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Effect of different level of resistant starch in induce diabetic rats

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Abstract: The objective of this study to evaluate the effect of Resistant Starch (RS) on lipid profile, blood glucose, hormones and TNF-α in Type 2 Diabetes (T2DM). 45 Wister male rats were divided into 5 groups each having 9 rats: without T2DM negative control (NC) with T2DM positive control (PC), resistant starch: 0.20g/kg body weight ($HM_{0.20}$), resistant starch: 0.30g/kg body weight ($HM_{0.30}$) and resistant starch: 0.40g/kg body weight ($HM_{0.40}$). Different levels were added in basal diets while negative and positive control received basal diet. Animals fed on different diets were induced type 2 diabetes 60mg/kg streptozotocin solution injected intraperitoneally in rats. Results of blood glucose showed significantly (P<0.05) lower in all rats fed $HM_{0.20,}$ $HM_{0.30}$ and $HM_{0.40}$. In case of lipid profile results indicated that $HM_{0.04}$ showed significant (P<0.05) increase in HDL level while cholesterol, LDL, triglycerides were reduced. After treatment hormonal profile, leptin, insulin and TNF- α level were significantly (P<0.05) reduced. It may be concluded that RS is the new approach to treat the T2DM.

Keywords: Resistant starch; diabetes; blood glucose; hormones, TNF-α, and lipid profile.

INTRODUCTION

The major source of food use in human diet is carbohydrates, which are important energy source for many human societies. However, starches is one of the carbohydrates, which make quite specific contribution to human health such as increasing microbial flora, control cholesterol level, glycemic index and as well as control in diabetes (Ahmadi *et al*., 2017; Srikaeo & Sangkhiaw, 2014).

Generally, RS are divided into different categories according to their nature and structure, which are RS_1, RS_2, RS_3 and RS_4. Among different types of RS, the RS_2 plays an important role to lower postprandial glucose level and also improve metabolic control in T2DM (Michael *et al*., 2012).

RS_2 used as a substrate in large intestine to produce short chain fatty acid (SCFA) that cause raise in some bacterial growth which having an anti- inflammatory characteristics that reduce the incidence of insulin resistance and development of T2DM (Maria *et al*., 2010).

RS in the diet use as a natural bioactive food component to increase gut hormones that are effective in the reduction of energy intake, so may be an effective natural approach to the treatment of obesity. Leptin hormone that is produced by differentiated adipocytes and play significant role in the regulation of body fat stores (O'Connor *et al*., 2017).

Diabetes and its associated diseases are important health threats in developing countries like Pakistan. The incidence of diabetes is increasing due to various factors like obesity, dietary pattern, lifestyle, feeding behavior, physical activity etc. that cause distress due to disturbance in physiological mechanism and leads to death. The increasing trend in diabetic people will be 376 million in Pakistan at the end of 2030 (Wild *et al*., 2004). The objective of this study to evaluate the effect of Resistant Starch on lipid profile, blood glucose and hormones in induced diabetic rats.

MATERIALS AND METHODS

The study was conducted at the Institute of Home and Food Sciences and Department of Physiology, Government College University, Faisalabad and Department of Animal Sciences, University of Agriculture Faisalabad. The ethical Committee number is 2469.

Product used

RS_2 (Hi Maize 260) use for research was provided by Rafhan Maize products company private limited Faisalabad, Pakistan as gifted sample

Procuring rats and their management

Forty-five male Wistar Albino rats 75±5 days old each weighing 150-200 grams were taken from the Department of Physiology, Government College University Faisalabad. All the rats were kept at 25± 1°C and 40 to 50% relative humidity under 12-h light and 12-h dark cycle. A principle of Laboratory Animal Care (NIH) methods was followed during the experiment. Procedure

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of experiment was approved through Animal Ethical Committee. Normal diet fed to all rats and water was offered *adlibitum*. Diet was prepared *Isocaloric* and *isonitrogenous* intake of feed and water was recorded weekly.

Experimental protocol
In this *in vivo* trial, all healthy rats were divided into five groups (9 rats per groups) named according to diets viz.
Group 1: Negative control rats (NC)
Group 2: Streptozotocin was injected intraperitoneally (60mg/kg/body weight) to overnight starve rats to induce type 2 diabetes named (PC group)
Group 3: T2DM rats received resistant starch ($HM_{0.20}$ g/kg body weight)
Group 4: T2DM rats received resistant starch ($HM_{0.30}$ g/kg body weight)
Group 5: T2DM rats received resistant starch ($HM_{0.40}$ g/kg body weight)

NC and PC groups were fed basal diet. In this trial, rats were divided in to a fully completely Randomized Design (CRD). Each treatment was repeated 3 times to make 15 experimental units, each of which has three white rats including 45 rats as a whole. At the end of the trail, rats were killed and blood samples were collected to assess the hormone and lipid profile.

Data collection
Blood glucose was collected weekly during this experiment.

Biochemical analysis
Lipid Profile was checked by microplate reader URIT660. Cholesterol was determined with kit method by using Biosystem cholesterol kit REF. 11783 (Barcelona, Spain). Triglyceride was estimated by Triglycerides liquiform mono reagent kit (Paris, France). HDL and LDL were determined by Wiener kit having REF. 1220322 and REF 1220245 respectively (Rosario, Argentina). Blood glucose was determined by glucose glucometer Accuchek Active®. Leptin levels were determined using sandwich enzyme-linked immunosorbent assay (ELISA) kit (EIA-2395 Germany). TNF-α levels were determined using an ELISA kit.

STATISTICAL ANALYSIS

The Collected data measured for mean and standard error. The analysis was performed by using SPSS (Version 17). Duncan Multiple Range (DMR) test used to observe the mean comparison between groups (Steel *et al*., 1997).

RESULTS

Effect on Lipid Profile
The statistical results regarding cholesterol, triglycerides, HDL and LDL levels of rats fed different level of resistant starch have been shown in table 1. Results indicated that rats fed high level of resistant starch $HM_{0.40}$ g/kg body weight) exhibited significant decrease ($P<0.05$) in LDL, triglycerides and cholesterol in diabetic rats. Level of HDL was reducing in all groups induce diabetes as compared to NC. After diet treatment the level of HDL significantly increased in high level of resistant starch $HM_{0.40}$ (46.7±0.61) group which showed a significant improvement in HDL levels compared to PC. Mostly, the results between $HM_{0.20}$ $_{and}$ $HM_{0.30}$ were non-significant. $HM_{0.30}$ and $HM_{0.40}$ were also non-significant to each other.

Hormones & TNF alpha Profile
The results of hormonal profile showed that insulin and leptin level increased in all diabetic groups shown in table 2. After the treatments, insulin and leptin level were significantly lower ($P<0.05$) in $HM_{0.03}$ and $HM_{0.04}$ groups. Therefore, all treatments significant from PC but non-significant to each other. Level of TNF alpha reduces in $HM_{0.04}$ group which was significant from PC and other groups.

Effect on Blood Glucose
The results showed that after the induction of diabetes, blood glucose levels increased significantly as compared to NC group depicted in table 3. The addition of different level of HM $_{0.02}$, HM $_{0.03}$ and $HM_{0.04}$ diets have not any significant effect on blood glucose levels till the last of 4^{th} week. After the 4^{th} week of the experiment, dietary treatments were significantly reduced ($P<0.05$) blood glucose levels rather than PC. In the next three weeks (5^{th}, 6^{th} and 7^{th}) blood glucose reduction levels were non-significant to each other but all were significant from PC. In last three weeks (8^{th}, 9^{th} and $10^{th)}$ $HM_{0.40}$ showed best results as compared to other treatment groups.

DISCUSSION

Adding different level of resistant starch has shown beneficial effects on the lipid profile because it has enhanced the level of High-density Lipoprotein (HDL) and decreased serum cholesterol, triglyceride, low density lipoprotein (LDL). The RS characterized as hypolipidaemic which had ability to reduce the cholesterol abundant by providing a substrate to produce a SCFA, especially propionate and butyrate. Those SCFA prevents the synthesis of cholesterol in the liver which caused the increased excretion of bile acids. Specifically, cholesterol is also the result of initial metabolism in the formation of bile acids and plays a role in fat removal (Wahjuningsih *et al*., 2018). In this study, we showed that RS2 0.4g /kg body weight decrease TNF-α, blood glucose and increase HDL. It supported by the recent result (*Sailendra et al.,* 2014) stated that supplementation with 30g RS decrease TNF-α in type 2 diabetic patients. Of note, all the results indicated that treatment of food with high resistant starch could reduce the total cholesterol levels and increase the HDL levels.

Table 1: Effect of different level of resistant starch on lipid profile (mg/dL) in diabetic induced rats

Parameters	Treatment				
	NC	PC	$HM_{0.20}$	$HM_{0.30}$	$HM_{0.40}$
Cholesterol	144.0 ± 0.79[a]	189.2 ± 0.62[c]	178.2± 0.58b[b]	173.5± 0.21[b]	169.8± 0.51[b]
Triglycerides	93.9 ± 1.98[a]	146.4 ± 0.71[c]	130.2± 0.26[b]	129.3± 0.46[b]	126.4±0.46[b]
HDL	50.1 ± 0.79[a]	38.5 ± 0.84[d]	43.2± 0.90b[c]	44.2± 0.63[c]	46.7± 0.61[b]
LDL	138.7± 0.46[a]	170.1 ± 0.51[c]	168.2± 0.76[b]	160.5± 0.15[b]	154.4±0.31[b]

Negative control (NC), Positive control (PC), Resistant starch: 0.20g/kg body weight ($HM_{0.20}$), Resistant starch: 0.30g/kg body weight ($HM_{0.30}$), Resistant starch: 0.40g/kg body weight ($HM_{0.}$40), High density lipoproteins (HDL), Low density lipoproteins (LDL), Within a row means indicated by a different letters (a, b, c & d) are significant ($p < 0.05$)

Table 2: Effect of different level of resistant starch on hormone & TNF-α in diabetic induced rats

	Treatment				
	NC	PC	$HM_{0.20}$	$HM_{0.30}$	$HM_{0.40}$
Insulin (uIU/mL)	7.43 ± 0.72[a]	11.51± 0.63[d]	11.10± 0.78[c]	10.20±0.66[b]	10.40± 0.91[b]
Leptin, ng/mL	14.16 ± 0.65[a]	11.32±0.79[d]	12.72±0.96[c]	13.23±0.84[b]	13.56±0.86[b]
TNF-α, pg/mL	11.15±5.8 [a]	19.3± 0.69 [d]	17.91±0.86 [c]	16.78±0.96 [c]	14.98±0.94[b]

Negative control (NC), Positive control (PC), Resistant starch: 0.20g/kg body weight ($HM_{0.20}$), Resistant starch: 0.30g/kg body weight ($HM_{0.30}$), Resistant starch: 0.40g/kg body weight ($HM_{0.}$40), Within a row means indicated by a different letters (a, b, c & d) are significant ($p < 0.05$)

Table 3: Effect of different level of resistant starch on blood glucose (mg/dL) in diabetic induced rats

Weeks	Treatment				
	NC	PC	$HM_{0.20}$	$HM_{0.30}$	$HM_{0.40}$
1st	107.15±1.16[a]	214.11±0.78[b]	189.43±0.53[b]	180.03±0.26[b]	171.83±0.60[b]
2nd	106.57±1.49[a]	215.67±0.88[b]	184.00±1.52[b]	179.70±1.13[b]	169.33±1.42[b]
3rd	106.78±1.35[a]	208.00±0.57[b]	190.50±0.76[b]	185.33±0.35[b]	174.40±0.87[b]
4th	104.60±1.53[a]	206.67±0.88[b]	185.33±1.20[b]	179.00±1.15[b]	172.33±0.88[b]
5th	104.58±1.47[a]	213.92±1.47[c]	190.67±0.93[b]	181.67±0.93[b]	176.00±0.58[b]
6th	99.13±1.04[a]	212.44±1.12[c]	187.00±1.52[b]	180.00±1.52[b]	175.00±0.58[b]
7th	103.83±1.48[a]	213.10±1.20[c]	190.67±1.20[b]	181.67±1.20[b]	173.33±1.85[b]
8th	105.33±1.45[a]	209.89±1.49[d]	185.73±0.81[c]	177.73±0.81[c]	168.63±1.17[b]
9th	107.44±1.09[a]	212.67±1.02[d]	192.67±0.88[c]	184.67±0.88[c]	178.83±0.44[b]
10th	106.52±1.75[a]	213.44±1.28[d]	193.83±1.17[c]	186.83±1.17[c]	176.00±0.58[b]

Negative control (NC), Positive control (PC), Resistant starch: 0.20g/kg body weight ($HM_{0.20}$), Resistant starch: 0.30g/kg body weight ($HM_{0.30}$), Resistant starch: 0.40g/kg body weight ($HM_{0.}$40), Within a row means indicated by a different letters (a, b, c & d) are significant ($p<0.05$)

The results of this study was similar to data obtain from Peterson *et al*., (2018) which showed that 10g RS effect on blood glucose and insulin response. Furthermore, another study on humans reported that the consumption of RS2 decrease postprandial blood glucose level as compared to other carbohydrates and also play an important role by improving metabolic control in T2DM subjects (Reader *et al.,* 1997). Supplementations of RS2 for four weeks effect on blood glucose and insulin resistance in type II diabetic subjects. Mechanism of RS on glycemic status is due to delaying gastric time and slow release of glucose in to the blood that lowering postprandial glucose level, hepatic muscle glucose transport causing increase level of short chain fatty acids (Diamant *et al*., 2011). Our results are similar to the study of (Mindy *et al*., 2017) that glucose homeostasis after consuming 30 g HAM-RS2 for 6 weeks in overweight adults show significant reduction in glucose and leptin.

Leptin is one of the important ipocytes and its level increases with increasing body mass index (BMI). It plays an important role in the regulation of food intake and immune function. It also directly regulates glucose metabolism through its actions via the central nervous system. Identification of the specific neuronal subsets downstream of leptin action, which link communication between the brain and peripheral tissues to control both hepatic glucose production and glucose uptake, will help facilitate the development of new approaches to diabetes treatment. In present study improvement in insulin resistance and glucose may be due to decrease in TNF- α level. Tumor necrosis factor alpha (TNF-*α*) is a cytokine that is released by adipocytes and inflammatory cells in response to chronic inflammation (Alzamil, 2020). Type 2 diabetes mellitus (T2DM) is believed to be associated with low-grade chronic inflammation. In this study results showed that higher level of leptin and TNF- α in induced diabetic rat as compared to control group. In the study of (Gargari *et al.,* 2015) results show that significant decrease in TNF-α after eight weeks of RS2 supplementation in type II diabetic patients.

CONCLUSION

Supplementation of different levels of resistant starch in diet improve lipid profile, blood glucose, leptin and TNF-α in diabetic rats. TNF- α and leptin level in diabetic subjects are closely related to insulin resistance. The present study was conducted to exert the effect of different level of resistant starch supplementation in induced diabetic rats. Resistant starch is a source of dietary fiber that improves metabolic factors and prevent from diabetic complications.

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