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Effect of High Fat Diet on Liver Steatosis and Renal Function of Male and Female Wistar Rat

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ABSTRACT

Nonalcoholic fatty liver disease (NAFLD) and chronic kidney disease (CKD) are the most common forms of liver and kidney disorders, respectively, characterized by the excessive accumulation of fat. This study aimed to establish a rat model for NAFLD with steatosis and renal dysfunction, having distorted nephrons, induced by a high-fat diet (HFD). A total of 30 Wistar rats, 15 males and 15 females, were randomly divided into 5 groups (n=3). The 3 experimental groups were fed with HFD i.e., ghee-based HFD, oil-based HFD, and ghee + oil-based HFD. The negative control group was given normal chow, while the positive control group was fed vegetables. At the end of the trial, rats were dissected to analyze serum biochemistry and lipid profile of the blood. The results revealed a significant increase in serum alanine aminotransferase and aspartate aminotransferase activities and creatinine and urea levels in the experimental groups. The rise in serum lipid profile parameters was observed except for high density lipoprotein in the experimental group as compared to the control group. Oxidative parameters were highest in the ghee + oil-based HFD group, indicating the highest level of reactive oxygen species in this experimental group compared to the control groups. The significant increase in organ weight was also observed in all experimental groups. The organ function of the liver and kidneys was analyzed by histological examination, which reveals accumulation of huge fat droplets in HFD-treated groups, which is associated with NAFLD and renal damage.

KEY WORDS: HFD, Obesity, Renal dysfunction, NAFLD

INTRODUCTION

Generally, a diet rich in fats, known as a high-fat diet (HFD), tends to promote the onset of metabolic syndrome[1]. One of the main indicators of metabolic syndrome is obesity, which is characterized by the co-occurrence of diabetes, high blood sugar, abnormal cholesterol levels, and cardiovascular problems[2]. In the current era, obesity is widely acknowledged as a significant and standalone contributor to the onset of numerous health conditions[3,4].

According to WHO, obesity is a health condition characterized by the accumulation of excessive body fat to a degree that can potentially harm one's well-being. This complex ailment results from a persistent disparity between the intake and expenditure of energy over an extended period[5]. A recent research investigation in China, focusing on nutrition and health, has revealed a significant increase in the prevalence of obesity among the population[6]. According to another survey, global obesity rates have approximately doubled from 1980 to reach levels similar to those in 2014. Obesity has led to elevated rates of both mortality and morbidity[7].

Several studies have demonstrated the detrimental effects of HFD on human health[8,9,10]. There is a significant correlation between the occurrence of numerous diseases and HFD, such as NAFLD, obesity, and cardiovascular disease[11,12,13]. Metabolic disorders, such as obesity and NAFLD, have seen an increased prevalence in various regions across the world in recent years[14,15]. Chronic kidney disease (CKD) and NAFLD represent significant global public

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health concerns, affecting approximately 10% and 25% of the general population, respectively[16]. Numerous studies have demonstrated robust associations between NAFLD and both standard and non-traditional risk factors for CKD[17,18].

HFD enhances reactive oxygen species (ROS) in the body, which affects the body's metabolic rate. Some enzymes effectively degrade these ROS i.e., superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), and glutathione reductase (GR). An elevated level of these enzymes indicates a higher level of ROS in the body[19].

Non-alcoholic fatty liver disease (NAFLD) is a significant factor in the prevalence of chronic liver conditions on a global scale. It is often associated with obesity, inflammation, impaired fat tissue function, and insulin resistance[20]. The increased likelihood of developing NAFLD and severe fibrosis is connected to the onset of obesity and insulin resistance[21,22]. The NAFLD, which is associated with various metabolic disorders, is characterized by the accumulation of fat in the liver[23]. Simple steatosis, non-alcoholic steatohepatitis (NASH), and pericellular fibrosis all fall within the range of liver conditions categorized as NAFLD. It can ultimately progress to liver cirrhosis and hepatocellular carcinoma (HCC)[24,25].

Studies have shown that extended consumption of HFD also alters lipid metabolism in the kidneys and results in lysosomal dysfunction, ultimately leading to renal damage in mice[26]. The CKD is characterized by two primary indicators: diminished estimated glomerular filtration rate (eGFR) and significant proteinuria exceeding 500 mg[27]. According to a number of recent research, a HFD may cause renal proximal tubular damage[26,28,29] which may be linked to the activation of inflammatory pathways. These results suggest that renal proximal tubular inflammatory damage from HFD may contribute to CKD[30].

The examination of human diseases and the discovery of novel therapeutic targets have been greatly aided by employing mouse models[31,32]. The purpose of the present study is to evaluate the effect of HFD on rat hematological and serum parameters. Moreover, to evaluate the organ function by feeding rats with HFD.

MATERIALS AND METHODS

Experimental animals

Thirty Wistar rats (*Rattus norvegicus*), aged 4-6 weeks old, both males and females, were purchased from the University of Veterinary and Animal Sciences and housed in animal house of Government College University Lahore, Punjab, Pakistan, under a controlled environment (65-80ºF and >40% humidity) with free availability of water and air. The normal chow typically contains carbohydrates (45-60%), proteins (14-20%), fats (4-10%), fibers (4-6%), vitamins (trace), and minerals (trace). Rats were acclimatized for 1 week and were given a normal chow diet during this period.

Preparation of HFD

HFD was prepared before the start of the trial. For the preparation of the diet, the vegetable oil and banaspati ghee (used) samples were collected in a sterile container from different regions of Lahore, Pakistan. The HFD was prepared by mixing ghee and oil in powdered chow at 30:70 ratio[33].

Experimental design

Rats (male and female) were divided into five groups each of three as G1 (negative control), G2 (positive control), G3 (experimental group I), G4 (experimental group II), and G5 (experimental group III). Negative control groups were maintained on the standard diet containing 4% fat. The positive control group rats were fed with vegetables, cereals, beans, and pulses. The G3, G4, and G5 were fed with ghee, oil, and a mixture of ghee and oil, respectively.

At the 30th day of the trial, the rats were weighed and then dissected after an overnight fasting that standardizes the metabolic state of all mice and avoids postprandial effects. Blood samples were collected by the cardiac puncture method.

Estimation of biochemical parameters

The serum was isolated after centrifugation of blood at 1000 rpm/min and stored at -80°C for biochemical analysis of liver function tests (LFTs), renal function tests (RFTs), and lipid profile. Liver and kidney tissues were also collected, fixed in formalin, and processed for histopathological examination[34].

Estimation of oxidative stress markers

To assess oxidative stress in Wistar rats, subjected to an HFD, catalase (CAT)[19], superoxide dismutase (SOD), glutathione peroxidase (GPx)[19], and glutathione reductase (GR) were estimated by following the protocol used[35].

Histopathological examination of liver and kidney

Fixed tissues were dehydrated in serial concentrations (30%-90%) of ethanol and then prepared for embedding in paraffin. About 5 µm-thick sections were cut and then stained with hematoxylin and eosin. Finally, the prepared slides were observed at 400X by using light the slides was observed using light microscope[36].

Statistical analysis

The SPSS (version 10.0) was used to process data for analysis. The data were expressed as Mean ± SEM. The comparison between groups was analyzed by one-way ANOVA following a T-test, and significance was measured at $p<0.05$. Alphabets were found by MINITAB version 17, which expresses significant differences. Graphs were made by Graph Pad version 5.0 and a Microsoft Excel worksheet.

RESULTS

Effect on body weight

HFD caused a significant increase in the body weight of Wistar rats (Table I). In males, the weight gain was highest in G3 fed on ghee-based HFD i.e., 122±1.4, followed by G5 fed on ghee + oil HFD and G4 fed on oil-based HFD i.e., 97±0.88 and 73±1.45, respectively. The G1 and G2 showed the least weight gain compared to G3, G4, and G5.

Table 1. Effect of high-fat diet (HFD) fed for 30 days on the weight (Mean ± SEM) of male and female Wistar rats.

Groups	X	Gender	Initial body weight (g) (Day 1)	Final body weight (g) (Day 30)	Weight gain (g)
G1 (Negative control)	3	M	106±3.05^{c}	156±4.91^{c}	50±3.17^{d}
	3	F	119±3.05^{ab}	166±2.33^{c}	47±0.88^{d}
G2 (Positive control)	3	M	117±2.33^{bc}	145±3.60^{c}	27±2.18^{e}
	3	F	107±1.15^{c}	140±2.60^{d}	33±1.45^{e}
G3 (Ghee based feed)	3	M	119±1.52^{ab}	241±2.18^{a}	122±1.45^{a}
	3	F	129±3.21^{a}	205±2.64^{b}	76±1.15^{c}
G4 (Oil based feed)	3	M	126±3.21^{ab}	199±1.85^{b}	73±1.45^{c}
	3	F	128±1.15^{a}	236±1.15^{a}	108±1.15^{a}
G5 (Ghee + oil based feed)	3	M	130±2.33^{a}	228±2.90^{a}	97±0.88^{b}
	3	F	113±1.20^{bc}	209±1.85^{b}	96±1.15^{b}

The superscripts (a, b, c, d) show significant differences between means of groups ($p < 0.05$).

In female Wistar rats, the highest weight gain was observed in G4 (oil-based HFD) i.e., 108±1.15 and a slight increase was observed in G3 and G5 i.e., 76±1.15, 96±1.15, respectively. While both G1 and G2 showed the least weight gain compared to experimental groups (Table I).

Effects on serum LFTs and RFTs

Table II shows in the males, the highest value (112 ± 1.45 U/l) of ALT was recorded in G5, whereas the lowest value (46±1.76 U/l) was seen in G2, in male rats. In females, G4 shows the highest value (98 ± 0.88 U/l) of ALT whereas lowest value was shown by G2 (46±1.76 U/l). In males, AST was highest (316 ± 1.15 U/l) in G5 and lowest (86 ± 1.76 U/l) in G2, while in females, the highest value (231±1.20 U/l) was observed in G3 and the lowest (94±1.15 U/l) was seen in G2.

In males, the lowest albumin value (2.33 ± 1.95 g/dL) was observed in G5 and highest value (4.43 ± 3.67 g/dL) was observed in G1. In females, both G3 and G5 showed the lowest value of albumin 3.13 ± 0.03 g/dL and G1 showed the highest value of 4.33 ± 0.14 g/dL. In males, lowest bilirubin value (0.13 ± 0.01 g/dL) was recorded in group G5 and G1 shows the highest value of 0.43 ± 0.28 g/dL. In females, both G3 and G5 showed the lowest value (0.13 ± 0.03 g/dL) of bilirubin while G1 showed the highest value; 0.43 ± 0.03 g/dL (Table II).

The highest value of urea was recorded in G3 i.e., 42±0.57 mg/dL, 47±0.57 and lowest value (15±0.57, 17±0.88) was seen in G2 in both male and female groups, respectively. The highest value of Creatinine was seen in G3; in both male (1.7±0.05) and female groups (1.9±0.05). The lowest value (0.43±0.03, 0.4±0.05) was seen in G2 both male and female groups, respectively.

Effect on serum lipid profile

Table III show TC and serum TG levels both increase in all HFD-treated groups**.** A rise in TC and TG was observed in HFD-treated groups, while their levels were normal for control groups. In males, G3 showed maximum value of TG (197 ± 1.15) and TC (290 ± 1.73); and the lowest value were

Table II. Effect of high-fat diet on serum LFTs of different groups of male and female Wistar rats presented in Mean ± S.E.M and their significance.

Parameters	Gender	G1	G2	G3	G4	G5	P value
ALT (µ/dL)	M	53±1.15^{d}	46±1.76^{d}	96±1.76^{b}	66±1.76^{c}	112±1.45^{a}	0.000
	F	53±1.15^{d}	46±1.76^{e}	65±1.15^{c}	98±0.88^{a}	85±1.52^{b}	0.002
AST (µ/dL)	M	103±1.15^{d}	86±1.76^{e}	205±1.15^{b}	133±1.45^{c}	316±1.15^{a}	0.001
	F	106±0.88^{d}	94±1.15^{e}	231±1.20^{a}	213±1.45^{c}	222±1.76^{b}	0.000
Albumin (g/dL)	M	4.43±3.67^{a}	3.703.45^{b}	2.56±2.18^{d}	3.13±2.98^{c}	2.33±1.95^{d}	0.000
	F	4.33±0.14^{a}	3.73±0.08^{b}	3.13±0.03^{c}	3.23±0.08^{c}	3.13±0.03^{c}	0.003
Bilirubin (mg/dL)	M	0.43±0.28^{a}	0.33±0.47^{ab}	0.16±0.03^{c}	0.26±0.12^{bc}	0.13±0.01^{c}	0.001
	F	0.43±0.03^{a}	0.33±0.03^{ab}	0.13±0.03^{c}	0.23±0.03^{bc}	0.13±0.03^{c}	0.000
Urea (mg/dL)	M	22±0.57^{d}	15±0.57^{e}	42±0.57^{a}	28±0.57^{c}	33±0.57^{b}	0.000
	F	21±0.57^{d}	17±0.88^{e}	47±0.57^{a}	35±0.57^{c}	41±0.88^{b}	0.005
Creatinine (mg/dL)	M	0.7±0.05^{d}	0.43±0.03^{e}	1.7±0.05^{a}	1±0.05^{c}	1.3±0.05^{b}	0.005
	F	0.7±0.05^{d}	0.4±0.05^{e}	1.9±0.05^{a}	1.1±0.05^{c}	1.5±0.05^{b}	0.001

For details of groups and statistical details, see Table I. ALT, alanine aminotransferase; AST, aspartate aminotransferase.

Table V. Effect of high fat diet on serum lipid profile of different groups of male and female Wistar rats presented in Mean ± S.E.M and their significance.

Parameters	Gender	G1	G2	G3	G4	G5	p-value
TC (mg/dL)	M	190±2.33	136±5.13	290±1.73	229±2.08	259±2.33	0.001
	F	196±1.52	175±1.52	240±1.73	290±2.64	265±1.76	0.000
TG (mg/dL)	M	145±1.20	136±1.45	197±1.15	168±0.57	186±1.15	0.000
	F	143±1.73	116±0.88	210±1.45	245±1.15	230±1.20	0.002
HDL (mg/dL)	M	68±1.20	60±0.88	31±0.88	44± 0.88	38±0.57	0.000
	F	73±0.57	63±1.45	47±0.57	28± 0.57	34±0.88	0.001
LDL (mg/dL)	M	94±1.53	81±1.29	141±0.73	122±2.05	134±2.22	0.000
	F	95±0.89	86±0.69	126±0.93	148±1.44	135±1.32	0.003
VLDL (mg/dL)	M	28±0.43	22± 0.50	46±1.01	33±0.84	40±0.92	0.000
	F	26±1.07	16±0.81	53±0.88	75±1.19	67±0.88	0.002

For details of groups and statistical details, see Table I. TC, total cholesterol; TG, triglycerides; HDL, high density lipoproteins; LDL, low density lipoproteins; VLDL, very low density lipoproteins.

Table IV. Effect of HFD on organ weight of different groups of male and female Wistar rats presented in Mean ± S.E.M and their significance.

Organ weight	Gender	G1	G2	G3	G4	G5	p Value
Liver	M	6.3 ± 0.11^{d}	5.8 ± 0.26^{d}	12.3 ± 0.08^{a}	10.2 ± 0.10^{b}	9.5 ± 0.12^{c}	0.000
	F	5.9 ± 0.08^{d}	5.1 ± 0.06^{e}	8.2 ± 0.08^{b}	9.2 ± 0.05^{a}	7.2 ± 0.08^{c}	0.001
Kidney	M	0.62 ± 0.005^{d}	0.59 ± 0.005^{d}	1.25 ± 0.005^{b}	1.29 ± 0.008^{a}	1.06 ± 0.005^{c}	0.000
	F	0.66 ± 0.005^{d}	0.61 ± 0.005^{e}	0.95 ± 0.005^{b}	1.02 ± 0.008^{a}	0.91 ± 0.005^{c}	0.001

For details of groups and statistical details, see Table I.

seen in the G2 group i.e. 136 ± 1.435, 136 ± 5.13. In female Wistar rats, G4 exhibited the maximum values of TG and TC; (290 ± 2.64 245 ± 1.15), respectively. The lowest value was seen in the G2 group (175 ± 1.52, 116 ± 0.88), respectively. The HDL value of serum declined while VLDL and LDL rose in all HFD-fed groups. In male, G3 exhibited lowest HDL (31 ± 0.88) value and the highest value of LDL and VLDL 141 ± 0.73, 46 ± 1.01, respectively. In female Wistar rats, G4 showed the lowest value of HDL 28 ± 0.57 and the highest value of LDL 148 ± 1.44 and VLDL 75 ± 1.19, respectively (Table III).

Effect on organ weight

The normal liver tissues look dark brown while fatty liver has a yellowish-brown color. The normal and healthy liver tissue was fresh dark brown in color and light weight approx. 1.2-1.6 kg. Whereas, fatty liver was yellowish brown (Table I), moreover, liver weight was increased in all experimental groups. In the case of male rats, the maximum liver weight was in the G3 group 12.3 ± 0.08. In the case of female rats, the maximum liver weight was in G4 group 9.2 ± 0.05.

Normal and healthy kidneys were fresh and reddish brown, with a weight of approximately 0.63 and 0.57g for male and female Wistar rats. Whereas the fatty kidneys were yellow, and weight increased in the experimental groups. In both male and female rats, maximum weight was observed in G4 group; 1.29 ± 0.008, 1.02 ± 0.008.

Effect on oxidative stress parameters

Table V shows analyses of oxidative stress parameters showed that G5 fed with mixed HFD had the highest levels of all parameters i.e., SOD, CAT, GPx, and GR. It showed that this is the most affected group as it faced the highest level of ROS. Higher levels of ROS caused an increase in oxidative enzymes in response in both male and female rats. The positive group showed the lowest level of oxidative enzymes, which means that rats were healthier, compared to all other groups (Table V).

Histopathological analysis

Microscopic histology of the liver revealed that there was an accumulation of huge fat droplets, which were most prominent in the pericentral (centrilobular) zone, displacing the nucleus towards the periphery with bloated hepatocytes in all experimental groups. However, in positive and negative control groups, hepatocytes were almost normal, and no tissue change was observed (Fig. 1). The hepatic cords were polygonal, so having a normal shape, and no change in

cytoplasm and nucleus was observed. Sinusoids and portal area were also normal (Fig. 2).

Histological analysis of kidney tissues showed that HFD increased lipid accumulation in kidney tissues. There was deposition of huge fat droplets and glomerular injuries between the kidney tissues in the experimental groups. While in the control groups (positive and negative), glomeruli are without any injuries. Glomerular space also remains intact (Figs. 3, 4).

Table V. Effect of HFD on oxidative enzymes of different groups of male and female Wistar rats presented in Mean ± S.E.M and their significance.

Parameters	Gender	G1	G2	G3	G4	G5	p value
SOD (U/mg protein)	M	3.7 ± 0.3^{cd}	2.2 ± 0.2^{d}	8.9 ± 0.6^{b}	5.2 ± 0.4^{c}	11.0 ± 0.7^{a}	<0.001
	F	2.9 ± 0.3^{bc}	2.2 ± 0.4^{c}	7.2 ± 0.7^{a}	4.9 ± 0.4^{b}	8.5 ± 0.8^{a}	<0.001
CAT (U/mg protein)	M	29.4 ± 0.7^{c}	21.2 ± 0.7^{d}	55.7 ± 0.9^{b}	32.4 ± 0.9^{c}	60.6 ± 1.1^{a}	<0.001
	F	26.3 ± 1.4^{cd}	21.2 ± 1.3^{d}	52.7 ± 1.1^{b}	30.9 ± 1.4^{c}	60.2 ± 1.7^{a}	<0.001
GPx (U/mg protein)	M	7.0 ± 0.5^{bc}	5.35 ± 0.5^{c}	15.1 ± 0.8^{a}	8.4 ± 0.4^{b}	16.5 ± 0.8^{a}	<0.001
	F	6.4 ± 0.4^{cd}	5.0 ± 0.6^{d}	12.4 ± 0.7^{b}	8.2 ± 0.5^{c}	16.0 ± 1.0^{a}	<0.001
GR (U/mg protein)	M	3.2 ± 0.4^{c}	2.8 ± 0.5^{c}	6.2 ± 0.4^{ab}	4.5 ± 0.4^{bc}	7.9 ± 0.5^{a}	<0.001
	F	3.4 ± 0.3^{cd}	1.9 ± 0.3^{d}	6.68 ± 0.31^{b}	4.9 ± 0.5^{bc}	8.6 ± 0.7^{a}	<0.001

For details of groups and statistical details, see Table I. CAT, catalase; SOD, superoxide dismutase; GPx, glutathione peroxidase; GR, glutathione reductase.

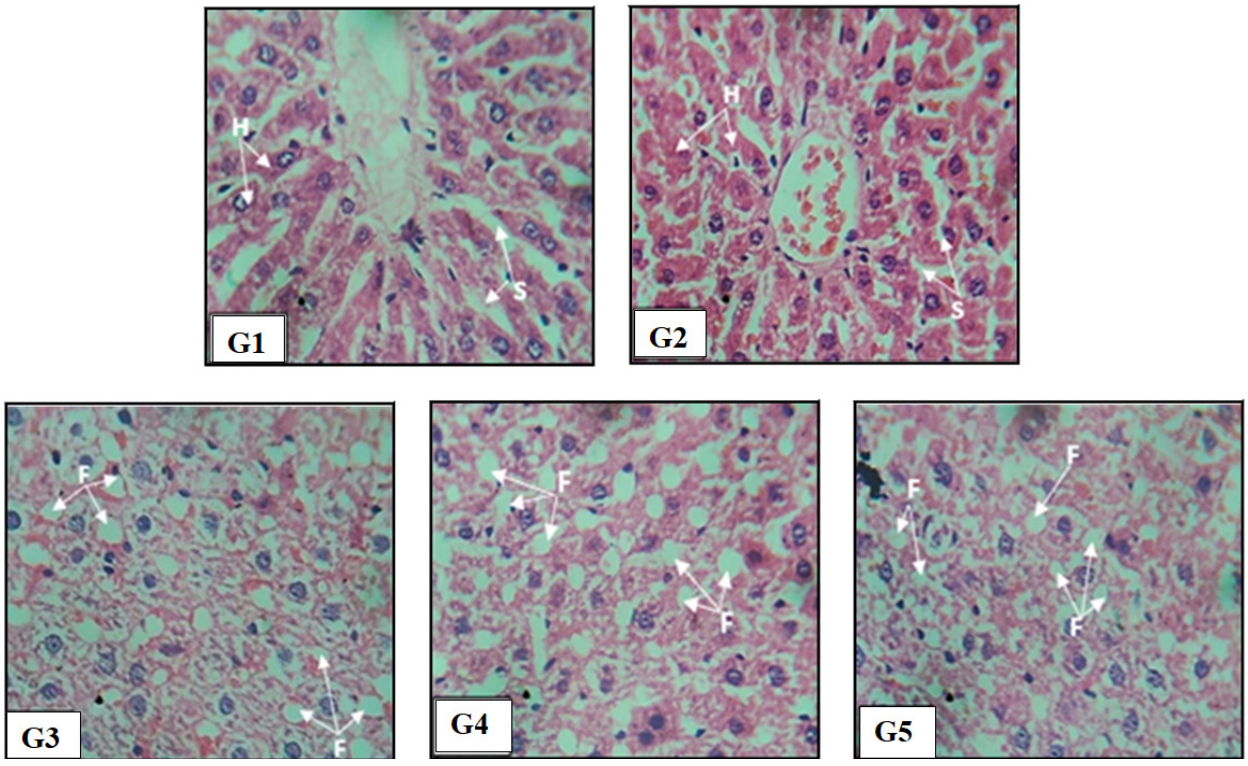

Fig. 1. Micrographs of male Wistar rats liver; G1 and G2 showing normal liver histology, H, hepatocytes; S, sinusoids, G3, G4, and G5 show histological changes in the liver with fat droplets (F) accumulation. G5 shows the highest degree of abnormal changes with distorted sinusoids and larger fat droplets. H and E staining (400x).

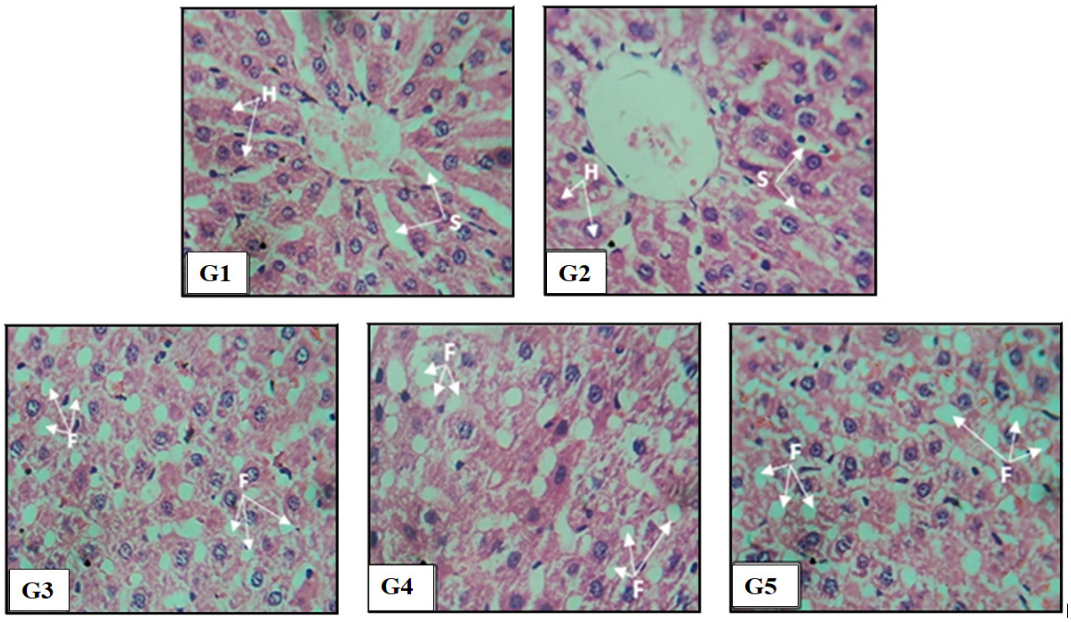

Fig. 2. Effect of high fat diet on histological structure of liver of female Wistar rats. G1 and G2 showing normal liver histology, H, hepatocytes; S, sinusoids, G3, G4, and G5 show histological changes in the liver with fat droplets (F) accumulation. G5 shows the highest degree of abnormal changes with distorted sinusoids and larger fat droplets. H and E staining (400x).

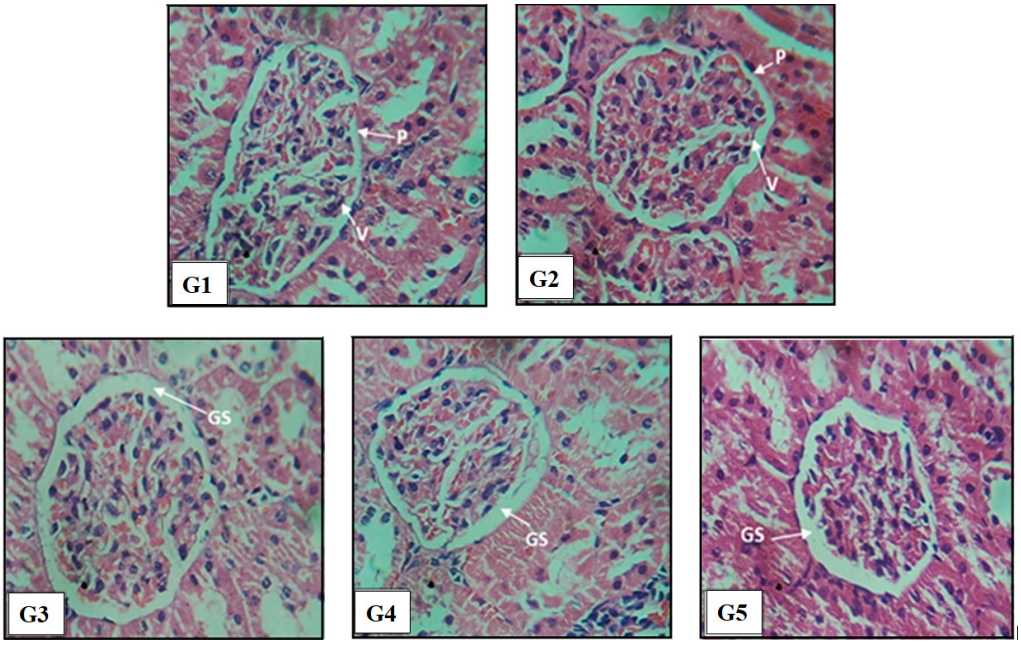

Fig. 3. Effect of high fat diet on histological structure of kidenys of male Wistar rats. G1 and G2 groups show normal renal histology P, glomerular capsule; V, visceral layer of the glomerular capsule, G3, G4, and G5 show histological changes in the kidney; GS, glomerular spaces. Highest changes were observed in G5. H and E staining (400x).

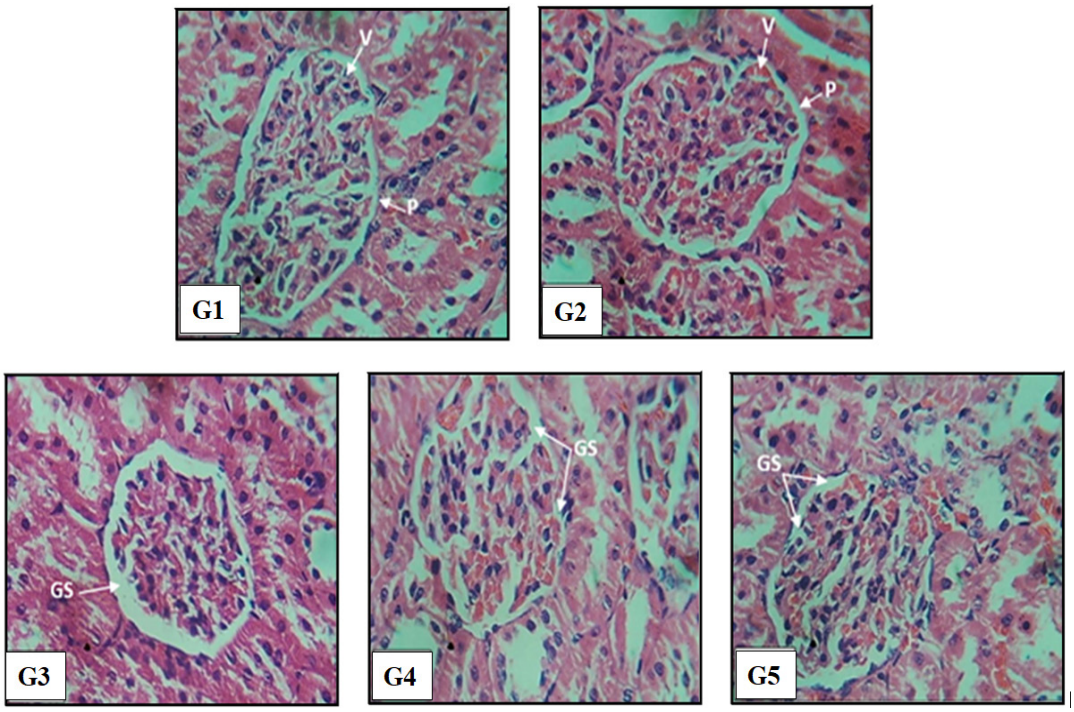

Fig. 4. Effect of high fat diet on histological structure of kidney of female Wistar rats. G1 and G2 show normal renal histology. P, glomerular capsule; V, visceral layer of the glomerular capsule; G3, G4, and G5 show histological changes in the kidney. GS, glomerular spaces. The highest changes in GS were observed in G5. H and E staining (400x).

DISCUSSION

There is a relationship between dietary fats and their effects on body mass, liver functions, and renal functions. The main objective of the study was to compare the effects of HFD and standard diet (SD) on liver and renal functions. It also reveals high fat deposition in both liver and kidneys which in turn increases the organ weight[37]. HFD increases the serum lipid profile levels (TG, TC, LDL, and VLDL) which then affect the kidneys, liver, and its functions[38]. HDL level declines in HFD-fed groups and rises in SD groups.

The weight of organs increased in groups fed with a HFD. The weight of the left kidney in male and female rats is higher than right. The kidney weight of female rats increased more than male rats while the male liver gained more weight than the female[39].

High fat deposition in the renal and liver tissues is caused by the high-fat content in the diet (dietary fats). Arteriosclerosis was the term used for the damaged arteries. Risk factors for arteriosclerosis were high cholesterol, TG levels, and high intake of saturated fats[37]. RFTs and LFTs (BUN, CBT, ALT, and AST) increased while SAT and bilirubin levels decreased in HFD-fed groups and vice versa in the control groups (Table I). [40]showed that rats fed with HFD for 8 weeks caused obesity in the experimental groups. The body mass increases by 10 % per week in rats. The TC and TG levels in the blood rise due to the high concentration of saturated fats in the diet. Histological study revealed that the HFD groups showed glomerular and tubular injuries. Results showed that a significant relationship existed between liver functions (ALT, Bilirubin, and AST), renal functions (Cr and U), body mass index, and triglyceride which is consistent with the statistical analysis issued[41,42].

This study reveals which animal model is more suited for the research on HFD effect on Wistar rats or Sprague-Dawley rats. High-fat diet added in diet of both models. Outcomes revealed that the pair influenced the body mass; but the functional results were better noticeable in Wistar rats compared to others[43].

The hepatic oxidative damage, steatosis, and inflammation are noticed in the rats fed with high fat which is in cahoots with the statistics of[44] in contrast to standard diet rats. The liver enzymes (ALT, AST, and ALP) are revealed to identify the hepatocyte damage. Statistics indicate that the rise in hepatic enzymes is related to liver tissue damage caused by fat deposition in the hepatocytes. The oxidative stress caused by fat eating high fats is correlated with

nephrons and hepatocyte damage. The outcomes are in agreement with the results[45].

A HFD instigates a buildup of fats and causes anomalies in both shape and function. High-fat consumption causes fat buildup and tubular injuries. The results are in cahoots with the[30]. In renal and liver tissues, lipid profile parameters (TG, TC, LDL, and VLDL) levels rise except HDL, which is a good fat, and in diseased conditions, its level decreases. Blood levels of TG, TC, LDL, and VLDL increased due to the consumption of an HFD, while blood level of HDL decreased. Liver function enzymes (ALT and AST) and RFT levels rise in HFD groups which coincides with the results[46,47].

This study reveals that RFTs (blood urea nitrogen, creatinine blood test) level rises in HFD-fed groups. Our results reveal that the BUN and CBT levels increased in HFD-fed groups and standard diet (SD) groups. It then designates that the kidneys are injured in the HFD-fed groups. Histology reveals that in HFD-fed groups the tubules were structurally distorted and caused kidney dysfunctionality. HFD significantly elevates ALT and AST functionality along with the lipid and hematological profiles. These results are in good agreement with the results[48,49]. HFDs prompt obesity. It influences liver and renal functions as well as serum lipid profiles. The current study indicates that HFD affects health by targeting organs like kidneys and liver. It causes obesity, increased cholesterol; and TG in the blood which is a determinant for arteriosclerosis. HFD causes tubular or glomerular injuries either changing their shape or influencing their function[50]. Liver function enzymes (ALT, AST, and Bilirubin) and lipid profile levels elevate in the groups fed with HFD. These statistics are in cohorts with those published[38].

The purpose of this study was to find the cause of the weakening of renal activity and stimulating digestive diseases. In this article investigator reveals the causes of catabolic and anabolic impairment disease (high blood sugar, high blood fats, and overweight), and renal function disablement. This research caused the diseases revealed to be the intemperance of a diet containing large amounts of sugars and fats in clear-term overeating. The energy after intemperance surpasses the body's needs and it causes organ activity (especially cardiac, hepatic, and renal activity) to overexert itself which then causes disability of organs. The renal activity is certainly influenced by hyperlipidemia (High blood fats) that leads to fat buildup and shows distortion of balance among lipogenesis and lipolysis. It causes alterations in the shape and activity of organs that progress into nephron injuries. The treatment for long-term renal disorder is considered to be reducing the intemperance of sugar and fats[51].

In this study it was noted that G3 fed with mixed HFD had increased levels CAT, SOD, and GPx enzymes as compared to the control groups. Similar findings were noted in a study reported[52]. In another study Liebert and Murias[53], reported that HFD can cause increase in enzyme GR in rats which resembles with present study. Increased antioxidant enzyme level indicates that HFD has induced an increase in ROS in the body and the body has responded by elevating the antioxidant level.

Being overweight was the cause of the long-term renal disorder but the process was difficult to find. In this research, the investigator reveals that a diet containing high fats instigates kidney injury in animal models (mice). The animal model feeding on a diet containing high fats for 4 whole months had progression of over mass index, high blood sugar, and renal deterioration indicated by high albumin in urine and buildup of UN and Cr in serum. The damage of glomeruli and tubules was noticed[3]. Our study showed similar results. The damage to the glomeruli and tubules in the kidneys was evident and showed structural alterations. High albumin in urine (albuminuria), obesity, and hyperlipidemia in tissue (fat deposition) were noticed in the histopathology of renal tissues.

In the late decennium rising in commonness of long-term renal disorder and the over-weight index had developed. Fat poisoning in the kidneys is linked with being overweight. The buildup of fat in renal tissues was the source of deterioration and kidney scarring. If the fat buildup surpasses the amount the body can accumulate then fatty acids leak into the blood and then accumulate in various other organs including renal organs. This study aimed to reveal that fat poisoning causes alterations in kidney physiology and its activity[54].

CONCLUSION

Our results exhibited a significant increase in the weight of HFD-fed Wistar rats. Serum LFTs and RFTs parameters were elevated which indicated hepatic and renal injury. Hematological parameters showed significant alterations and the serum lipid profile has higher values except HDL. The rise in TG and TC levels indicated the arteriosclerosis and tubular injuries in renal tissues. Fat deposition in the liver caused steatosis while in renal tissues caused nephron damage. Histology of liver showed inter-hepatocytic accumulation of huge fat droplets. Renal histology also indicated fat deposition in glomeruli and tubules (nephrons) in HFD-fed groups in contrast to control groups.

DECLARATIONS

Authors' contribution

DAB conceived and supervised the study. AR edited the manuscript. SM, KM, Arifullah, and AK contributed to the experiments and wrote the manuscript.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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