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Some Biochemical Changes in Rats Maintained on High Fat Diets Supplemented with *Pennisetum purpureum* (Schumach)

[*1]Ijeh, I. I., [1,2]Egedigwe, A. C., [1]Eke, I. N. and [1]Uzoho, M. C.

[1]Department of Biochemistry, College of Natural and Applied Sciences,
Michael Okpara University of Agriculture, Umudike, PMB 7267, Umuahia, Abia State, Nigeria.
[2]Department of Chemistry/Biochemistry/Molecular Biology, Faculty of Science and Technology, Federal University Ndufu-Alike, Ikwo, PMB 1010 Abakaliki, Ebonyi State, Nigeria.

Abstract: The effects of graded dietary incorporation of *Pennisetum purpureum* on plasma lipid profile, oral glucose tolerance test, relative organ and body weight changes in high-fat diet (HFD) fed rats were investigated. Lipid profile estimation was done using standard kits while blood glucose concentration was determined using a glucometer kit. The results show that there were significant ($p<0.05$) decreases in total cholesterol (TC), triacylglycerol (TAG), LDL-cholesterol (LDL-C) concentrations in animals fed HFD-incorporated with both 10 and 20 % *Pennisetum purpureum* relative to those fed HFD only. While a significant ($p<0.05$) increase in HDL cholesterol concentrations was observed in the test rats relative to the animals fed HFDs only. Oral glucose tolerance tests significantly improved in the group fed 10% *Pennisetum purpureum.* Relative weights of the spleen, kidney, liver, heart and intestine showed no significant ($p>0.05$) changes relative to the control group fed HFD. These findings are indicative that dietary incorporation of *Pennisetum purpureum* could modulate blood glucose responses and blood lipid profile in high fat diet fed rats. This may be beneficial to individuals who are predisposed to high fat diet related obesity and its associated metabolic disorders. It may therefore warrant further investigation, perhaps in humans.

KEYWORDS: *Pennisetum purpureum*, High fat diets, Body weight, Obesity, Lipid profile

1.0 Introduction

Obesity has become one of the most important public health problems and is rapidly turning into an epidemic. In 2014, more than 1.9 billion adults, 18 years and older were overweight. Of these over 600 million were obese (WHO, 2014). Obesity and overweight have been reported to be associated with diet-related chronic diseases, including type II diabetes, cardiovascular disease, and several forms of cancer. Individuals who are obese are at higher risk from coronary artery disease, hypertension, hyperlipidemia, gall bladder disorders, osteoarthritis and sleep apnea (Flegal *et al.*, 2007; Eckel, 2008)

Currently, due to the dissatisfaction with high costs and potentially hazardous side-effects of conventional drugs, the potential of natural products for treating obesity is under exploration and this may be an excellent alternative strategy for developing future effective, safe anti-obesity drugs (Park *et al.*, 2005; Nakayama *et al.*, 2007; Mayer *et al.*, 2009). Therefore, medicinal plants have been looked upon for the management of obesity and overweight, which could be better tolerated and more efficacious (Yun, 2010). Herbal plants and medicines are being considered for treating obesity due to their successful use in traditional medicine. Furthermore, it is far more convenient for individuals to apply dietary means in the management of non-communicable chronic diseases such as diabetes and obesity. *Pennisetum purpureum* is one plant that holds a lot of promise in this wise, hence this study.

***Corresponding Author**
Tel.: +23408064719842
E-mail: ijeh.ifeoma@mouau.edu.ng

Pennisetum purpureum is classified as a weed grass. It is native to Africa and Australia (Archer and Bunch, 1953). Its common names are elephant grass, Napier grass and Meker grass. Its local name among the Igbo tribe in Nigeria is "achara". Various communities in Umuahia are distinctively known for this stem vegetable which are used for soup preparations such as in preparing "ofe achara" , 'ofe ukazi' and "ofe ugu". The matrixes of the matured shoots are used for preparing these special soups (Okaraonye and Ikewuchi, 2009).

This study aimed at investigating the lipid profile and blood glucose responses in rats fed high fat diets incorporated with *Pennisetum purpureum* Schumach. The results may offer insights into alternative means of preventing and managing diseases associated with hyperlipidaemia and hyperglycaemia.

2.0 Materials and Methods

2.1 Plant Material

Fresh pseudo stems of *Pennisetum purpureum* were purchased from Ahiaukwu Olokoro market in Abia State and were identified by Dr Omosun G. of the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike. After ridding them of dirt, their outer, hard and fibrous portion (Figure 1B) were removed and discarded, while the inner fresh, tender and edible portion was retained (Figure 1A). This edible portion was washed properly and air dried for 4 days. Then blended and stored in air-tight containers.

Fig 1: (A) Soft edible tillers of *Pennisetum purpureum;* **(B)** Harvested pseudostems of *Pennisetum purpureum*

2.2 Animal Handling and Grouping

Eighteen male albino rats aged 6-7 weeks were purchased from the Faculty of Veterinary Medicine of the University of Nigeria, Nsukka. They were housed in standard cages in the animal house of the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike and acclimatized for two weeks. The animals were randomly divided into three groups of six animals each. Rats in Group A (control) were fed a High fat diet (HFD) only; those in Group B received a 10% *Pennisetum purpureum*-incorporated HFD diet; and rats in Group C were fed a 20% *Pennisetum purpureum*-incorporated HFD diet (Table 1). Pelleted diets and clean tap water were provided to all animals by means of pair feeding in their respective cages. The compounded diets were fed to the albino rats for 14 days and daily weights recorded. Change in body weight was measured and calculated using the formula:

Body weight = final body weight − initial body weight.

After 14 days, the blood was collected by cardiac puncture.

2.3: Determination of Lipid profile

Total Cholesterol, HDL–cholesterol and Triacylglycerol concentrations were determined using standard commercial test kits (RANDOX Laboratories, London) following the enzymatic colorimetric methods of Allain *et al.* (1974), Lopes-Virella *et al*. (1977), and Tietz (1990), respectively. LDL-Cholesterol was determined by difference (Friedwald *et al.*, 1972). VLDL-Cholesterol was calculated using the formula: VLDL = [Triacyglycerols (mg/dl)]/5. Relative organ weight was calculated thus:

$$\text{Relative organ weight} = \frac{\text{Organ weight (g)}}{\text{Body weight of animal (g)}}$$

Table 1: Composition of High Fat Diets and Incorporated Diets

	HFD (g/100g)	HFD + 10% PP	HFD + 20% PP
Maize	38.88	38.88	28.88
Groundnut Cake	13.39	13.39	13.39
Crayfish	2.16	2.16	2.16
Vitamin/mineral	1.98	1.98	1.98
Bone meal	1.98	1.98	1.98
Palm oil	6.95	6.95	6.95
Palm kernel oil	6.95	6.95	6.95
Egg yolk Powder	5.84	5.84	5.84
Non-nutritive cellulose	0.40	0.40	0.40
Cornstarch	21.45	11.45	11.45
Pennisetum purpureum	0.00	10.00	20.00
Total	100.00	100.00	100.00

HFD and PP represent high fat diets and *Pennisetum purpureum* respectively.

2.4 Oral Glucose Tolerance Test

Oral glucose tolerance test was carried out using a modification of the method described by Taiwo *et al.* (2009). Rats were fasted overnight and given an oral glucose load of 2 g/kg body weight *per os*. Following the oral glucose load, blood was obtained at 0, 30, 60, 90 and 120 minutes from the tail vein of the rat and analysed for glucose using a glucometer (Accu-check Advantage, Roche Diagnostics, Mannheim).

2.5 Statistical Analysis

Results were expressed as Mean ± Standard deviation. One way ANOVA test with Duncan Multiple Range test was used to determine if differences between the groups were significant. A p value < 0.05 was considered significant. Data were analysed statistically using SPSS Version 16.0.

3.0 Results and Discussion

Total cholesterol, triacylglycerol, LDL and VLDL cholesterol concentrations decreased significantly ($p<0.05$) while HDL cholesterol concentrations significantly ($p<0.05$) increased in test rats, relative to the control group (Figures 2 and 3).

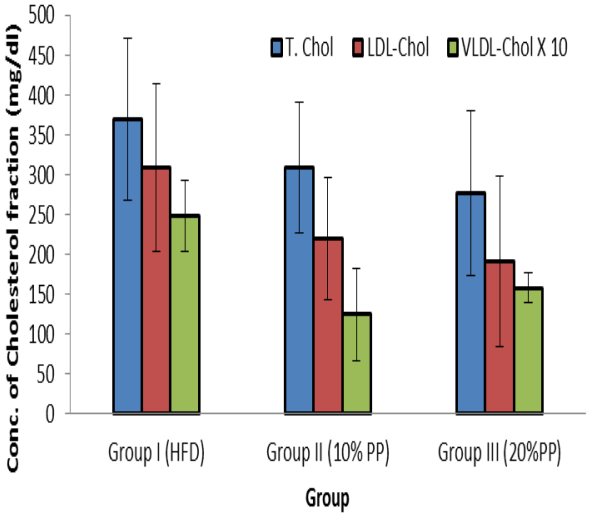

Fig 2: Concentrations of Total Cholesterol, LDL-Cholesterol and VLDL-Cholesterol in albino rats fed high fat diets incorporated with *Pennistum purpureum*

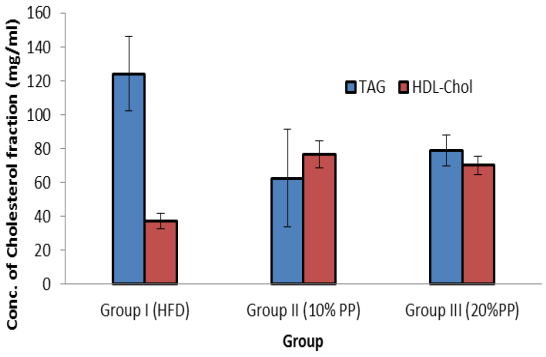

Figure 3: Triacylglycerol and HDL-Cholesterol concentrations in albino rats fed high fat diets incorporated with *Pennistum purpureum*

The reduction in serum cholesterol could be beneficial to individuals with hypercholesterolemia thereby reducing the risk of cardiovascular diseases (Ijeh and Egedigwe, 2010). Dietary incorporation of *Pennisetum purpureum* decreased triacylglycerol concentrations, and could therefore improve hypertriglyceridemia and the associated obesity. Increased LDL concentrations are associated with artherosclerosis, heart attack, stroke and cardiovascular diseases (Bordia and Verma, 1998; Cromwell and Otvos, 2004) and could enhance obesity. Dietary incorporation of *Pennisetum purpureum* reduced LDL susceptibility to oxidation and possibly increased the resistance of plasma LDL to oxidation. It could therefore prevent obesity. *Pennisetum purpureum* probably plays an anti-atherogenic role through the inhibition of lipid oxidation and therefore could promote the reverse cholesterol transport pathway. Findings from this study show that dietary incorporation of stems of *Pennisetum purpureum* clearly modulated hyperlipidemia positively. Okaraonye and Ikewuchi (2009) reported the presence of saponins in *Pennisetum purpureum*. Saponins have been reported to reduce the uptake of cholesterol at the gut through intra-lumenal physicochemical interaction (Price *et al.*, 1987). The serum lipid modulating property of *Pennisetum purpureum* may therefore be attributable to its saponins content.

The improvement in oral blood glucose tolerance was time dependent as seen in Figures 4 and 5.

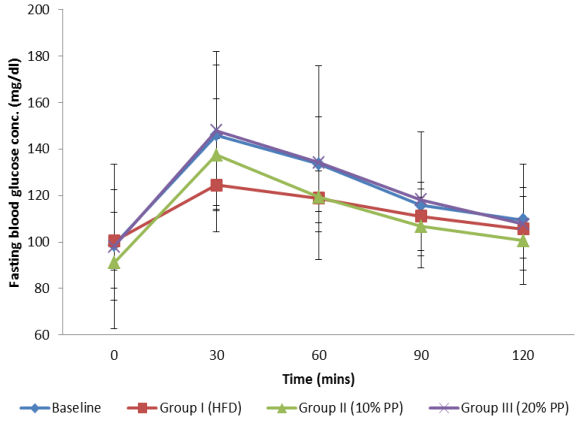

Figure 4: Oral Glucose Tolerance Tests (OGTT) in animals fed diets incorporated with 10% and 20% *Pennnisetum purpereum* diets on the 7th day

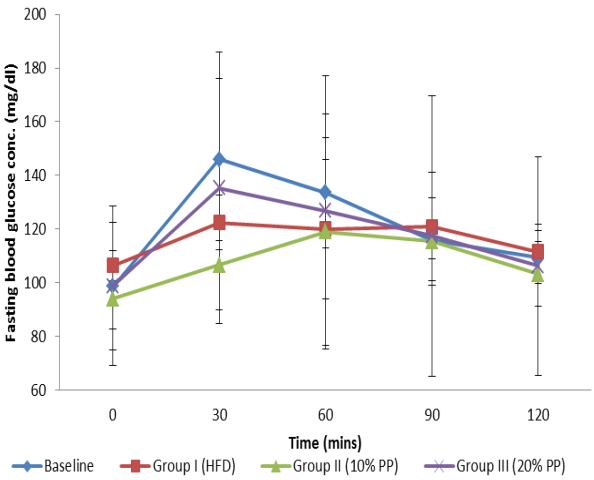

Fig 5: Oral Glucose Tolerance Tests (OGTT) in animals fed diets incorporated at 10% and 20% *Pennnisetum purpereum* diets on the 14th day

This suggests that when consumed over time, it could be useful in the management of impaired glucose tolerance and associated conditions. At baseline blood glucose concentrations (BGC) peaked at 30 minutes before declining in all the groups studied. The results show that after one week of feeding (Figure 4) on the test diets, the blood glucose concentration (BGC) of rats in Groups 3 and 4 peaked at 30 minutes following an oral glucose load before it started declining. On the fourteenth day of dietary incorporation of *Pennisetum purpureum* (Figure 5), the BGC of rats in Group 2 peaked at 60minutes while that of rats in Group 3 peaked at 30 minutes before declining. These results show that *Pennisetum* incorporated diets clearly improved blood glucose of the test rats. The mechanism by which *Pennisetum purpureum* achieved it oral glucose modulatory effect may be through the reduction in glucose uptake from the lumen. Dietary fibres have been reported to be present in *Pennisetum purpureum* (Okaraonye and Ikewuchi, 2009) and plants that contain fibres are known to reduce glucose uptake following a carbohydrate-rich meal.

These fibres also promote a sense of satiety which helps to prevent overeating and weight gain (De Moura *et al.*, 2009). Furthermore, dietary fibres slow down the rate of absorption of cholesterol in the gastro intestinal tract. These

findings show that dietary incorporation of *Pennisetum purpureum* improved oral glucose tolerance as indicated by the lower glucose concentrations at peak blood glucose concentrations in the test groups.

Body weight decreased ($p<0.05$) significantly in groups fed the test diets as shown in Figure 6. The decrease in body weight could be attributed to the high fibre content of the *Pennisetum purpureum* alluded to earlier. Despite the decrease in body weight in the test groups, the relative organ weight of the various organs were statistically similar ($p>0.05$) (Figure 7) suggesting that the weight loss may have been due to loss in body fat as organ masses were spared.

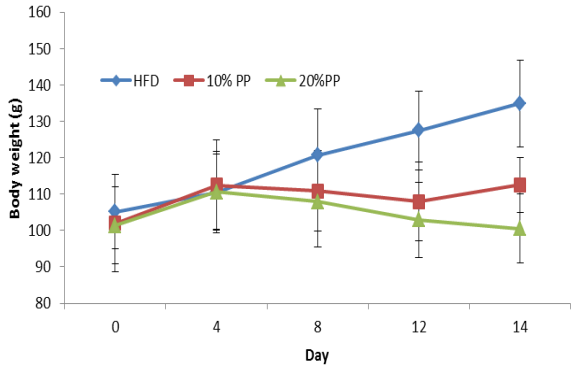

Fig 6: Body weight in albino rats fed high fat diets incorporated with *Pennistum purpureum*

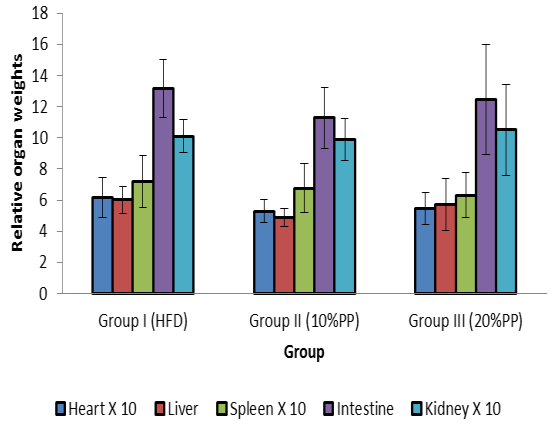

Fig 7: Relative organ weight in animals fed HFD and diets incorporated with *Pennisetum purperum*

Consumers of various local soups prepared with *Pennisetum purpureum* may benefit from the reported modulation of serum lipids, improvement of blood glucose, and weight loss potential of the plant. These could open new vistas in the management of metabolic derangements related to the above factors. However, this is to our knowledge the first report of the usefulness of *Pennisetum purpureum* in the improvement in lipid profile parameters, oral glucose tolerance and weight loss. Further studies on *Pennisetum purpureum* are warranted, and are underway in our laboratory.

This study concludes that rats fed the test diets lost significant amounts of weight without any reduction in relevant relative organ weights. The test diets also modulated oral glucose tolerance, as well as serum lipid profile of the rats, positively. These results may find application in the management of diabetes, impaired glucose tolerance, lipidaemias and associated disorders.

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