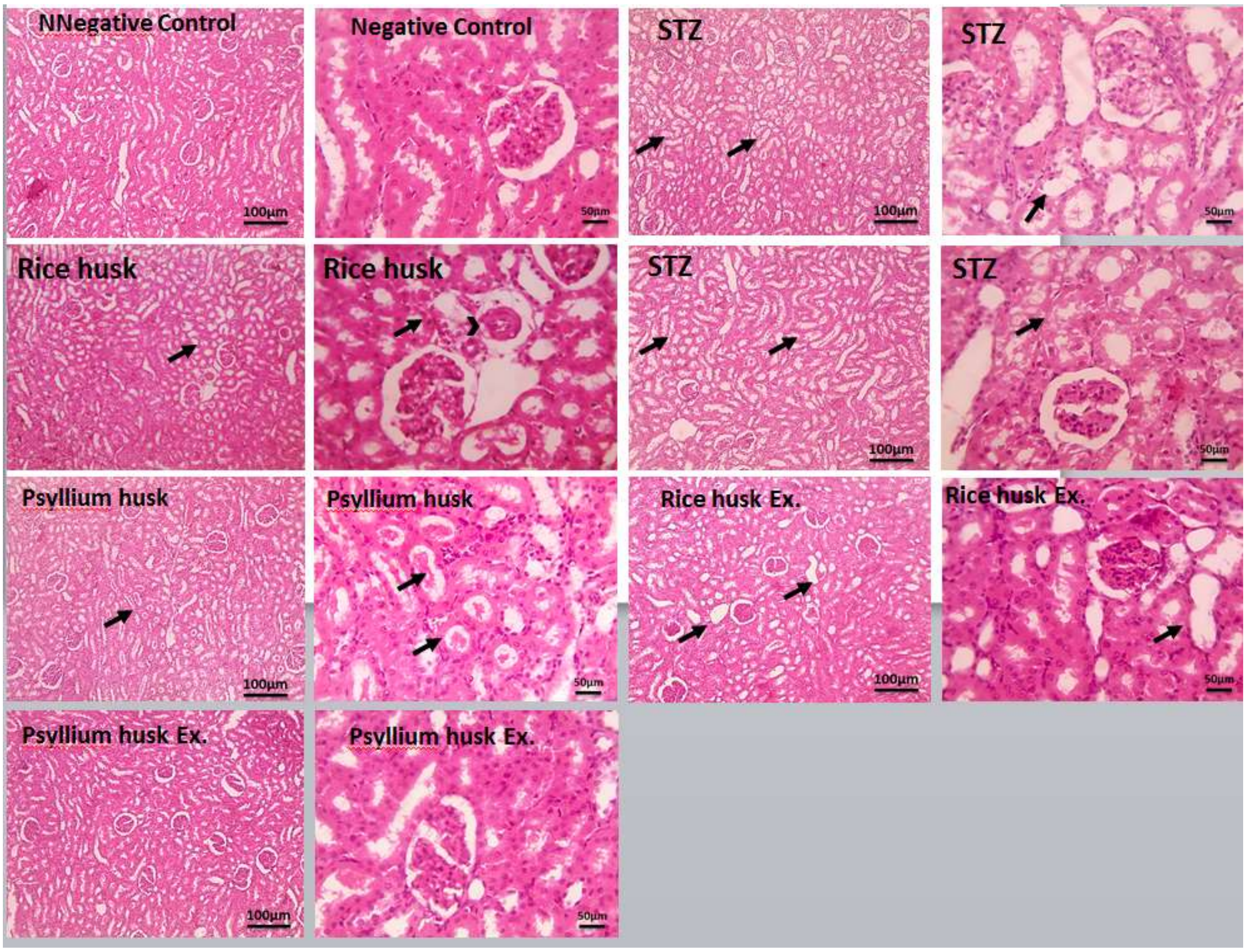

Fig.19: The microscopic H&E stained renal tissue sections showing normal tubules, glomeruli and interstitial tissue in negative control group. Meanwhile, renal tissue sections from STZ group showing markedly dilated tubules with hydropic degeneration in tubular epithelium (thin black arrows). Renal tissue sections from rice husk group showing reduced tubular dilation with very mild hydropic degeneration in tubular epithelium (thin black arrows) and mild perivascular edema (arrowhead). Renal tissue sections from Se group showing tubular dilation with cast formation (thin black arrows). Renal tissue sections from rice husk extract group showing few dilated tubules (thin black arrows). Renal tissue sections from psyllium husk extract group showing normal tubules, glomeruli and interstitial tissue. Low magnification X: 100 bar 100 and high magnification X: 400 bar 50

The abnormal changes noticed in the liver, kidneys, and pancreas of STZ groups were consistent with previous studies. Wherein STZ causes irreversible cell necrosis in a random and quick manner by means of a pancreatic selective cell toxicity. STZ has selective toxic effects on β-cells of pancreatic islets because of high affinity for β-cell membrane, low capacity of β-cells to scavenge free radicals, and low NAD+/DNA ratio in islets. Due to the accumulation of STZ in pancreatic β-cells by Glut2, other organs like the kidney and liver are also damaged by STZ **(Salazar-Vazquez *et al.*, 2006).** Our study is in agreement with **Hashem *et al* . (2021),** who found that the administration of psyllium husk ethanolic extract (PHEE) relieved the histopathological changes in the liver and pancreas caused by hyperlipidemia. In addition, **(Ali, 2017**) revealed that plantago psyllium seeds has a significant antioxidant activity and can be used to protect tissue from oxidative stress as indicated in microscopic examination of pancreatic tissue showed amelioration in the appearance of cells. Also, the histological examination of the study **(Nnadiukwu *et al.*, 2023a)** of the liver and kidney tissues revealed that rice husk methanol extract (RHE) showed a hepatorenal ameliorative potential in a dose-dependent manner.

4. Conclusion:

It could be concluded that using psyllium and rice husks and their extracts were effective in treating or relieving diabetes mellitus and its other side effects. This effect may be due to the high content of phenolics compunds and fibers in these husks. Thus calls for further investigation and isolation of bioactive compounds of their it.

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دراسة تأثير قشور الأرز والسيليوم ومستخلصاتهما على الفئران المصابة بداء السكري

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الملخص العربي

يمثل داء السكري مجموعة معقدة من الاضطرابات الأيضية التي تختلف في آلياتها المرضية، لكنها تتشارك في النهاية في السمة الأساسية المتمثلة في فرط سكر الدم. اجريت هذه الدراسة لتقييم تأثير قشور السيليوم والأرز ومستخلصاتهما على الفئران المصابة بداء السكري. تم تقسيم ستة وثلاثين من ذكور الفئران البالغة من سلالة ألبينو إلى مجموعتين رئيسيتين على النحو التالي: المجموعة (1): تم تغذيتها على النظام الغذائي الأساسي فقط وتم الاحتفاظ بها كمجموعة ضابطة سالبة. المجموعة (2): مجموعة السكري (ثلاثين فأرًا) بعد صيام طوال الليل تم حقنها بجرعة واحدة (60 مجم / كجم) من ستربتوزوتوسين مذابة في 10 مل من محلول سترات (درجة الحموضة 4.5). بعد ذلك تم تقسيم الفئران إلى خمس مجموعات متساوية (6 فئران لكل منها) على النحو التالي: المجموعة (1): تركت كمجموعة ضابطة موجبة وتغذت على النظام الغذائي الأساسي فقط. المجموعة (2): تلقت مستخلص قشور السيليوم بجرعات 100 مجم / كجم من وزن الجسم. المجموعة (3): تغذت على النظام الغذائي الأساسي مضاف إليه 5% من السيليوم (50 جم / كجم من النظام الغذائي). المجموعة (4): تلقت مستخلص قشور الأرز بجرعات 100 ملجم / كجم من وزن الجسم. المجموعة (5): تغذت على النظام الغذائي الأساسي مضاف إليه 5% من قشور الأرز (50 جم/كجم من وزن الجسم). أُعطيت الجرعات لمدة 28 يومًا متتالية. . في نهاية التجربة تم حساب المأخوذ الغذائي (FI) والنسبة المئوية للزيادة المكتسبة في وزن الجسم (BWG) ومعدل كفاءة الغذاء (FER) وتم تقدير مستوى الجلوكوز في المصل والكوليسترول الكلي والدهون الثلاثية والبروتين الدهني عالي الكثافة والبروتين الدهني منخفض الكثافة، بالإضافة لإنزيمات الكبد (AST, ALT, ALP) واليوريا وحمض اليوريك والكرياتينين. كما تم إجراء الفحص النسيجي للبنكرياس والكلى والكبد. وأظهرت النتائج أن هذه العلاجات حسّنت مستويات السكر في الدم ودهون الدم ووظائف الكلى والكبد. لذلك قد يكون تناول قشور السيليوم والأرز ومستخلصاتهما مفيدًا لتحسين سكر الدم.

الكلمات المفتاحية: ستربتوزوتوسين، قشور السيليوم - قشور الأرز- جلوكوز الدم- وظائف الكبد- وظائف الكبد- دهون الدم