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High macronutrient dietary composition modifies biophysical and biochemical indices in male Wistar rats

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Abstract. *Amballi AA, Olooto WE, Aladesusi MO, Ogunfolu IA, Onayemi AA. 2025. High macronutrient dietary composition modifies biophysical and biochemical indices in male Wistar rats. Asian J Trop Biotechnol 22: 41-47.* Nutrition is one of the most important factors to achieve and maintain a healthy status. This requires a balanced diet in terms of both the macronutrients and micronutrients. In Nigeria, there is a gradual transition from the traditional diet to Western diet. This is increasing the burden of non-communicable diseases and macronutrients play a major role. This study was designed to evaluate the effects of macronutrient composition on biophysical and biochemical indices using Wistar rat (*Rattus norvegicus* (Berkenhout, 1769)) as a pilot study. Twenty-five male Wistar rats weighing 26-46 g were randomly divided into 5 groups. Dietary composition was done, the rats were given feed and water *ad libitum*, weighing was done weekly for 8 weeks, and fasting blood samples were collected. Fasting blood glucose, lipid profile, liver and kidney function tests were conducted. In this study, the macronutrient caused increased body weight across all the groups with highest increase in the High Fat Diet (HFD) group, a tendency to cause increased body weight or obesity. Fasting Blood Sugar (FBS) was observed to increase significantly only in the HFD group, a tendency to cause Diabetes mellitus. A non-significant increase across the test groups was observed in the liver enzymes and total protein while a significant increase in albumin level was observed. However, no change was observed in the bilirubin levels across the test groups. A significant increase occurred in urea and creatinine in the HFD rats. Lipid profile in this study showed significant increase in triglycerides, cholesterol and low-density lipoprotein and a significant decrease in high-density lipoprotein among HFD-fed rats. The atherogenic and coronary risk indices were also significantly increased in HFD fed rats. No significant difference in the electrolytes. This study showed that HFD can predispose to risk factors of non-communicable diseases. Liver and kidney functions are not significantly disrupted.

Keywords: Health status, lipid profile, nutrition, obesity, Western diet

INTRODUCTION

Nutrition is one of the most important factors to achieve and maintain a healthy state. This requires the habitual intake of an adequate and balanced diet, which includes both the macronutrients and micronutrients. The macronutrients are needed in large amount in our body while the micronutrients are needed in little amounts, however they both have specific functions to maintain a good health status. The macronutrients (carbohydrates, proteins and lipids) majorly supply energy (calories) to the body and each has other specific functions while micronutrients are vitamins and minerals with their specific functions. Furthermore, the importance of hyperlipidaemia in health status must be emphasized because it plays a major role in the pathogenesis of cardiovascular disease. For clinical evaluation of cardiovascular disease it is important to estimate plasma lipid profile as well as the artherogenic and coronary risk indices (AI and CRI).

The principal energy source for normal cellular activities is derived from three major calorigenic nutrients (carbohydrates, proteins, and lipids), food fibers, and other organic compounds (Carreiro et al. 2016; Savarino et al. 2021). Lipids give about 9 kcal per gram; proteins and carbohydrates each give 4 kcal per gram; while fibers give less calories due to their low digestibility and absorption in the gastrointestinal tract (GIT) (Carreiro et al. 2016; El-Zayat et al. 2019; Morris and Mohiuddin 2023).

Changes in body weight over time are a measure of an imbalance between the energy content of ingested foods and energy expended on life maintenance and physical activities. The rate of calories released from foods for cellular and physical activities is a function of the rate of glucose, amino acids, and fatty acid production, which are combustible metabolic fuels needed for energy generation. The availability of these units of metabolic fuel is dependent on factors like the glycemic index of ingested macronutrients, GIT motility and transition period, absorptive state of GIT epithelial surfaces, presence of anti-nutrients in ingested foods, availability of micronutrients that serve as cofactors for metabolically active enzymes, the rate of gastric emptying, and health status of individuals. The changes in body weight over time causes underweight, overweight or obesity, which are results of either undernutrition or overnutrition. The indicators of nutritional status (underweight, overweight and obesity) are changing in

Low-to-Middle-Income-Countries (LMICs) (Ahmed et al. 2020). Both undernutrition and overnutrition appear to be a growing burden on LMICs (Abdullah 2015). This growing burden is due to transition from traditional diet (high-fiber diets) to western-style diet (fast foods rich in sugar and fat). Unhealthy dietary habit is a major contributor to the burden of non-communicable diseases. Non-communicable diseases such as chronic respiratory diseases, cardiovascular disease, cancer, and diabetes mellitus are the primary causes of death in African countries with lower incomes, such as Nigeria (Gowshall and Taylor-Robinson 2018; Mapis 2020). Obesity among children is a growing concern, and children in LMICs are exposed to an unhealthy diet high in sugar and fat (Jaacks et al. 2017). These children face the danger of developing chronic diseases later in life.

Excessive intake of protein, carbohydrate, or fat in the form of energy-dense, highly processed foods and a lack of physical activity contribute to obesity-related diseases and obesity (e.g., insulin resistance, hyperlipidemias, cardiovascular disease, and cancer) (Seidelmann et al. 2018). In this circumstance, changes in energy balance, and biochemical entities are expected. A study in a Nigerian community has reported that dietary indiscretion (Western-style fast foods), poor health care funding, endemic poverty and lack of quality care to those with Non-Communicable Diseases (NCDs) are factors causing the increasing prevalence of NCDs in Nigeria (Oso 2023). Other studies have highlighted the level of financial hardship experienced by households with NCDs in Nigeria due to out-of-pocket expenses and lost productivity (Odunyemi et al. 2023).

The prevalences of hypertension, diabetes and dyslipidaemia vary amongst rural, semi-urban, and urban settings and were reported as 35.3%, 4.6% and 41.3% respectively in a community in Lagos State (Nigeria) (Idris et al. 2020). This highlights the need for researchers to tackle NCD burden. Non-Communicable Diseases (NCDs) cause about 71% of all deaths globally (equivalent to 41 million) each year and represent the leading cause of death worldwide (GBD 2016), and the four top killers are cardiovascular disease, cancer, respiratory diseases, and diabetes mellitus (GBD 2016; Bigna and Noubiap 2019). The threatening burden of NCDs in Sub-Saharan Africa has also been emphasized by some researchers (Gouda et al. 2019). The incidence of NCDs in Sub-Saharan Africa has been on an alarming increase in the past decades. It has been ascribed to the deliberate adoption of a Western diet pattern instead of a traditional diet (high-fiber diets), rich dietary pattern by Africans in general. Hence, adopting a healthy dietary pattern may aid in lowering the development of non-communicable disease (Ruthsatz and Candeias 2020). Important efforts are therefore needed to curb the burden of NCDs (Bigna and Noubiap 2019) and improve the well-being of people living with NCDs in the region. However, in the environment of this study which is a typical Nigerian community, there is no comprehensive study done to assess the effects of macronutrient dietary composition on biophysical and biochemical indices, which could be useful in guiding health policy makers and healthcare givers to improve the well-being of people living with NCDs and the public. This is the purpose of this study, although Wistar rats were used in this study because of the limiting factors in making use of humans.

MATERIALS AND METHODS

Procedures

Procurement and care of animals

Twenty-five healthy three-week-old male Wistar rats (*Rattus norvegicus* (Berkenhout, 1769)) weighing 26-46 g were procured from animal house at the Federal University of Agriculture Abeokuta. They housed (5 rats per cage) in the animal house of the Department of Anatomy, Olabisi Onabanjo University, under controlled lighting (12 h light/dark cycle, lights on 6:00). Each cage was floored with wood-shaven to accommodate animal urine and feces. All rats were provided with water and standard rat chow ad libitum for a week of acclimatization prior to the dietary manipulation. Handling of the rats conformed to the National Research Ethics Committee Guidelines (NREC 2019).

Experimental design

The study is a longitudinal study involving a total of 25 male Wistar albino rats. The rats were then randomly divided into five groups after a week of acclimatization namely: controls, High Carbohydrate Diet (HCD), High Protein Diet (HPD), High Fat Diet (HFD) and an equal proportion of carbohydrate, protein, and fat (MN) groups. Each group contains 5 male Wistar rats as described: Group 1: Fed on standard rat chow and water *ad libitum*, Group 2: Fed on a high carbohydrate diet (powder form) consisting of 75% carbohydrate, Group 3: Fed on a high protein diet (powder form) consisting of 75% protein, Group 4: Fed on a high fat diet (semi-solid oily form) consisting of 75% fat, Group 5: Fed on a diet (powder form) consisting of 25% each of fat, protein, and carbohydrate.

The rats were allowed access to water ad libitum and the compounded feeds as indicated in group 2-5 for 8 weeks.

DIETS' composition and feeding

The composition of the diets was based on the guidelines for nutrient requirements of laboratory animals (Chukwudike et al. 2017). The feeds for the control and test groups were prepared from ingredients purchased from Forlard feed mills in Sagamu, Ogun State, Nigeria, according to the composition shown in Table 1.

Food and energy intake

Hence, 24 hours of total food intake were recorded daily, and body weight of rats in each group was measured weekly. Food intake (FI) values were calculated as the difference between the total food given (initial diet, Di) and the amount of food remaining per day (final diet, Df) divided by the number of rats in the cages: (FI (g) = (Di - Df) * 0.2) (Malta et al. 2014). Energy intake was calculated based on weekly food intake (g/100g body weight) and diet density (kcal/g).

Table 1. Nutrient requirement of laboratory rats

Ingredients (dry matter)	Control (g/kg)	HCD group (g/kg)	HPD group (g/kg)	HFD group (g/kg)	MN group (g/kg)
Maize	654.0 g	750.0 g	100.0 g	100.0 g	250.0 g
Soyabean meal	50.0 g	20.0 g	400.0 g	20.0 g	150.0 g
Fish meal 72%	20.0 g	10.0 g	200.0 g	10.0 g	20.0 g
FF soya	40.0 g	10.0 g	50.0 g	10.0 g	30.0 g
GNC	60.0 g	20.0 g	100.0 g	10.0 g	50.0 g
Soya oil	70.0 g	70.0 g	50.0 g	750.0 g	250.0 g
Corn bran	10.0 g	20.0 g	24.0 g	24.0 g	70.05 g
PKC	30.0 g	34.0 g	10.0 g	10.0 g	100.5 g
Bone meal	25.0 g	25.0 g	25.0 g	25.0 g	30.0 g
Limestone	5.0 g	5.0 g	5.0 g	5.0 g	10.0 g
Lysine	7.0 g	7.0 g	7.0 g	7.0 g	10.0 g
Methionine	4.5 g	4.5 g	4.5 g	4.5 g	5.0 g
Toxin binding	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g
Enzyme binding	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g
Salt	2.5 g	2.5 g	2.5 g	2.5 g	2.5 g
Vitamin premix	20 g	20 g	20 g	20 g	20 g
Metabolizable energy (Kcal/kg)	3484.05	3490.95	2962.15	7589.15	4253.79
Crude protein (%)	16.69	10.47	40.69	3.80	16.58

Specimen collection, preparation, and storage

At the expiration of 8 weeks, the rats were fasted overnight. Blood samples were collected through periorbital /orbital venous plexus bleeding into heparinized and plain bottles, centrifuged at 10,000 rpm for five minutes to obtain the plasma and serum respectively which were stored at -20°C until assayed.

Biochemical parameters

The collected specimens were analyzed for the biochemical parameters notably FPG, triglycerides, total cholesterol, HDLC, aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), total protein, albumin, bilirubin, urea, and creatinine according to standard procedures (Jendrassik and Grof 1938; Kadish and Sternberg 1969; Anon 1970; Wybenga et al. 1971; Friedewald et al. 1972; Schettler and Nussel 1975; Nägele et al. 1984). The LDLC, and globulin were computed for all samples.

Data analysis

The statistical analysis on descriptive statistics and bar charts was done using SPSS software version 25 to describe and represent the variables studied. The obtained data showed normal distribution ($p = 0.764$), and thus an independent t-test was considered to compare the differences in mean between two groups while one-way ANOVA was used to compare differences in mean between more than two groups. The level of statistical difference was set at $p < 0.05$.

RESULTS AND DISCUSSION

Effects of dietary composition on weight

The result of the effects of dietary composition on weight among control and treatment groups, using the differences between initial weight as at week 0 and the final weight as at the end of week 8 across groups I-V, showed a weight increase (Table 2). The percentage increment in the weight in each group was observed to be 280% in the group fed on normal rat chow, 300% in the HCD-fed group, 250% in the HPD-fed group, 350% in the HFD-fed group, and 250% in the equal proportion diet fed group (Figure 1).

Effects of dietary composition on plasma hepatorenal markers

The result of plasma glucose showed an increase in FPG among HFD-fed rats and a decrease in FPG among HPD-fed rats. The result of hepatic function markers showed a non-significant ($p > 0.05$) increase in plasma AST, ALT, ALP and total protein, while a significant increase in albumin level was observed among all text groups when compared to the group fed on normal rat chow (Table 3). Also, a little or no change was observed in plasma total and conjugated bilirubin concentration among the test groups (Table 3). However, a significant increase ($p < 0.05$) in plasma urea ($p = 0.000$) and creatinine ($p = 0.030$) concentrations was observed among HPD- and HFD-fed rats when compared to rats fed on normal chow (Table 3), indicating a possible impairment in chronic fat diet.

Effects of dietary composition on plasma lipid and lipoproteins

The result of lipid profile showed a significant increase ($p < 0.05$) in plasma cholesterol (p = 0.000), triglycerides ($p = 0.000$), LDLC ($p = 0.000$), and a significant decrease ($p < 0.05$) in plasma HDLC ($p = 0.000$) among HFD-fed rats (Table 4). A significant ($p < 0.05$) decrease in plasma cholesterol ($p = 0.000$), triglycerides ($p = 0.000$), and LDLC ($p = 0.000$) was also observed among HPD and HCD-fed rats (Table 4). Atherogenic and coronary risk indices were observed to be significantly increased ($p = 0.000$; $p < 0.05$) among HFD-fed rats when compared to other groups (Table 4).

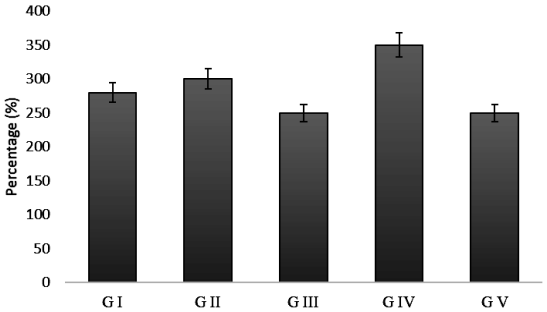

Figure 1. Percentage weight changes among the different groups. Group I = Normal rat chow, Group II = High carbohydrate diet (75%), Group III = High protein diet (75%), Group IV = High fat diet (75%), Group V = Equal proportion of carbohydrate, protein, and fat diet (25% each). Values are expressed as mean ± standard deviation (mean) and are statistically significant at $p < 0.05$

Table 2. The effects of dietary composition on weight among control and treatment groups

Weight	G I	G II	G III	G IV	G V	F	P value
Week 0	42.2±5.97	43.2±6.91	43.2±14.72	41.6±10.01	43.4±4.16	1.39	0.253
Week 1	57.6±14.60	58.0±8.51	65.2±11.61	66.2±16.02	55.0±9.08	5.58	0.001*
Week 2	73.0±25.18	72.6±9.40	68.0±35.33	77.2±16.99	66.2±12.70	7.69	0.000*
Week 3	95.2±30.79	91.6±11.44	96.8±10.03	89.4±20.88	84.0±16.63	15.29	0.000*
Week 4	112.2±34.45	116.2±10.76	116.0±7.97	106.2±23.97	100.0±14.99	24.45	0.000*
Week 5	126.4±18.22	135.8±14.18	130.2±10.03	141.8±36.40	123.8±31.67	29.64	0.000*
Week 6	141.4±20.39	147.0±20.62	138.2±6.98	158.2±37.52	136.2±32.09	32.76	0.000*
Week 7	156.8±24.99	160.4±23.27	146.0±7.38	173.2±37.84	151.6±38.66	37.50	0.000*
Week 8	161.6±25.43	174.2±24.85	149.4±9.04	185.4±41.69	154.0±43.30	37.67	0.000*

Note: Group I = Normal rat chow, Group II = High carbohydrate diet (75%), Group III = High protein diet (75%), Group IV = High fat diet (75%), Group V = Equal proportion of carbohydrate, protein, and fat diet (25% each). Values are expressed as mean ± standard deviation (mean) and are statistically significant at $p < 0.05$. Weights of the rats were taken using a digital precision scale

Table 3. The effects of dietary composition on plasma hepatorenal markers among the control and treatment

Parameters	G I	G II	G III	G IV	G V	F	P value
FPG (mg/dl)	85.60±11.70	82.00±14.77	77.13±22.84	127.25±28.04	80.78±7.29	5.63	0.000
AST (IU/L)	37.00±12.12	34.00±6.48	33.80±3.77	34.00±1.15	34.20±8.32	1.86	0.140
ALT (IU/L)	19.20±7.53	17.00±4.08	18.80±2.59	19.36±7.53	17.40±4.67	0.25	0.910
ALP (IU/L)	15.20±3.63	14.00±3.65	17.40±2.97	24.67±5.77	17.60±4.72	2.18	0.090
TP (mg/dL)	7.98±1.75	8.08±1.09	8.66±1.00	10.10±0.95	8.48±2.10	0.85	0.510
Alb (mg/dL)	3.92±0.38	4.00±0.89	4.30±0.51	5.10±0.26	4.46±0.44	3.67	0.010
TB (mg/dL)	0.04±0.01	0.04±0.01	0.05±0.01	0.05±0.15	0.04±0.01	2.10	0.100
CB (mg/dL)	0.02±0.01	0.03±0.01	0.03±0.01	0.03±0.01	0.03±0.01	0.78	0.540
Urea (mg/dL)	39.4±5.28	35.0±6.27	42.2±15.71	46.00±13.53	34.40±6.43	5.40	0.000
Creat (mg/dL)	0.9±0.03	0.7±0.04	1.3±0.05	1.6±0.06	0.7±0.02	3.18	0.030

Note: Group I = Normal rat chow, Group II = High carbohydrate diet (75%), Group III = High protein diet (75%), Group IV = High fat diet (75%), Group V = Equal proportion of carbohydrate, protein, and fat diet (25% each). Values are expressed as mean ± standard deviation (mean) and are statistically significant at $p < 0.05$

Table 4. The effects of dietary composition on plasma lipid and lipoproteins among the control and treatment groups

Parameters	G I	G II	G III	G IV	G V	F	P value
Chol (mg/dL)	146.2±64.4	120.0±16.2	87.8±21.1	244.0±14.0	92.60±23.51	14.79	0.000
Trig (mg/dL)	89.6±62.3	71.3±21.1	72.5±20.1	126.0±16.9	38.20±9.31	8.06	0.000
HDL (mg/dL)	48.8±21.6	45.5±6.1	44.3±7.8	43.3±4.6	29.6±4.33	12.70	0.000
LDL (mg/dL)	79.48±32.5	60.24±3.4	75.7±33.3	100.0±2.5	55.60±12.93	11.10	0.000
AI	1.63±0.12	1.32±0.01	1.71±0.03	4.05±0.06	1.89	74.27	0.000
CRI	2.99±0.05	2.64±0.04	3.04±1.63	5.64±0.14	3.32	10.03	0.000

Note: Group I = Normal rat chow, Group II = High carbohydrate diet (75%), Group III = High protein diet (75%), Group IV = High fat diet (75%), Group V = Equal proportion of carbohydrate, protein, and fat diet (25% each). Values are expressed as mean ± standard deviation (mean) and are statistically significant at $p < 0.05$

Table 5. The effects of dietary composition on plasma electrolytes among the control and treatment groups

Parameters	G I	G II	G III	G IV	G V	F	P value
Potas (mEq/L)	5.0±0.80	5.2±0.25	4.9±0.94	4.6±0.10	4.7±0.42	0.64	0.640
Sodiu (mEq/L)	143.4±7.64	142.8±6.40	147.0±7.97	140.0±5.13	146.4±5.73	2.43	0.070
Chlori (mEq/L)	100.0±6.89	100.8±7.45	98.4±10.06	102.0±2.65	101.0±7.18	0.75	0.570
Bicar (mg/dL)	20.5±1.42	21.28±3.92	19.0±1.02	26.0±5.51	21.9±3.85	0.60	0.670
Ph	7.18±0.85	7.68±0.32	7.02±0.84	8.20±0.10	7.46±0.56	0.19	0.940

Note: Group I = Normal rat chow, Group II = High carbohydrate diet (75%), Group III = High protein diet (75%), Group IV = High fat diet (75%), Group V = Equal proportion of carbohydrate, protein, and fat diet (25% each). Values are expressed as mean ± standard deviation (mean) and are statistically significant at $p < 0.05$

Effects of dietary composition on plasma electrolytes

The plasma electrolyte result revealed a non-significant decrease ($p > 0.05$) in potassium ($p = 0.064$) and sodium ($p = 0.070$) and a non-significant increase ($p > 0.05$) in plasma chloride ($p = 0.057$), bicarbonate ($p = 0.067$), and pH ($p = 0.094$) among HFD-fed rats compared to rats in other groups. However, the values are within normal ranges (Table 5).

Discussion

In human, the ideal carbohydrate intake is 40-70% of total energy intake, protein is 0.80 g/kg body weight, and total fat is 20-35% of total calories (Liu Ann et al. 2017; Shafiee 2019). Chronic administration of HFD has been reported to result in increased body weight, obesity and increased blood glucose (Putri et al. 2021). In this study, an increase in body weights was observed across all the groups but was most obvious in the HFD-fed group (Table 2). The percentage increment in body weight was 280% in normal rat chow, 300% in HCD, 250% in HPD, 350% in HFD and 250% in the equal proportion diet group (Figure 1). The observed increase in body weight among HFD-fed rats confirms the existence of obesity in this group as facilitated by the development of a positive energy balance leading to an increase in peripheral and visceral fat deposition and ultimately obesity. This finding corroborates reports from similar studies (Abi et al. 2020). The observed relatively low weight among HPD-fed group reflects a reduction in food and calorie intake due to increased satiety as determined by a marginal increase in satiety hormones secretion (GIP, and glucagon-like peptide-1) and reduction in ghrelin secretion, an anorexigenic hormone (Anyakudo and Adeniji 2020). The sustained satiety induces a negative energy balance, thereby promoting weight loss.

The macronutrient components of diet determine the digestibility and availability of end-products for oxidative generation of energy for cellular activities. Results from this study revealed an increase in FPG among HFD-fed rats and a decrease among HPD-fed rats when compared to other groups (Table 3). This corroborates a report from a previous study (Lozano et al. 2016). The observed increase in FPG among HFD-fed rats reflects existing visceral adiposity, some degree of insulin resistance, hyperinsulinemia, reduced fatty acid synthesis, increased basal lipolysis and consequent increase in fatty acid delivery to the liver. The observed little or no change in glucose concentration among HPD-fed rats reflects compensatory metabolic changes through glycogenolysis and gluconeogenesis involving lactate, glycerol, glucogenic amino acids, and odd-chain fatty acids to maintain glucose homeostasis. However, excess amino acids from HPD are oxidatively converted to glucose.

Excessive dietary components are absorbed through the intestinal mucosa to reach the liver through the portal vein, hence making the hepatocytes vulnerable to lesions. The presence of liver lesions or damage involving hepatocyte destruction with plasma membrane disruption is confirmed using plasma ALT, AST, and ALP activities, with ALT being more liver-specific and related to hepatic fat deposition and insulin resistance (Liu et al. 2021). Result from this study revealed a non-significant ($p > 0.05$) increase in plasma AST, ALT and ALP activities among rats fed on HCD, HPD, HFD and equal proportions of the macronutrients when compared with the control group, with highest activities among the HFD-fed group (Table 3). The increase in plasma ALT, AST and ALP among HFD-fed rats corroborates results from similar studies in rats (dos Santos Lacerda et al. 2018; Lasker et al. 2019). The observed increase in plasma ALT, AST and ALP among HFD-fed rats maybe due to an associated development of non-alcoholic fatty liver disease with disruption of liver functions and loss of hepatocellular integrity. Also, an increase in plasma total protein and albumin concentrations was observed among all test groups when compared to the group fed on normal rat chow (Table 3). A similar increase in plasma total protein and albumin concentrations has been reportedly found among HPD-fed rats (El-Deen et al. 2018).

Bilirubin is a product of the degradation of red blood cells in the liver, spleen, and bone marrow. The removal of this degradation product (bilirubin) from the body is done by bilirubin metabolism and its excretion by the liver. Hyperbilirubinemia results when there is a disease affecting liver function. In this study, no obvious changes in plasma total and conjugated bilirubin concentration were observed among the test groups when compared to normal rat chow-fed group (Table 3).

As a measure of the excretory function of the kidney, plasma urea and creatinine are widely used markers of adequate glomerular filtration. High plasma concentration of creatinine indicates a falling glomerular filtration rate and consequent decreased capability of the kidneys to excrete waste products. Result from this study, revealed a non-significant decrease ($p > 0.05$) in plasma urea and creatinine concentrations among HCD-fed rats and a significant increase ($p < 0.05$) in plasma urea and creatinine concentrations among HPD and HFD-fed rats when compared to rats fed on normal chow (Table 3). These findings agree with earlier reported findings by researchers (dos Santos Lacerda et al. 2018; El-Deen et al. 2018). This suggests that chronic exposure to HPD and HFD may predispose to renal dysfunction and exposure to HCD is safer.

Poor diet as indicated by hypertriglyceridemia, hypercholesterolemia and increase LDLC has been reported to be a major risk factor for some chronic diseases such as Cardiovascular Disease (CVD) (Hedayatnia et al. 2020). Results from this study showed a significant increase ($p < 0.05$) in plasma cholesterol, triglycerides, LDLC and a significant decrease ($p < 0.05$) in plasma HDLC among HFD-fed rats (Table 4). This finding corroborates reports from similar studies (Lasker et al. 2019). This may be due to high monounsaturated and saturated fat content of the HFD, increased de novo fatty acid synthesis, increased uptake and esterification of dietary fatty acids and a decrease in fatty acid oxidation. A significant ($p < 0.05$) decrease in plasma cholesterol, triglycerides, and LDLC was also observed among HPD-fed rats (Table 4). This finding is in contrast to a previous study (Tischmann et al. 2019). This observation reflects increased amino acid

contribution to energy generation, and compensatory increase in lipolysis as an alternative calorie generation due to decreased supply from dietary glucose.

Considering the impact of HCD on lipid profile, a decrease was observed in cholesterol, triglycerides, and LDLC concentrations among HCD-fed rats when compared with the rats fed on normal chow (Table 4). In contrast, an increase in plasma total cholesterol and triglyceride concentrations was reported by researchers in a previous study (Semiane et al. 2017). In determining the atherogenic effect of the administered feed, a significant increase ($p < 0.05$) in atherogenic ($p = 0.000$) and coronary risk indices ($p = 0.000$) was observed among HFD-fed rats when compared to other groups (Table 4). This indicates an increased chance of developing cardiovascular complications following ingestion of HFD by the rats.

Plasma electrolyte level reflects the hydration status, and its measurements are useful in investigating conditions that cause electrolyte imbalances, such as dehydration, kidney disease, lung diseases, endocrine (glandular) or heart conditions where high or low levels can be observed. Results from this study revealed a non-significant decrease ($p > 0.05$) in plasma potassium and sodium; and a non-significant increase ($p > 0.05$) in plasma chloride, bicarbonate, and pH among HFD-fed rats when compared to rats in other groups; however, the values are within normal ranges (Table 5). The observed changes in plasma electrolytes may be due to alterations in plasma tonicity and urinary excretion of electrolytes. This study has the support of a previous study on humans which reported the deleterious effects of excessive intake of carbohydrate on human health (Clemente-Suárez et al. 2022). Similarly diet low in fat had been reported to lower deaths from breast cancer and has a beneficial effect on human health (Billingsley et al. 2018). However, the place of protein in NCDs appears to be beneficial too (Azzini et al. 2022).

In conclusion, this study showed that HFD can predispose to obesity and Diabetes mellitus. Also the HFD fed rats developed disruption of lipid profile causing dyslipidemia and a significant increase in both Atherogenic and coronary risk indices. All these are risk factors for non-communicable diseases. The liver and kidney function markers did not show significant deleterious effects on the rats and electrolytes were not significantly affected, this study has shown that macronutrient with high fat composition can predispose to many risk factors of non-communicable disease. The findings in this pilot study highlight the need for further studies using humans in a large population.

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