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Effect of *Plantago rugelii* (Plantaginaceae) Methanol Whole Plant Extract on Body Weight and Blood Lipid Profiles on High Fat Diet-Induced Obese Wistar Rats: Implication for Public Health

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Abstract

Obesity is a chronic metabolic disorder characterized by increased adipose tissue mass due to positive energy balance. It is a public health challenge affecting all age groups including children and adolescents. The present study was designed to investigate the preventive effect of the whole plant extract of *Plantago rugelii* and a conventional drug Orlistat on the lipid profile in obese albino rats *viz-a-viz* its effect on the body mass. Thirty adult Wistar albino rats were sorted into six groups comprising of five animals per group. The first three (treatment groups) were administered 50, 100 and 150 mg/kg body weight of the extract in addition to the administration of 10, 25 and 50% high-fat diet. Groups IV and V (positive control groups) received 50% high-fat diet and normal standard diet respectively in addition to receiving 30 mg/kg body weight of orlistat. Group VI (negative control group) received normal standard diet and 1 mL 0.9 mL normal saline. All animals were fed with for 14 days' duration. The changes in the body weight was determined for all groups and blood were collected, centrifuged with the serum used for the lipid profile. There was no statistical significant difference in the total cholesterol, triglycerides and low density cholesterol levels among the extract treatment groups and the standard group but there were statistically significant differences between the extract treatment and standard groups when compared with that of the negative control group. The extract and the standard drug however brings about an increase in the good (HDL – C) and decrease (LDL – C) levels respectively when compared to the negative control group. Conclusively, *Plantago rugelii* whole plant extract had an anti-lipidemic activity with respect to improving HDL - Cholesterol status hence recommended for development as an anti-lipidemic agent.

Keywords: Lipids, Obesity, Orlistat, Plantago rugelii

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Introduction

Obesity has become a global health epidemic which accompanied with dyslipidemia, diabetes, insulin resistance, hypertension, stroke and arteriosclerosis which is an important contributor to essential hypertension in humans [1]. The Framingham Heart Study reports that about 78% of essential hypertension in men and 65% of essential hypertension in women can be directly attributed to obesity [2]. The consumption of a high-energy density, high-fat diet is thought to be one of the main factors responsible for obesity [3] as recent studies have shown that the consumption of dietary fats promote hypothalamic resistance to the main anorexigenic hormones, leptin and insulin, leading to the progressive loss of the balance between food intake and thermogenesis and, therefore, resulting in body mass gain [4 - 7]. Despite considerable efforts by scientists and health care professionals to understand and successfully treat obesity, its incidence continues to rise and he obesity-related health costs are staggering hence this study aim to was to investigate the impact of high-fat diet-induced obesity on the body mass index and lipid profile.

Experimental

Plant Materials Collection, Preparation and Identification

The fresh whole plant comprising the roots, stems and roots were freshly collected from Othame village in Etsako East LGA . The plant upon collection was washed with running tap water to remove earthy impurities. They were shaded dried until a constant weight was obtained. The fresh plant leaves was sent to Forest Research Institute of Nigeria (FRIN) for confirmation and affirmation of the earlier deposition made where herbarium specimen has earlier been deposited and voucher number 109775 issued. The dried plant materials were pulverized with mechanical grinder and stored in an air tight glass container until ready for use

Animals Procurement, Handling and Treatment

Adult Wistar albino rats (8 weeks old) and weighing (180 g $\pm$ 20) were sourced from the Animal House of the Department of Pharmacology and Toxicology, Faculty of Pharmacy, Madonna University Nigeria Elele Campus. The rats were accommodated in plastic cages (5 animals per cage) and kept under standard environmental conditions, including a temperature of 25^{o}C and a 12 h light/dark cycle. Ethical approval for the study was granted by the Madonna University Ethics Committee for Animal Use with the assigned number MU/ECAU/FPS/PCH/001.

Extract Preparation

The extraction of the plant material was done by macerating the pulverized plant materials with absolute methanol for 72 hours. The obtained marc was further remacerated with the same solvent for a further 5 days to ensure exhaustive extraction. This is as performed by Cyril *et al* [8]

Animal Groupings

The animals were given unrestricted access to a standard rodent diet (Ewu Mill). The animals were randomly divided into 6 groups: Groups I to III (treatment groups) received 10, 25 and 50% high-fat diet (HFD) (the percentages composition obtained by the reconstitution of the HFD and normal diet) in addition to receiving 50, 100 and 150 mg/kg body weight of *P. rugelii* extract, while IV and V (positive control) received 50% HFD and normal standard diet respectively in addition to receiving 30 mg/kg body weight of orlistat, group VI (negative control) received normal standard diet and 1 mL 0.9 mL normal saline. All animals were fed with HFD produced by the National Institute of Nutrition (NIN), Hyderabad, Andhra Pradesh, India for 14 days. Table 1 shows the detailed analysis of normal diet and HFD as reported by Rodrigues *et al* [9]. All other chemicals used were of analytical grade. Double distilled water was used for all biochemical assays.

Proximate Analysis

The normal experimental diet proximate composition was ascertained using the established AOAC procedures [10]. This included moisture content by oven drying, ash content by incineration in a muffle furnace, crude protein using the Kjeldahl method, crude fat by Soxhlet extraction, and carbohydrate by difference.

Table 1 Proximate analysis of the high-fat and normal diet

Description	Normal Diet	High Fat Diet (HFD)
Moisture and volatile matter (%)	12.46 ± 0.5	12.40 ± 0.1
Protein (%)	7.20 ± 0.2	17.90 ± 0.2
Ether extract (fat) (%)	4.50 ± 0.5	34.40 ± 1.1
Fiber (%)	2.70 ± 0.1	3.90 ± 0.3
Mineral content (%)	2.60 ± 0.1	2.60 ± 0.1
Carbohydrate (%)	15.00 ± 0.0	33.40 ± 0.2

Note: The percentage determination is based on dry weight analysis with determinations performed in triplicate and expressed as mean ± standard error of mean (SEM)

Body Weight Determination and Blood Analysis

Body weight measurements was done on a weekly basis by placing the animals individually in sterile containers. Blood samples were collected from caudal vein, without anesthesia using sterile syringes and transferred into EDTA tubes for

plasma separation. The blood was centrifuged within 30 min, at 1000 rpm for 5 min to obtain the serum using a bench centrifuge. The serum was subsequently utilized for the lipid profile determination.

Biochemical Assay

Standard techniques were used to determine the lipid profile. Commercial assay kits from Randox Laboratories were used to measure serum total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C). To guarantee the accuracy and precision of the findings, every analysis was performed in triplicate.

Statistical Analysis

Mean ± standard error of mean (SEM) was used to present the data. One-way analysis of variance was used to estimate group mean differences, and the Tukey test was used for all pairwise comparisons. Statistical significance is assumed at 95% confidence level.

Results and Discussion

Percentage yield

The percentage yield of the methanol whole plant extract of *P. rugelli* was found to be 4.73% as reported by Cyril *et al*. [8]

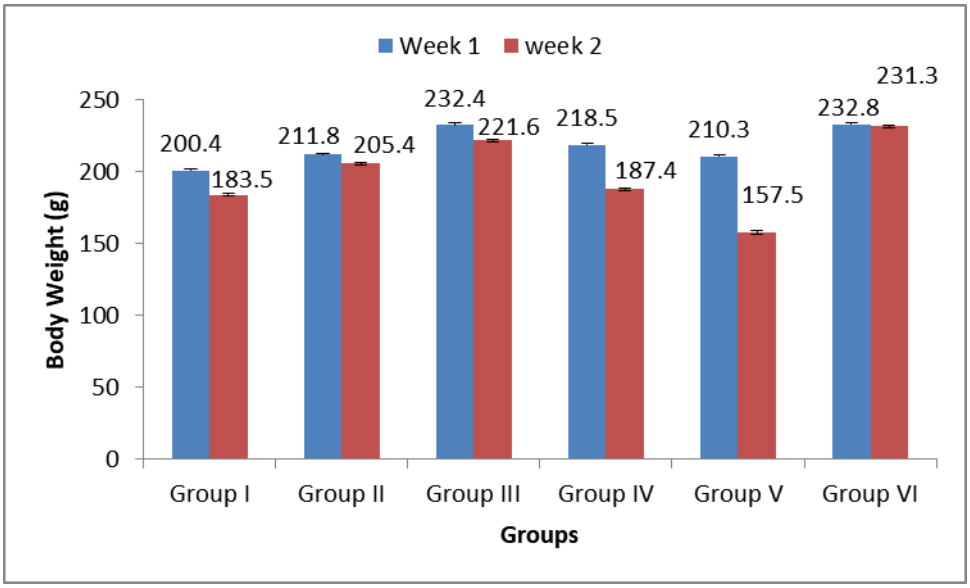


Figure 1 Effect of high-fat diet on changes in body weight

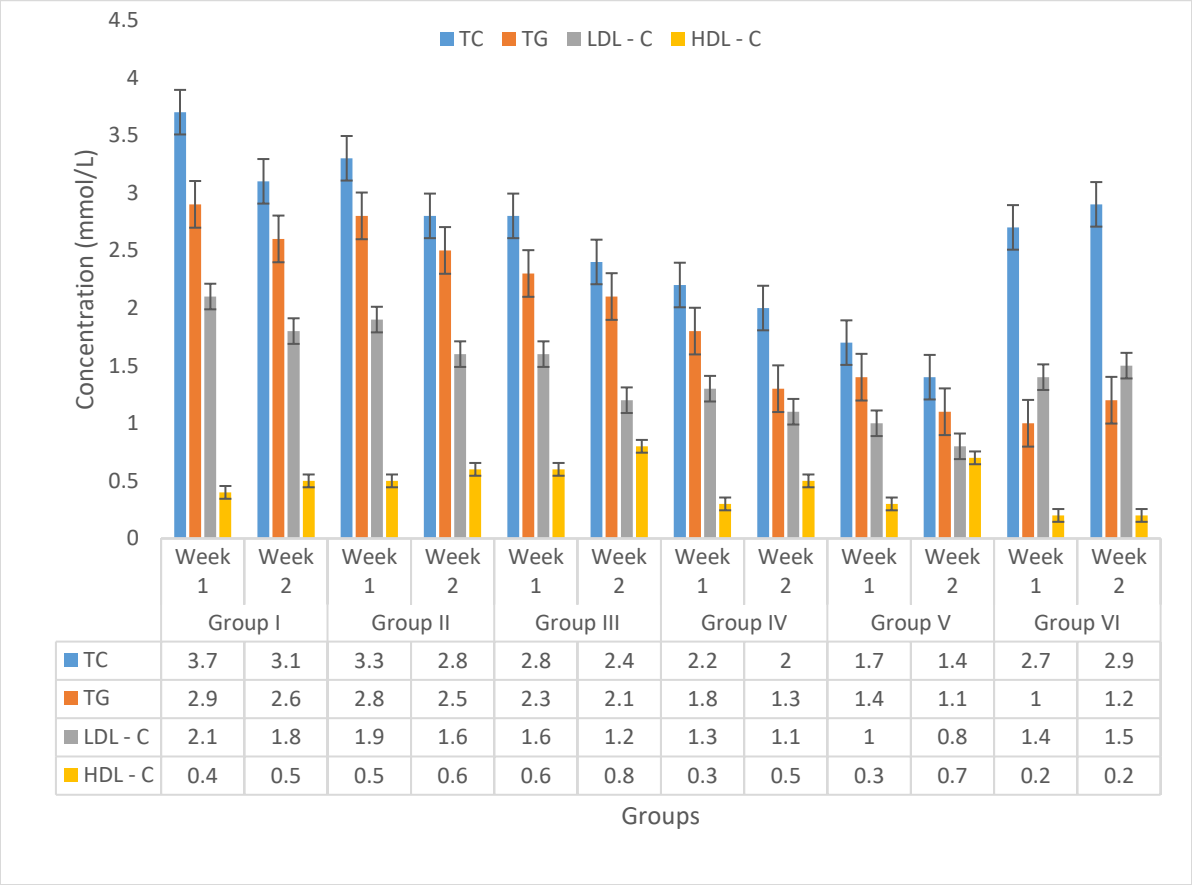
Effect of High-Fat Diet on Body Weight Changes

The impact of the administration of HFD in 2 weeks on the average weight of the animals is presented in Figure 1. Body weight increased gradually among groups I - IV unlike groups V and VI which received no HFD. The results for groups I - III agrees with the report of Yoshida a*t al* [11] which reports that *Plantago lanceolata* leaves prevent obesity in C57BL/G J mice fed with high fat diet. Animals in group V after 2 weeks (the duration of the study) had the least weight (hence best weight reducing ability) a result which is in agreement with the report of Hollywood and Ogden [12] who reports a significant weight weight loss among patient over a 6 months duration. This suggests that, dietary fat supplementation have significant on weight gain. Consistent food intake (results not presented) across all groups further supports the conclusion that the observed weight changes were not driven by differences in appetite or consumption patterns. Previous studies have reported mixed outcomes on the effect of high-fat diets on weight. For instance, Patel *et al* [13] found that diets rich in saturated fats tend to promote greater weight gain compared to unsaturated fats. Our findings align with the report of Shiraev *et al*. [14], who demonstrated that variations in dietary fat sources might have minimal impact on body weight if caloric intake is maintained. This suggests that calorie content, rather than fat type, may play a more prominent role in influencing body weight. The steady weight gain observed in

this study shows the potential risks associated with prolonged high-fat diet consumption, irrespective of fat type hence predisposes individuals to obesity and metabolic syndrome over time. These results highlight the significance of calorie moderation and dietary balance in preventing weight-related health issues.

Effect of High-Fat Diets on TC, TG, LDL - C and HDL - C

Fig. 2 presents the effect of various high-fat diets on TC, TG, LDL - C and HDL - C. Despite the variations, statistically significant differences were observed between the treatment and standard groups with that of the negative control group. This suggests that the tested high fat diet significantly elevate all investigated lipid parameters in agreement with the findings of Edem [15] who reports that diets high in refined fats or saturated fatty acids may slightly elevate cholesterol levels. It was observed that thou group IV were treated with the HFD, the simultaneous administration of the standard drug orlistat brought about a reduction in the lipid profile of group's I - III which received HFD and the plant extract. This confirms the standard drug has a better antihyperlipidemic activity than the plant extract. The antihyperlipidemic property of the administered plant extract increases in a dose dependent manner (groups I - III). This could be attributed to the presence of tannins, phenols and flavonoid which has earlier been reported by Cyril *et al* [8] to be present in the plant extract. These phytochemicals have been proposed to be able to enhance the activities of hepatic lipogenic and cholesterogenic enzymes such as malic enzyme. Fatty acid synthase, glucose - 6 - phosphate dehydrogenase and HMG - coA reductase which are all required for cholesterol synthesis [16 - 19] The difference in the statistical significance of this study compared to that reported by Yu *et al* [20] could be as a result of species-specific metabolic responses or the duration of dietary exposure. Across all groups, HDL- C levels were not significantly different, indicating that feeding the rats with the high-fat diet did not lead to substantial variations in HDL- C concentration when compared to the control. This suggests that the HFD have comparable impacts on maintaining HDL-C levels in the study, this confirms HDL - C as being a favorable component for cardiovascular health



	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2
	Group I		Group II		Group III		Group IV		Group V		Group VI	
TC	3.7	3.1	3.3	2.8	2.8	2.4	2.2	2	1.7	1.4	2.7	2.9
TG	2.9	2.6	2.8	2.5	2.3	2.1	1.8	1.3	1.4	1.1	1	1.2
LDL - C	2.1	1.8	1.9	1.6	1.6	1.2	1.3	1.1	1	0.8	1.4	1.5
HDL - C	0.4	0.5	0.5	0.6	0.6	0.8	0.3	0.5	0.3	0.7	0.2	0.2

Figure 2 Effect of high-fat diet on the different lipid profile. Key: TC = Total Cholesterol, TG = Triglycerides, LDL - C: Low Density Lipoprotein Cholesterol, HDL - C = High Density Lipoprotein Cholesterol

Conclusion

This study successfully investigated the intricate interactions between dietary fat content and metabolic health outcomes, such as the consumption of high-fat diet on the body. The results indicate that while the HFD led to weight

gain, the plant extract and the standard drug showed relatively favorable effects on lipid profiles which could potentially be attributed to their bioactive components. These findings underscore the importance of dietary fat selection, not merely for weight management but also for mitigating cardiovascular risk. This evidence supports targeted dietary recommendations prioritizing fats with healthier profiles and calls for further research into their long-term effects on human health to guide public health strategies and individualized nutrition planning.

Declaration of Competing Interest

There is no conflict of interest to declare.

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