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Research Article

A STUDY ON THE EFFECT OF MILLET AND PULSE BASED PASTA ON BLOOD GLUCOSE AND LIPID PROFILE IN ALLOXAN-INDUCED DIABETIC RATS

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ABSTRACT

The study of pasta having antidiabetic and hypolipidemic properties gives a new approach in the treatment of diabetes mellitus. The study was carried out to evaluate the antidiabetic and hypolipidemic effect of millet and pulse incorporated pasta (noodles) in alloxan-induced diabetic albino rats. The rats were divided into 7 groups of 6 animals each. Group I served as non-diabetic control, Group II as diabetic control and Groups III as treatment control group, while Groups IV, V, VI and VII served as treatment groups. Diabetes was induced in Group II rats by administration of alloxan monohydrate (150 mg/kg) through the intraperitoneal route, whereas all the treatment groups (including Group III) received millet and pulse incorporated pasta (100 mg/kg body weight). After 28 days of treatment body weight, blood glucose, haemoglobin, glycosylated haemoglobin, plasma insulin and lipid profile were determined. All the values are expressed as Mean ± SEM. The data were analyzed using analysis of variance (ANOVA) and the group means were compared by Newman-Keuls multiple range test (NKMRT). Values were considered statistically significant at $p<0.01$. The alloxan-induced diabetic rats given millet and pulse incorporated pasta at the dose of 100 mg/kg body weight showed highly significant reduction in blood glucose and serum lipid profile levels. It is concluded that millet and pulse incorporated noodles is effective in controlling blood glucose levels and improving lipid profile in diabetic rats.

INTRODUCTION

Diabetes mellitus is a silent disease and is now recognized as one of the fastest growing threats to public health in almost all countries of the world. Global incidence of diabetes is increasing in an exponential manner. It is estimated that the total number of people with diabetes in India would rise from around 50.8 million in 2010 to 87.0 million by 2030. With more than 41 million diabetics, India leads the world and thereby known as the "Diabetes Capital of the World" (IDF, 2011). Economic affluence coupled with sedentary lifestyles and changing food patterns are contributing to several chronic degenerative diseases such as diabetes mellitus, cardiovascular diseases and cancer. Diabetes is a multifactorial disease characterized by hyperglycemia, lipoprotein abnormalities, raised basal metabolic rate, defect in reactive oxygen species scavenging enzymes and high oxidative stress induced damage to pancreatic beta cells. Diet is a cornerstone for the management of diabetes mellitus. Therapeutic diets can alter the deleterious metabolic dearangement of diabetic state. Dietary management of diabetes mellitus involves the reduction of postprandial hyperglycemia and results in good glycemic control (Mani *et al*,. 1993). Therefore, there is a need to develop novel therapeutic foods containing complex carbohydrates with higher levels of dietary fibre and phytochemicals like antioxidants, polyphenols and phytates.

Millets have been reported to be a rich source of dietary fibre which is present in soluble and insoluble form, and is proved to play an important role not only in the management of metabolic disorders like diabetes mellitus and hyperlipidemia, but also improves bowel motility thereby reducing the incidence of colon

cancer (Hathan and Prasanna, 2011). The hypoglycemic effect of minor millets with their high crude fibre, dietary fibre, antioxidant, low carbohydrate content, low digestibility and presence of β-glucans which are water soluble gums is helpful in repairing glucose metabolism (Itagi *et al.,* 2012). These grains release sugar slowly in the blood and also diminish glucose absorption. The higher levels of complex carbohydrates, dietary fibre and resistant starch of minor millets have been attributed to the hypolipidemic and hypoglycemic effects (Pathak and Srivastava, 1998).

Pasta products are high in starch but low in protein, dietary fibre, vitamins, minerals and phenolic compounds; they are mainly made up of hard wheat flour which is deficient in lysine, an essential amino acid. With an increasing concern by the health conscious population, more nutritious pasta products rich in proteins, minerals, phenolic compounds and dietary fibre with low glycemic index were required. Hence, functional flour blends composed of whole wheat flour, modified millet flour, pulse flour and egg albumen were used to develop low glycemic functional pasta which are rich in proteins with high biological value, vitamins, minerals, dietary fibre and phytochemical compounds.

MATERIALS AND METHODS

Kodo millet or varagu (CO 3) (*Paspalum scrobiculatum),* little millet or samai (CO 6) (*Panicum sumatrens)* and pearl millet or cumbu (COC 9) (*Pennisetum typhoideum*) were obtained from the Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. Whole wheat (*Triticum aestivum*), horse gram and soybean were purchased from the local departmental store.

Preparation of sample

Optimization technology for the development of modified flour from millets

To optimize the technology for development of modified flour to be utilized as the functional food ingredient, the physical modification method was followed.

Physical modification (Autoclaving-Cooling Cycle)

The physical modification (autoclaving-cooling cycle method) technique was used and followed as per the standard Berry (1986) procedure for the preparation of modified starch (from kodo millet, little millet and pearl millet) with slight modification. The kodo millet, little millet and pearl millet grains were cleaned, washed separately and soaked for 2 hours, ground and then it was pressure-cooked at 121˚C (15 lb / in^2) for 1 hour in an autoclave. The gelatinized starch mixture was cooled to room temperature and it was frozen at 4°C for 24 hours. This entire process constitutes 1 cycle. Then, 3 additional cycles were carried out, followed by cabinet-drying for about 4-6 hours at 40°C according to the respective starches and ground into fine particles.

Preparation of horse gram flour

Horse gram was roasted at 120°C for 10 minutes till it changed to light brown color and developed roasted flavor. The roasted horse gram was ground into flour.

Preparation of soybean flour

Soybean was cleaned well, sprinkled with one per cent moisture and kept for one hour. It was roasted in a preheated hot sand bath (120°C) for 10 minutes and sieved using a metal sieve. The soybean was milled in a mini dhal mill and the hull was winnowed and ground into flour.

Optimization of millet and pulse based pasta products

The various treatments of whole wheat flour with combinations of modified millet flour and pulse flour was carried out in various proportions to formulate low glycemic pasta products. The process for development of pasta products with cereal, millet and pulse is given in Table 1. Hundred grams of functional flour blend was added with hot water (70ºC) and mixed well. Then, it was steamed in an idly steamer for 15 minutes. The steamed functional flour blend was fed in the barrel of extruder. Then, the blend was moistened with hot water (70ºC) and they were mixed thoroughly in the extruder by the shaft. The mass was allowed to knead for 15 minutes to ensure thorough distribution of moisture. The appropriate die was fixed and then extruded. After extrusion, the extruded products were steamed for 20 minutes using idly steamer. The steamed extruded products were then cooled and dried in a cabinet drier for 4 hours at 60°C.

Table 1: Proportions to formulate pasta products

Treatments	Whole wheat flour (g)	Kodo millet flour (g)	Little millet flour (g)	Pearl millet flour (g)	Horse gram flour (g)	Soy bean flour (g)	Egg white (g)	Guar gum (g)	Water (ml)	Salt (g)
T_1 (Control)	90	-	-	-	-	-	10	2	50	2
T_2	50	15	-	15	10	-	10	2	75	2
T_3	50	15	-	15	-	10	10	2	75	2
T_4	50	-	15	15	10	-	10	2	75	2
T_5	50	-	15	15	-	10	10	2	75	2

PHARMACOLOGICAL STUDY

Animal collection

Wistar albino rats each weighing 180-220g were obtained from Thiruvananthapuram Medical College, Thiruvananthapuram, India and the study was conducted at K.M. College of Pharmacy, Madurai, Tamil Nadu, India. The experiments were approved by the Institutional Animal Ethics Committee (AU/KMCP/IAEC/140/2014-15). The animals were housed in large spacious cages and they were fed with commercial pellets and access to water *ad libitum*. The animals were well acclimatized to the standard environmental condition of temperature (22 ± 5°C) and humidity (55 ± 5%), and 12-hr light dark cycles throughout the experimental period.

Induction of diabetes

Diabetes mellitus was induced in Wistar albino rats by single intraperitoneal injection of freshly prepared alloxan monohydrate solution (150 mg/kg of body weight) in physiological saline after overnight fasting for 12 hrs.

Alloxan is commonly used to induce diabetes mellitus in experimental animals due to its ability to destroy the β-cells of pancreas possibly by generating the excess reactive oxygen species such as H_2O_2, O_2 and HO^-. The development of hyperglycemias in rats is confirmed by plasma glucose estimation 72 hrs post alloxan injection. The rats with fasting plasma glucose level of 160-220mg/dl were used for this experiment.

Animal grouping and treatment

A total of 42 rats (36 diabetic surviving rats and six normal rats) were used for the study. The rats were divided into 7 groups of 6 each. Diabetes was induced in rats of 6 groups by injecting 150 mg/kg of alloxan monohydrate intraperitoneally 3 days before starting the experiment. The details of group division are as follows.

Treatment

Group – I

(Normal control) consisted of normal rats given 10 ml/kg of normal saline with normal diet.

Group – II

(Diabetic control) rats received 150mg/kg of Alloxan monohydrate through I.P. injection.

Group - III

(Treatment control group) Diabetic rats received whole wheat flour + egg white + guar gum incorporated noodles **(T_1)** at a dose of (100 mg/kg orally) for 28 days.

Group – IV

(Treatment group) Diabetic rats received whole wheat flour + kodo millet flour + pearl millet flour + horse gram flour + egg white + guar gum incorporated noodles **(T_2)** at a dose of (100 mg/kg orally) for 28 days.

Group – V

(Treatment group) Diabetic rats received whole wheat flour + kodo millet flour + pearl millet flour + soybean flour + egg white + guar gum incorporated noodles **(T_3)** at a dose of (100 mg/kg orally) for 28 days.

Group – VI

(Treatment group) Diabetic rats received whole wheat flour + little millet flour + pearl millet flour + horse gram flour + egg white + guar gum incorporated noodles **(T_4)** at a dose of (100 mg/kg orally) for 28 days.

Group – VII

(Treatment group) Diabetic rats received whole wheat flour + kodo millet flour + pearl millet flour + soybean flour + egg white + guar gum incorporated noodles **(T_5)** at a dose of (100 mg/kg orally) for 28 days.

Sample collection

After 28 days of treatment, body weight was measured and blood was collected from the eyes (venous pool) by sino-ocular puncture in EDTA (Ethylene Di-amine Tetra Acetic Acid) coated plasma tubes for the estimation of the following parameters. Blood glucose, haemoglobin, glycosylated haemoglobin, plasma insulin, total cholesterol, triglycerides, HDL-cholesterol and phospholipids were determined.

Nutrient analysis

The resistant starch content of pasta products was assessed using the method described by McCleary and Monaghan (2002). The soluble, insoluble and dietary fibres were quantified by Hellendoorn technique (James and Theander,

1981). Total phenols and phytate contents were determined by the spectrophotometric method of Sadasivam and Manickam (2008). The antioxidant activity of the sample was tested on the basis of its radical scavenging effect on the DPPH free radical, the method used by Goupy *et al*. (1999).

Biochemical analysis

The serum was separated and analyzed for blood glucose (Trinder, 1969), plasma insulin (Anderson *et al.,* 1993), total haemoglobin (Drabkin and Austin, 1932), glycosylated haemoglobin (Sudhakar and Pattabiraman, 1981), total cholesterol (Parkeh and Jung, 1970), HDL & LDL cholesterol (Gidez and Webb, 1950), phospholipids (Zilversmith and Davis, 1950) and triglycerides (Rice *et al.,* 1970).

Statistical analysis

The experiments were conducted in triplicates and the data were expressed as Mean ± Standard Deviation (S.D). For animal experiments, all the values were expressed as Mean ± SEM. The data was analyzed using analysis of variance (ANOVA) and the group means were compared by Newman-Keuls multiple range test (NKMRT). Values were considered statistically significant at $p<0.01$.

RESULTS AND DISCUSSION

Resistant starch and dietary fibre

The results of resistant starch and dietary fibre components of pasta products are presented in Table 2. Resistant starch and dietary fibre content was found to be high in experimental pasta when compared to control pasta due to the incorporation of modified millet flour and pulse flour. Among the treatments, resistant starch content was higher in T_4 (22.43 ± 0.47) treatment followed by other treatments and the values ranged from 21.12 ± 0.71 to 21.87 ± 0.67 per cent respectively. Timea (2009) studied the resistant starch content of maize, wheat, rice and tapioca incorporated with extruded samples and indicated that it contained 11.31±1.71 to 15.51±0.41 per cent. The soluble, insoluble and total dietary fibre content was found to be high in experimental pasta than control pasta. The soluble fibre content ranged from 2.47 ± 0.05 to 3.42 ± 0.12 g, insoluble fibre content ranged from 6.12 ± 0.20 to 9.91 ± 0.23 g and the values of total dietary fibre ranged from 8.59 ± 0.15 to 13.33 ± 0.50 g/100g respectively. Modification of millets by repeated autoclaving and cooling cycles showed an improvement in the dietary fibre content and this reflects in the higher soluble, insoluble and total dietary fibre content in the modified millet flour incorporated pasta products. Singh *et al.* (2004) stated that the soluble, insoluble and total dietary fibre content of foxtail millet based extruded products as 4.4, 3.8 and 8.2 g/100g respectively. The soluble form of dietary fibre is proved to be of clinical significance. It elicits lower glycemic index and lipidemic responses and hence, has a role in the management of such associated metabolic disorders. It is also proved that the insoluble form of dietary fibre adds to beneficial health effects by providing fecal bulk matter, reducing intestinal transit time, preventing constipation and in turn providing protection against colorectal cancer.

Phytochemical components

The results of phytochemical components of pasta products are given in Table 3. The total polyphenols, antioxidant content and phytate content were observed to be high in experimental pasta than control pasta due to the incorporation of modified millet flour and pulse flour. The total polyphenol and antioxidant content was high in T_5 (154.26 ± 6.55 and 22.32 ± 0.40 mg/100g) treatment followed by other treatments and the values ranged from 95.00 ± 2.83 to 142.96 ± 3.61 mg GAE/100g and 7.73 ± 0.09 to 21.74 ± 0.24 mg AAEAA/100g respectively. Dietary polyphenols and phytates are known for their ability to reduce carbohydrate digestibility and thereby regulate postprandial glycaemic response. Moreover, polyphenols are known to inhibit glucose absorption and prevent advanced glycation end product (AGE) formation (Scalbert *et al.,* 2005). Phenolics are known to impart antioxidant properties and serve as radical scavengers thereby imparting several health benefits like reducing the risk of cancer, diabetes, cardiovascular diseases etc. (Cevalos and Cisneros, 2010). Whole grain containing high amount of polyphenols and other antioxidant compounds have been associated with a decreased risk of number of chronic disease such as coronary heart disease and diabetes (Ryan *et al.,* 2011). Jorge *et al*. (2012) stated that polyphenols and antioxidant activity of amaranth flour incorporated extruded products as 69.50 mg GAE /100g and 44.10 mg Trolox equivalent (TE)/100 g sample. Dipika *et al.* (2013) found that phenolics content of the multigrain mixes made from cereals, millets and sprouted pulses ranged from 103.5 to 115.0 which increased on sprouting to 121.7-139.7 mg GAE/100g. The phytate content of modified millet and pulse flour incorporated noodles were recorded to be higher and it ranged from 13.42 ± 0.23 to 17.67 ± 0.77 mg/100g and that

of the control samples were 12.71 ± 0.35 mg/100g respectively.

Effects of functional pasta products on biological parameters

Results of the impact of the consumption of millet and pulse based pasta products by rats, for 28 days, on some biological parameters (body weight, blood glucose, haemoglobin, glycosylated haemoglobin, plasma insulin) and lipid profile (total cholesterol, plasma triglycerides, phospholipids, LDL and HDL Cholesterol) are presented in Table 4 to 6.

Body weight and blood glucose level changes

The results of body weight and blood glucose levels are given in Table 4. The relative body weight in experimental group was significantly higher ($P<0.01$) than that of the normal control (G1) and diabetic control (G2) groups due to the maintenance of optimum protein level. The ability of millet and pulse based pasta products at a dose of 100 mg/kg to prevent massive body weight loss seem to be due to its ability to reduce hyperglycemia. A significant weight loss was observed in the diabetic control (G2) ($P<0.01$). Fasting blood glucose level was significantly increased to 220.25 ± 9.19 mg/100ml in diabetic rats as compared to normal rats (82.60 ± 3.50). However, the level of fasting blood glucose, returned to near normal range (108.25 ± 3.70 to 121.45 ± 3.55 mg/100ml) in the experimental groups (G3-G7). Since the millet and pulse based pasta products contained high amounts of dietary fibre and resistant starch, these pasta products release sugar slowly in the blood and also diminish the glucose absorption. The slow digestion of resistant starch (RS) has implications in controlled glucose release applications (Brown, 2004 and Nugent, 2005). The metabolism of resistant starch occurs 5-7 hrs after consumption, in contrast to normally cooked starch, which is digested almost immediately. Digestion over a 5-7 hr period reduces postprandial glycaemia and insulinemia, and has the potential for increasing the period of satiety (Raben *et al.,* 1994). The effect of insoluble dietary fibre in the inhibition of glucose diffusion in the small intestine is suggested to be due to the absorption or inclusion of the smaller sugar molecules within the structure of the fibre particles (Lopez *et al*., 1996). It has been shown through *in vitro* studies and in humans that the fibres in the digestive system act as the main factor slowing the absorption of glucose, moderating the rise in blood glucose (Leclere *et al.,* **1994 and** Ou *et al.,* **2001)**[32, 33]; they are much more effective at lowering blood glucose when hydrated. (Wood **2002)**[34].

Changes in plasma insulin, haemoglobin and glycosylated haemoglobin level

The effect of plasma insulin, haemoglobin and glycosylated haemoglobin levels of normal and diabetic rats are presented in Table 5. The levels of total haemoglobin and plasma insulin levels were found to be significantly lower in diabetic control (G2) rats as compared to normal control (G1) rats whereas, glycosylated haemoglobin levels were found to be higher. However, the level of total haemoglobin, glycosylated haemoglobin and plasma insulin were found to be within normal range in the experimental groups (G3-G7). Alloxan brings about massive reduction in insulin release by the destruction of β-cells of the islets of Langerhans. The results indicate significant increase in the plasma insulin level in the experimental groups. This could be due to potentiation of the insulin effect of plasma by increasing the pancreatic secretion of insulin from existing β-cells of islets of Langerhans or its release from the bound form. During diabetes the excess glucose present in blood reacts with haemoglobin. Therefore, the total haemoglobin level is decreased in alloxan-induced diabetic rats (Sheela and Augusti, 1992). Administration of millet and pulse based pasta products for 28 days prevents a significant elevation in glycosylated haemoglobin thereby increasing the level of total haemoglobin in the experimental groups (G3-G7). This could be due to the result of improved glycaemic control produced by millet and pulse based pasta (noodles) products at a dose of 100 mg/kg of body weight.

Histopathological study of the pancreas

The histopathological studies of the pancreatic tissues of the rats (Figure 1) showed that the number and volume of islets cells were normal in the normal control group (G1) and severely swelled and decreased in the diabetic control group (G2), whereas, in the experimental groups (G3-G7) the number and volume of islets cells were found to be moderately swelled and decreased.

Changes in the Lipid profile

The results of lipid profile of normal and diabetic rats are shown in Table 6. The experimental groups showed significant reduction in the cholesterol level at the end of 28 days. The levels of total cholesterol, triglycerides, high density lipoprotein (HDL), low density lipoprotein (LDL) and phospholipids were found to be significantly

high, whereas HDL-C level was low in the diabetic control rats (G2) as compared to normal control rats and experimental rats. Rats fed with millet and pulse based pasta products (noodles) at a dose of 100 mg/kg body weight for 28 days showed decreased total cholesterol, triglycerides, low density lipoprotein (LDL) and phospholipid levels and increased HDL-C levels as compared to normal (G1) and alloxan-induced diabetic rats (G2). This effect could be related to the intake of soluble fibre, confirmed by several epidemiological studies, showing that independent of the fat intake, the soluble fibres are dietary components, that are important in preventing cardiovascular disease (Rimm *et al.,* 1996).

CONCLUSION

From the various findings of this study, it may be concluded that the alloxan-induced diabetes mellitus caused an increase in blood glucose, serum cholesterol and triglycerides. The levels of cholesterol, triglycerides and low density lipoprotein (LDL) were found to be almost normal in rats fed with millet and pulse based pasta products at the dose of 100 mg/kg body weight in alloxan-induced diabetic rats.

The results of this animal experiment prove that millet and pulse based functional pasta products have hypoglycemic and hypolipidemic effects, and hence its dietary consumption would be a significant way to increase the fibre intake and reduce the glycemic index. It is also concluded that the development of enriched pasta (noodles) with a higher dietary fibre content from kodo millet / little millet / pearl millet, horse gram and soybean and improved resistant starch content would result in a product for specific nutritional purposes.

Table 2: Resistant starch and dietary fibre content of pasta products (Per 100g)

Nutrients	T_1	T_2	T_3	T_4	T_5
Resistant starch	21.12 ± 0.71	21.87 ± 0.67	21.21 ± 0.90	22.43 ± 0.47	21.77 ± 0.68
Soluble dietary fibre	2.47 ± 0.05	3.31 ± 0.13	3.34 ± 0.14	3.38 ± 0.10	3.42 ± 0.12
Insoluble dietary fibre	6.12 ± 0.20	8.55 ± 0.17	8.46 ± 0.23	8.64 ± 0.12	9.91 ± 0.23
Total dietary fibre	8.59 ± 0.15	11.86 ± 0.34	11.80 ± 0.52	12.02 ± 0.51	13.33 ± 0.50

All data are the Mean ± S.D of three replicates

Table 3: Phytochemical components of pasta products

Nutrients	T_1	T_2	T_3	T_4	T_5
Total polyphenols (mg GAE/100g)	95.00 ± 2.83	142.96 ± 3.61	138.69 ± 4.50	137.80 ± 4.14	154.26 ± 6.55
Antioxidant activity (mg AAEAA/100g)	7.73 ± 0.09	21.46 ± 0.77	21.74 ± 0.24	20.50 ± 0.70	22.32 ± 0.40
Phytates (mg/100g)	12.71 ± 0.35	15.04 ± 0.34	17.67 ± 0.77	13.42 ± 0.23	16.06 ± 0.43

All data are the Mean ± S.D of three replicates

Table 4: Effect of millet and pulse based functional pasta products on body weight and blood glucose levels of normal and diabetic rats

Groups	Body weight (g)		Blood glucose (mg / 100ml)	
	Initial	Final	Initial	Final
G1	210 ± 8.2	222 ± 8.6	78.45 ± 3.25	82.60 ± 3.50
G2	200 ± 7.5	155 ± 5.0**(a)	80.62 ± 3.64	220.25 ± 9.19**(a)
G3	210 ± 8.2	220 ± 8.8	82.90 ± 3.75	110.05 ± 3.15**(b)
G4	195 ± 7.4	225 ± 9.0	80.30 ± 2.80	115.40 ± 2.72**(b)
G5	215 ± 8.0	225 ± 8.15	84.20 ± 3.93	121.45 ± 3.55**(b)
G6	220 ± 8.5	235 ± 9.8	86.15 ± 4.05	108.25 ± 3.70**(b)
G7	220 ± 7.9	230 ± 8.6	83.60 ± 3.75	110.40 ± 3.20**(b)

G1 - Normal Control; **G2** - Diabetic Control; **G3** - Treatment control group (**T_1**);
G4 - Treatment group (**T_2**); **G5** - Treatment group (**T_3**); **G6** - Treatment group (**T_4**);
G7 - Treatment group (**T_5**)
** (a) Significantly different from normal control G1 at P<0.001
** (b) Significantly different from Diabetic control G2 at P<0.01

Table 5: Effect of millet and pulse based functional pasta products on plasma insulin, haemoglobin and glycosylated haemoglobin in normal and diabetic rats

Groups	Haemoglobin (gm/100ml)	Glycosylated haemoglobin HbA_1 (%)	Plasma Insulin (µU/ml)
G1	12.20 ± 1.20	0.27 ± 0.06	25.30 ± 0.75
G2	6.15 ± 0.70**(a)	0.92 ± 0.10**(a)	11.90 ± 0.20**(a)
G3	11.95 ± 1.20**(b)	0.34 ± 0.08**(b)	21.50 ± 0.45**(b)
G4	11.65 ± 1.04**(b)	0.32 ± 0.06**(b)	20.30 ± 0.46**(b)
G5	11.90 ± 1.14**(b)	0.30 ± 0.05**(b)	22.50 ± 0.50**(b)
G6	11.95 ± 1.08**(b)	0.34 ± 0.06**(b)	22.75 ± 0.70**(b)
G7	11.80 ± 1.06**(b)	0.35 ± 0.09**(b)	21.78 ± 0.45**(b)

G1 - Normal Control; G2 - Diabetic Control; G3 - Treatment control group (T_1);
G4 - Treatment group (T_2); G5 - Treatment group (T_3); G6 - Treatment group (T_4);
G7 - Treatment group (T_5)
** (a) Significantly different from normal control G1 at P<0.001
** (b) Significantly different from Diabetic control G2 at P<0.01

Table 6: Effect of millet and pulse based functional pasta products on lipid profile of normal and diabetic rats

Groups	Total Cholesterol (mg/dl)	Triglyceride (mg/dl)	HDL-C (mg/dl)	Phospholipids (mg/dl)	LDL (mg/dl)
G1	76.80 ± 2.45	82.30 ± 2.30	58.60 ± 1.75	120.55 ± 2.30	14.35 ± 1.30
G2	240.90 ± 6.35**(a)	165.85 ± 4.74**(a)	35.40 ± 1.30**(a)	220.60 ± 6.15**(a)	35.85 ± 2.35**(a)
G3	86.80 ± 2.45**(b)	85.72 ± 2.35**(b)	53.90 ± 1.50**(b)	124.40 ± 2.90**(b)	17.20 ± 1.85**(b)
G4	83.75 ± 2.50**(b)	84.30 ± 2.50**(b)	53.60 ± 1.45**(b)	128.94 ± 2.68**(b)	18.45 ± 1.90**(b)
G5	84.70 ± 2.42**(b)	87.30 ± 2.80**(b)	51.65 ± 1.30**(b)	130.42 ± 2.80**(b)	16.20 ± 1.70**(b)
G6	88.50 ± 2.70**(b)	86.80 ± 2.50**(b)	52.70 ± 1.40**(b)	126.38 ± 2.90**(b)	17.45 ± 1.82**(b)
G7	87.25 ± 2.50**(b)	92.80 ± 3.15**(b)	53.30 ± 1.45**(b)	129.50 ± 2.80**(b)	18.25 ± 1.95**(b)
Normal range	**180-200**	**<150**	**>50**	**155-275**	**<100**

G1 - Normal Control; **G2** - Diabetic Control; **G3** - Treatment control group (**T_1**);
G4 - Treatment group (**T_2**); **G5** - Treatment group (**T_3**); **G6** - Treatment group **(T_4)**;
G7 - Treatment group (**T_5**)
** (a) Significantly different from normal control G1 at P<0.001
** (b) Significantly different from Diabetic control G2 at P<0.01

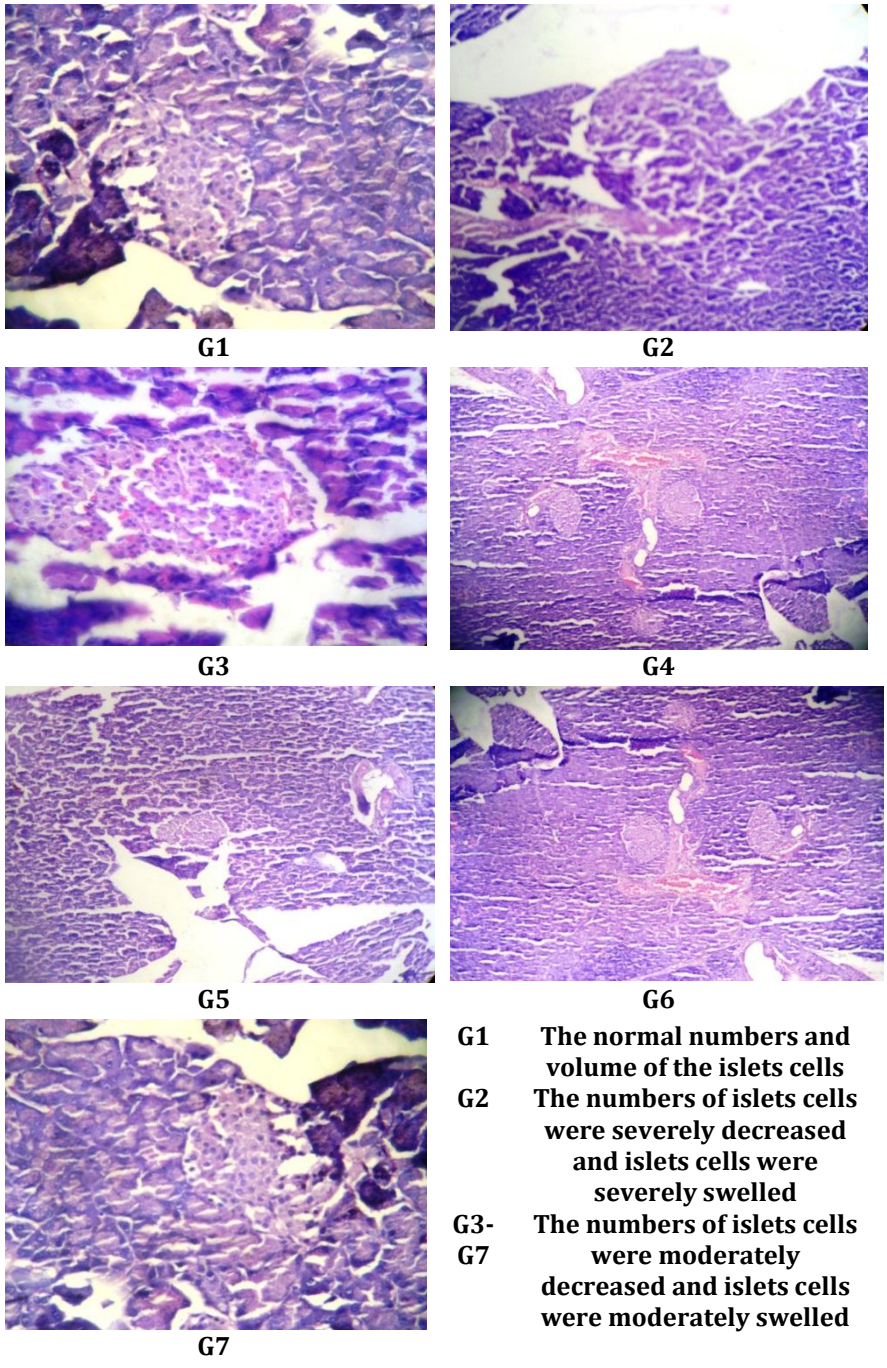

Fig. 1: Histopathology Study of Pancreas of Rats

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