Effects of replacing high fat diet by low fat high-protein diet supplemented with two levels of unripe bananas powder and its peels on obese rats.

Shimaa Mohammed Hasnin Aboelnaga
Assistant Professor of Nutrition and Food Science
Self – development skills Department, Deanship of Preparatory Year, University of Hail

Abstract: This study was undertaken to determine whether replacing from high fat diet by low fat - high protein diet fortified with two levels of unripe bananas powder and its peels would alter the quantity of lipid fraction, liver enzymes, leptin hormone and glucose of rats suffering from obesity. Two main experimental groups of rats were used in this experiment. The first main group (6 rats) were fed on basal diet as a control negative, while the second main group (42 rats) were fed on high fat diet (for 6 weeks) to induce obesity. Then, the second main group was divided into seven subgroups (n = 6) according to the following: Subgroup 1: fed on high fat diet (HFD) as a control positive group, subgroup (2): was fed on low fat diet (LFD). Subgroup (3): was fed on low fat and high protein diet (LF) and (HPD). Subgroups (4 and 5): were fed on LF and HPD (containing 3% and 6% unripe banana powder flour, respectively). Subgroup (6 and 7): were fed on LF and HPD (containing 3% and 6% banana peels powder, respectively). Feeding rats on (HFD) induced defectiveness in lipid profile, leptin hormone, glucose and liver enzymes. Feeding obese rats with LF & HP diets containing the two levels from unripe banana and its peels (3 & 6%) led to decrease in body weight gain, serum biomarkers (i.e. cholesterol, triglycerides, low & very low density lipoprotein, leptin, glucose and liver enzymes) significantly, while high density lipoprotein increased significantly ($p < 0.05$), as compared to the positive control group fed on HFD, obese group fed on LFD and obese group fed on LF&HPD. In conclusion, feeding obese rats with LF & HPD supplemented with unripe banana and banana peels resulted in significant reduction in body weight gain and blood lipids.

Key words:: obesity, unripe banana, lipids profile, glucose, leptin and liver enzymes.

INTRODUCTION

Genetic and environmental factors play a role in the development of obesity, and diet is one of the main environmental factors that contribute to this disease. Human studies have shown that increased fat intake is associated with body weight gain which can lead to obesity and other related metabolic diseases. Animal rodent models are therefore useful tools for studying obesity as they will readily gain weight when fed high-fat diets (Buettne et al., 2007).

National Institutes of Health (2000) & Eurodiet core report (2001) reported that, in order to prevent cardiovascular disease, cancer, obesity and type 2 diabetes it is recommended that, dietary fat should be reduced from the current 35- 45% of the total energy content in most Western diets to below 30%. Westerterp-Plantenga et al. (2012) and Dong et al. (2013) reported also, substantial evidence exists that supports the consumption of increased dietary protein (ranging from 1.2 to 1.6 g protein / kg / d) as a successful strategy to prevent or treat obesity through reductions in body weight and fat mass concomitant with the preservation of lean mass. The effectiveness of these diets may be due, in part, to modulations in energy metabolism and appetitive signaling leading to reduced energy intake. Furthermore, improvements in cardio metabolic risk factors were also observed with higher protein diets.

Figuerola et al. (2005) reported that, carbohydrates constitute the main fraction of unripe fruits, starch and non-starch polysaccharides (dietary fiber) are the major constituents. Bananas contain various antioxidants, such as vitamin C, vitamin E, and ß-carotene. Antioxidant capacity of a fruit may be due to other antioxidants, such as flavonoids Paul and Southgate (1978) and Kanazawa & Sakakibara (2000). Green bananas have a large amount of starch during its unripe stage, which consists of around 20-25% found in the pulp of the fruits Cordenunsi and Lajolo (1995). Unripe banana flour is a starchy food that contains a high proportion of indigestible compounds such as resistant starch, and non-starch polysaccharides, which are included in the dietary fiber content Pitiporn et al. (2011).

Banana fruits have been reported to prevent anemia by stimulating the production of hemoglobin in the blood. Its role to regulate blood pressure has been associated with the high content of potassium. Banana helps in solving the problem of constipation without necessary resorting to laxatives (Akinyosoye, 1991).

Ethyl acetate and water-soluble fractions of green banana peel showed high antimicrobial and antioxidant activity. Most of the compounds isolated from green peel (ß-sitosterol, malic acid), showed 12-hydroxystrearic acid and succinic acid, showed significant antibacterial activities and low antioxidant activities. While, those compounds isolated from water soluble extracts glycoside and monosaccharide components showed significant antioxidant and low antimicrobial activity Matook and Fumio (2005). Total phenolics compounds are more abundant in peel (907 mg/ 100 g dry weight) than in pulp (232 mg/100 g dry wt.) (Someya et al., 2002).

Banana peel has been widely used in traditional Chinese medicine for the treatment of inflammation of the oral cavity and to promote bowel movements (Sang et al., 2006). Furthermore, as banana peel contains large amounts of vitamins and minerals, it may be used to produce cosmetics as industrial products. In addition to vitamins and minerals, banana peel contains a certain quantity of polyphenols (Liu et al., 2009). Therefore, this study aimed to investigate the effect of replacing high fat diet by low fat high protein diet supplemented with two levels of unripe bananas powder and its peels on obese rats.

MATERIALS AND METHODS

Materials

- Casein, vitamins, minerals, cellulose and choline chloride were purchased from El-Gomhoria Company, Cairo Egypt.
- Corn starch, saturated fat, soybean oil and sucrose were purchased from local market, Cairo, Egypt.
- Unripe banana was obtained from agricultural research center, Giza, Egypt.
- Forty eight male albino rats (Sprague Dawley Strain) (150±10g) were purchased from the Animal House of the Institute of Ophthalmology, Giza, Egypt.

Methods

Unripe banana and peels powder preparation:

Commercial hard green (unripe) preclimacteric banana (*Musa paradisiaca* L.) fruits were obtained from agricultural research center, Giza, Egypt. The unripe banana and its peels were cut into 1cm slices, immediately rinsed in citric acid solution (0.3% w/v). The slices were dried at 50º C, ground using a commercial grinder and stored at 25º C in sealed plastic containers for further analyses Juarez-Garcia et al. (2006).

Chemical analysis of unripe banana and its peels:

Moisture, fiber, ash, protein and fat of banana and its peels were determined according to the method outlined in A.O.A.C. (1990), while a total carbohydrate was calculated by difference. Biological Part: Forty-eight Albino rats (150±10g) were kept in individual stainless steel cages under hygienic conditions and fed one week on basal diet ad libitum for adaptation. After this period, the rats were divided into two main groups. The first main group (6 rats) fed on basal diet, as a control negative group. The second main group (42 rats) was fed eight weeks on high fat diet HFD containing (saturated fat 19%, soybean oil 1% to provide essential fatty acids, sucrose 10%, casein 14%, cellulose 5%, vitamin mixture 1%, salt mixture 3.5%, choline chloride 0.25% and the remainder is corn starch) to induce obesity in rats (Min et al., 2004)**.**

Then the rats in the second main group were divided into seven subgroups (n=6) according to the following. Subgroup (1): fed on HFD as a control positive group (obese group), Subgroup (2): was fed on low fat diet LFD (containing saturated fat 9%, soybean oil 1%, sucrose 10%, casein 14%, cellulose 5%, vitamin mixture 1%, salt mixture 3.5%, choline chloride 0.25% and the remainder is corn starch). Subgroup (3): was fed on low fat and high protein diet LF and HPD (containing saturated fat 9%, soybean oil 1%, sucrose 10%, casein 20%, cellulose 5%, vitamin mixture 1%, salt mixture 3.5%, choline chloride 0.25% and the remainder is corn starch). Subgroup (4, and 5): were fed on LF and HPD (containing 3% and 6% unripe banana flour, respectively). Subgroup (6 and 7): were fed on LF and HPD (containing 3% and 6% banana peels, respectively).

During the experimental period (6 weeks), the diets consumed and body weights were recorded every week. At the end of the experiment, the rats were fasted overnight, then were anaesthetized and sacrificed, and blood samples were collected from the aorta. The blood samples were centrifuged and serum was separated to determine biochemical parameters, i.e. serum total cholesterol, triglycerides, high density lipoprotein (HDL), low density lipoprotein (LDL), very low density lipoprotein (VLDL), glucose, leptin hormone, aspartate amino transaminase (AST), alanine amino transaminase (ALT), alkaline phosphatase (ALP), uric acid, urea nitrogen and creatinine. Atherogenic Index (AI) was calculated according to this equation [AI = LDL-cholesterol / HDL-cholesterol], while Coronary Risk Index (CRI) was calculated according to this equation [CRI = total cholesterol/ HDL-cholesterol] according to the methods described by (Adeneye and Olagunju, 2009). Results of biological evaluation of each group were statistically analyzed (mean ± standard deviation and one way ANOVA test) using SAS package and compared with each other using the suitable test (least significant differences at $P<0.05$.

RESULTS AND DISCUSSION

Chemical composition of unripe banana powder and its peels

The mean values of moisture, ash, protein, lipid dietary fiber and starch of unripe banana and its peels dried powder were (6.30, 4.85, 3.66, 3.09, 15.62 and 66.48 g/100g) and (5.75, 4.42, 7.55, 6.63, 49.77 and 25.88 g/100g), respectively (Table 1). The mean values of total protein, lipid and dietary fiber increased in banana peels, than that of unripe banana.

Table (1): Proximate chemical analysis of unripe banana powder and its peels (g/100 g dry basis).

Sample / Component	Unripe banana powder	Peels powder
	g/100g dry basis	
Moisture	6.30	5.75
Ash	4.85	4.42
Protein	3.66	7.55
Lipid	3.09	6.63
Dietary fiber	15.62	49.77
Total starch	66.48	25.88

These values are the means of two determinations.

On the other hand, the amounts of moisture, ash and starch in unripe banana powder increased than that of banana peels. The chemical composition of banana varieties depends of the ripening state; however, agronomic traits, the type of soil, and climatic conditions alter the major and minor components of the fruit Aurore et al. (2009). Bananas (Musa ssp) are also known as a source of energy, fibers and resistant starch. Banana pulp powder contain 61-76% of starch, 6-15% of total fibers, 2-3% of soluble fibers and 4-12% of insoluble fibers Vieira da Mota et al. (2000). On the other hand, our results was agreement with Juarez-Garcia et al. (2006) who reported that, banana flour contains Moisture (7.1%), Ash (4.7%) Protein (3.3%) Lipid (2.7%) Dietary fiber (14.5%) Total starch (73.4%) Available starch (56.3%) and Available starch (17.5%).

Mosa and Kkalil (2013) reported that, dried banana peels contain 7.25% protein, 4.81% fat, 60.81 carbohydrates, 6.73% moistures, 1.34% ash and dietary fiber 44.28%.

As shown in table, 2 the mean value of feed intake in obese rats fed on HFD decreased significantly $P<0.05$, as compared to the negative control group. On the other hand, feed intake of obese rats fed on LF diet or LF & HPD showed non-significant changes, as compared to the positive control group fed on HFD. All treated groups showed non-significant differences in the mean value of feed intake, except the group fed on low fat, high protein diet containing 6% unripe banana, as compared to obese group fed on low fat and high protein diet only.

The data presented in the same table showed non-significant differences in the initial weight between all groups (un-treated and treated groups). On the other hand the final weight and body weight gain% (BWG%) of obese group fed on high fat diet (control positive) increased significantly $P<0.05$, as compared to healthy group fed on basal diet (control negative group). Final weight and (BWG %) of obese group fed on low fat diet decreased significantly, as compared to the positive control group. On the other hand, final weight and (BWG%) of obese group fed on LF&HPD decreased significantly, as compared to the groups fed on HFD or LFD. Treating obese groups with LF&HPD containing 3% and 6% (unripe banana or banana peels) led to significant decrease in the final weight and (BWG%), as compared to (the control positive group; obese rats fed on LFD; and obese rats fed on LF&HPD). The lowest decrease in the final weight and (BWG%) recorded for the groups fed on LF&HPD containing 3% unripe banana, as compared to the other treated groups, while the highest decrease in these parameters was found in obese group fed on LF&HPD containing 6% banana peels.

Table (2): Effects of a shifting high fat diet to low fat high protein diet fortified with two levels of unripe bananas and its peels on feed intake and body weight gain % of obese rats.

Parameters / Groups		Feed Intake g/day/each rat	Weights (g)		Body weight gain % (BWG %)
			Initial	Final	
Control (-ve)		16.875^{a} ± 0.423	154.666^{a} ± 3.502	189.333^{e} ± 7.004	22.380^{g} ± 1.748
Control (+ve)		15.191^{d} ± 0.518	153.333^{a} ± 3.076	240.333^{a} ± 7.312	56.712^{a} ± 1.705
Obese rats fed on LFD		15.733^{bcd} ± 0.451	153.000^{a} ± 2.449	227.000^{b} ± 7.402	48.335^{b} ± 2.627
Obese rats fed on “LF & HPD”		15.368^{cd} ± 0.426	154.666^{a} ± 2.065	215.666^{c} ± 6.055	39.420^{c} ± 2.339
Obese rats feed on LF & LPD containing	3% unripe banana	15.828^{bc} ± 0.473	155.000^{a} ± 3.521	204.500^{d} ± 5.822	31.935^{d} ± 2.328
	6% unripe banana	16.253^{b} ± 0475	155.666^{a} ± 3.723	196.333^{e} ± 5.887	26.124^{ef} ± 2.339
	3% banana peels	15.510^{cd} ± 0.463	155.333^{a} ± 3.881	197.166^{e} ± 4.665	26.954^{e} ± 2.477
	6% banana peels	15.843^{bc} ± 0.483	155.500^{a} ± 4.183	192.000^{e} ± 5.513	23.486^{fg} ± 2.411

LFD: Low fat diet. **LF&HPD:** Low fat and high protein diet
Values are expressed as mean ± SD. Significant at $p<0.05$ using one way ANOVA test.
Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

In this respect, Westerterp-Plantenga et al. (2004) who found that protein and not carbohydrate content is the more important factor in promoting short-term weight loss, but that this may be due to increased satiety rather than increased energy expenditure. On the other hand, Abete et al. (2008) cleared that high protein diets lower energy intake, enhance weight loss, improve body composition, and help to maintain a reduced body weight following food restriction in humans. Also Claessens et al. (2009) suggested that protein rich diets are postulated to induce stronger satiety; this leads not only to a lower energy intake but also to a reduction in energy efficiency because of increases in metabolic rate and postprandial energy expenditure (EE). Indeed, pair-feeding experiments has shown that a lower energy intake cannot account entirely for reduced adiposity in rats.

Unripe banana flour containing resistance starch (RS), animal studies showed that diets containing high levels of RS (16%) reduce body weight gain and /or adiposity in rodents Aziz, et al., (2009). Moderate levels of RS (4-6%) also reduced weight gain in healthy rats Toden et al. (2007) and adiposity during weight regain in obese rats Higgins et al. (2011). In this respect, Zhou et al. (2009), reported that, resistance starch reduces adipocyte size, and lowers the lipogenic capacity of adipose tissue.

Jorge et al. (2010) demonstrated that native banana starch 24 g/day during 4 weeks lowers body weight and increases insulin sensitivity in a group of obese type 2 diabetics. NBS supplementation could be a cheap alternative to reduce body weight and improve glucose homeostasis on subjects with insulin resistance.

Banana and its peels contain high amount of dietary fiber, Slavin (2005) reported that, dietary fiber has been widely used as an effective way to decrease calorie intake and maintain a healthy body weight. Some studies supported that increased fiber intake decreases hunger, provide a feeling of fullness and play a role in the control of energy balance Slavin and Green (2007).

The data presented in this table (3) revealed that, all lipid parameters, except HDL-c increased significantly $P<0.05$ in obese group fed on HFD, as compared to the healthy group fed on basal diet. Treating obese group with LFD led to significant decrease $P<0.05$ in all parameters, except HDL-c, as compared to (the positive control group fed on HFD). On the other hand feeding obese group on LF&HPD showed significant decrease $P<0.05$ in serum cholesterol, triglyceride, low and very low density lipoprotein – cholesterol (LDL-c & VLDL-c), while high density lipoprotein-cholesterol (HDL-c) increased, as compared to the positive control group fed on HFD, and obese group fed on LFD.

All treated obese groups (LF&HPD containing 3% and 6% unripe banana or banana peels) showed improvement in all lipid parameters, as compared to the positive control group and obese group fed on LFD or LF &HPD. Lipid profile improved gradually in the groups fed on high levels of unripe banana and banana peels, as compared to the low levels. Group of rats which was fed on LF&HPD containing 6% banana peels recorded the best results in lipid profile; this treatment showed significant decrease $P<0.05$ in serum cholesterol, triglyceride, and low and very low density lipoprotein – cholesterol (LDL-c & VLDL-c), as compared to the other treated groups.

Table (3): Effects of a shifting high fat diet to low fat high protein diet fortified with two levels of unripe bananas and its peels on lipid profile of obese rats.

Parameters / Groups		Lipid Fractions (mg/dl)				
		Cholesterol	Triglycerides	HDL-c	LDL-c	VLDL-c
Control (-ve)		82.634^{g} ±2.966	44.945^{g} ±1.813	47.235^{a} ±2.663	26.426^{h} ±2.318	8.989^{g} ±0.362
Control (+ve)		185.601^{a} ± .496	93.555^{a} ±4.755	20.658^{g} ±2.389	146.232^{a} ±4.541	18.710^{a} ±0.951
Obese rats fed on LFD		171.094^{b} ±7.610	83.801^{b} ±5.705	25.076^{f} ±2.529	129.258^{b} ±4.230	16.760^{b} ±1.141
Obese rats fed on "LF & HPD"		163.215^{c} ±4.978	76.061^{c} ±3.543	29.763^{e} ±2.373	118.240^{c} ±3.441	15.212^{c} ±0.708
Obese rats feed on LF & LPD containing	3% unripe banana	150.413^{d} ±5.305	67.586^{d} ±3.661	35.242^{d} ±2.291	101.654^{d} ±4.034	13.517^{d} ±0.732
	6% unripe banana	135.297 ^{e} ±4.912	58.199^{e} ±3.988	39.945^{bc} ±1.536	83.712^{f} ±4.230	11.639^{e} ±0.797
	3% banana peels	144.208^{d} ±5.612	62.708^{e} ±2.989	37.454^{cd} ±2.167	94.212^{e} ±5.086	12.541^{e} ±0.597
	6% banana peels	127.432^{f} ±4.738	52.716^{f} ±4.042	42.100^{b} ±1.474	74.604^{g} ±3.995	10.543^{f} ±0.808

LFD: Low fat diet. **LF&HPD:** Low fat and high protein diet
HDL-C: High density lipoprotein-cholesterol **LDL-c:** Low density lipoprotein-cholesterol
VLDL-c: Very low density lipoprotein-cholesterol Values are expressed as mean ± SD. Significant at p<0.05 using one way ANOVA test. Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

As shown in table (4) AI and CRI of obese rats fed on HFD (control positive group) increased significantly $p<0.05$, as compared to normal rats fed on basal diet (7.141±0.672 & 9.053±0.735 mg/dl) vs. (0.561±0.073 & 1.751±0.077 mg/dl), respectively.

The mean values ± SD of AI and CRI of obese rats fed on LF&HPD decreased significantly $p<0.05$, as compared to the positive control group fed on HFD and obese group fed on LFD. Treating obese groups with LF&HPDs containing 3% and 6% (unripe banana or its peels) led to significant decrease $p<0.05$ in AI and CRI, as compared to the positive control group and obese rats treated with LFD or LF & HPD. The mean values of AI and CRI decreased gradually with increasing the levels of unripe banana and banana peels. The highest decrease in AI and CRI recorded for the obese group fed on LF&HPD containing 6% unripe banana and 6% banana peels.

Table (4): Effects of a shifting high fat diet to low fat high protein diet fortified with two levels of unripe bananas and its peels on atherogenic index and coronary risk index of obese rats.

Groups \ Parameters		Atherogenic Index (AI) (mg/dl)	Coronary Risk Index (mg/dl)
Control (-ve)		0.561±0.07 [f]	1.751±0.077[g]
Control (+ve)		7.141±0.672[a]	9.053±0.735[a]
Obese rats fed on LFD		5.187±0.415[b]	6.858±0.439[b]
Obese rats fed on "LF & HPD"		3.992±0.327[c]	5.505±0.354[c]
Obese rats feed on LF & LPD containing	3% unripe banana	2.893±0.211[d]	4.277±0.226[d]
	6% unripe banana	2.097±0.117[e]	3.388±0.123[f]
	3% banana peels	2.522±0.211[d]	3.858±0.218[e]
	6% banana peels	1.773±0.112[e]	3.028±0.115[f]

LFD: Low fat diet. **LF&HPD:** Low fat and high protein diet

Values are expressed as mean ± SD. Significant at $p<0.05$ using one way ANOVA test.

Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

Yin, et al. (2008) found that the lipid peroxidation of plasma and lipoproteins, and the susceptibility to oxidative modification of LDL of healthy individuals were significantly decreased following the consumption of banana meal. Also Vijayakumar et al. (2009) reported that, bananas are sources of flavonoids and chemical compounds which possess the capacity of modulating lipid metabolism. Oral administration of flavonoids extracted from unripe fruits of Musa paradisiaca showed significant hypolipidemic activities in male rats at a dose of 1 mg/100 g body weight (BW) /day. Flavonoids reduced total cholesterol by increase in the degradation and elimination of cholesterol via bile acids and neutral sterols. Besides, they decreased the levels of serum triacylglycerols by increase of the activity of lipase lipoprotein in the adipose tissue.

Hemicellulose and other neutral detergent fibers (NDF) from the unripe M. paradisiaca fruit showed low absorption of glucose and cholesterol and low serum and tissue levels of cholesterol and triglycerides Usha et al., (1989). Unripe banana flour contains saponins and tannin Visavadiya and Narasimhacharya (2007) reported that steroid-type saponins seemed to be mainly responsible for the plasma cholesterol-lowering effect in rats fed a high cholesterol diet due to the reduction in the absorption of cholesterol. Also Elekofehinti et al. (2013) indicated that administration of diabetic rats with saponins (20–100 mg/kg) for 21 days significantly reduced the elevated levels of glucose, decreased total cholesterol (TC), total triglycerides (TG), low density lipoprotein (LDL) and increased high density lipoprotein (HDL) in the serum towards normalcy when compared to the diabetic control. In addition, saponins exhibited strong inhibition of lipid peroxidation and increased the levels of antioxidant enzymes (superoxide dismutase and catalase) in the serum liver and pancreas.

Saraswathi and Gnanam (1997) reported that M. paradisiaca inhibits cholesterol crystallization in vitro which may have an effect on atherosclerosis plaque and gallstones *in vivo*. Yin et al. (2008) further studied the effect of banana in human and found that plasma oxidative stress was significantly reduced and the resistance to oxidative modification of LDL was enhanced only after a single banana meal. The effect may be due to the presence of dopamine, ascorbic acid and other antioxidants present in banana.

Animal studies have shown that banana has the potential to lower cholesterol. It was suggested that the dietary fiber component in banana pulp was responsible for its cholesterol-lowering effect (Sampath et al., 2012).

Kai-mei et al. (2013) reported that, banana peel polyphenol has antihyperlipidemic and antioxidative effects on hyperlipidemic model rats.

As shown in table (5), leptin hormone and serum glucose increased significantly in obese rats fed on HFD "control positive group", as compared to rats fed on basal diet. Feeding obese groups on LFD or LF&HPD led to significant decrease $p \le 0.05$ in the mean value of leptin hormone and serum glucose, as compared to the positive control group. On the other hand, LF&HPD was more effective in reducing these parameters, as compared to LFD only.

Table (5): Effects of a shifting high fat diet to low fat high protein diet fortified with two levels of unripe bananas and its peels on liptin hormone and serum glucose of obese rats.

Parameters / Groups		Leptin ng/ml	Glucose md/dl
Control (-ve)		6.058 ± 0.485^{g}	76.166 ± 4.445^{h}
Control (+ve)		20.205 ± 2.623^{a}	156.500 ± 4.593^{a}
Obese rats fed on LFD		17.600 ± 1.306^{b}	139.000 ± 3.794^{b}
Obese rats fed on "LF & HPD"		15.455 ± 1.424^{c}	128.500 ± 2.664^{c}
Obese rats feed on LF & LPD containing	3% unripe banana	12.268 ± 0.557^{d}	117.000 ± 2.366^{d}
	6% unripe banana	9.317 ± 0.682^{ef}	100.500 ± 3.937^{f}
	3% banana peels	10.715 ± 0.576^{e}	108.500 ± 1.974^{e}
	6% banana peels	8.251 ± 0.415^{f}	90.166 ± 3.816^{g}

LFD: Low fat diet. **LF&HPD:** Low fat and high protein diet
Values are expressed as mean ± SD. Significant at $p<0.05$ using one way ANOVA test.
Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

Feeding obese groups on LF&HPD supplemented with (3% and 6%) unripe banana or banana peels showed significant decrease in the mean values of leptin and serum glucose, as compared to the positive control group and the groups fed on LFD or LF&HPD. The mean value of serum glucose and leptin hormone decreased with increasing the levels of unripe banana or banana peels. Treating obese rats with the high levels of unripe banana or banana peels recorded the best results in serum glucose and leptin hormone. These treatment showed significant decrease in these parameters, as compared the groups treated with low levels in these materials.

A high-protein diet lowers blood glucose postprandially in persons with type 2 diabetes and improves overall glucose control (Gannon et al., 2003). On the other hand, higher protein intake increases satiety and enhances the leptin concentrations in central nervous system (CNS) as well as elevates leptin sensitivity which tends to maintain body weight (Weigle et al., 2005).

The green fruit of M. paradisiaca has been reported to have hypoglycemic effect due to stimulation of insulin production and glucose utilization (Ojewole and Adewunmi, 2003). Its high potassium (K) and sodium (Na) content has been correlated with the glycemic effect (Rai et al., 2009). Fibers from M. paradisiaca fruit increased glycogenesis in the liver and lowered fasting blood glucose (Usha et al., 1989). The chloroform extract of flowers of M. sapientum showed considerable reduction in blood glucose and glycosylated haemoglobin and total hemoglobin increase after oral administration in rats (Pari and Maheshwari, 1999).

Dhanabal, et al. (2005) reported that oral administration of the ethanolic extract of flowers of Musa sapientum (Musaceae) (120 mg/kg), showed significant decrease in blood glucose, significantly scavenge oxygen free radicals, superoxide dismutase (SOD), catalase (CAT) and also malondialdehyde. The anti-diabetic activity observed in this plant may be attributed to the presence of flavonoids, alkaloids, steroid and glycoside principles. Also Salau, et al. (2010) observed that oral administration of methanolic extract of Musa sapientum Linn. at tested doses (5mg and 10mg kg-1/ day) led to significant decrease in fasting blood glucose level compared with the diabetic control rats. On the other hand, Nammi et al. (2003) suggests that the mode of action of the active ingredients of M. paradisiaca is probably mediated by an enhanced secretion of insulin, like sulphonyl ureas. In this respect, Jachak (2002) reported that, the hypoglycemic effect on blood glucose might be due to unripe banana contained an insulin like action and / or other products which stimulate insulin secretion from pancreatic beta cells or increase the rate of entrance of various sugars via glucose transporters in the plasma membrane.

De-feng et al. (2012) reported that, banana skin polysacc-haride maintains blood glucose and body weight of Diabetes within the normal range. And concluded that, banana skin polysaccharide has a good DM hypoglycemic effect.

Vitamin C has been shown to inhibit leptin secretion and glucose uptake (Garcia-Diaz et al., 2010). Moreover, retinoic acid and vitamin E have been shown to decrease leptin expression and secretion (Hollung et al., 2004 and Felipe et al., 2005).

The data presented in Table (6) revealed that, liver enzymes including (AST, ALT and ALP) increased significantly $p<0.05$ in obese group fed on HFD, as compared to the negative control group fed on basal diet. The mean value of serum AST, ALT and ALP increased by about 162.759%, 217.717% and 121.299% in the positive control group, than that of the negative control group. Obese groups which were feeding on LFD or LF&HPD showed significant decrease p<0.05 in liver enzymes, as compared to the positive control group. The low fat and high protein diet decreased the mean values of serum AST, ALT and ALP enzymes significantly, as compared to low fat diet only.

Statistical analysis in this Table showed that, all tested groups recorded significant decrease p<0.05 in AST, ALT and ALP, as compared to the positive control group fed on HFD; obese group fed on LFD and obese group fed on LF&HPD. The data presented in this Table showed that, treating obese groups with LF&HPDs containing 6% (unripe banana or banana peels) led to significant decrease in AST, ALT and ALP, as compared to the obese group which treated with 3% (unripe banana or banana peels), respectively. The best results in liver enzymes recorded for the group which treated with 6% unripe banana, this treatment showed significant decrease in AST, ALT and ALP, as compared to the other treated groups.

Table (6): Effects of a shifting high fat diet to low fat high protein diet fortified with two levels of unripe bananas and its peels on liver enzymes of obese rats.

Groups \ Parameters		Liver enzymes (u/l)		
		AST	ALT	ALP
Control (-ve)		57.720[g] ±3.899	21.893[g] ±1.582	80.410[g] ±3.101
Control (+ve)		151.665[a] ±4.751	69.558[a] ±3.438	177.947[a] ±6.876
Obese rats fed on LFD		138.489[b] ±4.910	61.355[b] ±3.890	167.121[b] ±5.363
Obese rats fed on “LF & HPD”		128.761[c] ±4.159	53.499[c] ±3.879	156.845[c] ±5.271
Obese rats feed on LF & LPD containing	3% unripe banana	109.606[e] ±3.658	39.809[e] ±4.238	140.008[e] ±5.487
	6% unripe banana	96.564[f] ±4.257	30.142[f] ±2.032	126.032[f] ±3.985
	3% banana peels	118.337[d] ±2.964	45.952[d] ±5.157	150.730[d] ±6.289
	6% banana peels	106.049[e] ±6.725	38.187[e] ±1.985	135.854[e] ±4.511

AST: Aspartate Amine Transaminase **ALT:** Alanine Amine Transaminase
ALP: Alkaline Phosphatase **LFD:** Low fat diet.
LF&HPD: Low fat and high protein diet Values are expressed as mean ± SD. Significant at p<0.05 using one way ANOVA test. Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

In this respect, Duarte et al. (2014) demonstrated that a high protein, hypocaloric diet were associated with improvement of lipid profile, glucose homeostasis and liver enzymes in nonalcoholic fatty liver disease “NAFLD” independent on BMI decrease or body fat mass reduction. Dikshit, et al. (2011) evaluated the hepatoprotective activity of aqueous extract of central stem of Musa sapientum (AqMS) against carbon tetrachloride induced hepatotoxicity in rats, and they found that treatment with AqMS prevented rise in MDA & increased GSH and SOD levels. Maximum hepatoprotective effect was observed with 50 mg/kg dose.

Nirmala, et al. (2012) reported that pretreatment with alcoholic extract of Musa Paradisiaca (500 mg/kg), more significantly and to a lesser extent the alcoholic extract (250 mg/kg) and aqueous extract (500 mg/kg), reduced the elevated levels of the serum enzymes like serum glutamic-oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), alkaline phosphatase (ALP) and bilirubin levels and alcoholic and aqueous extracts reversed the hepatic damage towards the normal, which further evidenced the hepatoprotective activity of stem of M. paradisiaca.

Polyphenols exert a marked antioxidative effect, and the most evident manifestation of liver damage is oxidative damage of liver cells (Kang et al., 2013). As a result, polyphenols may be able to protect liver cells against oxidative damage and promote the repair of oxidatively-damaged cells, in order to maintain health (Sebai et al., 2010). Polyphenols present in banana peel may function in a similar manner.

Wang et al. (2016) reported that, banana peel polyphenols BPPs appeared to significantly reduce the serum levels of AST, ALT and LDH in a CCl4-induced mouse model of hepatic damage. The researchers concluded that, that BPPs are able to significantly improve a number of the symptoms of CCl4-induced liver damage in mice, and that the effect is more marked with an increased treatment dose. In future, banana peel could be used in waste utilization or may be used as medicine or a functional compound.

Conclusion: Feeding obese rats with low fat LF & high protein diet HPD supplemented with unripe banana and banana peels resulted in significant reduction in body weight gain and blood lipids.

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تأثير استبدال علائق مرتفعة الدهون بعلائق منخفضة الدهون وعالية البروتين ومدعمة بمستويين من مسحوق الموز غير الناضج وقشوره على الفئران البدينة

شيماء محمد حسنين أبو النجا

أستاذ مساعد تغذية وعلوم الأطعمة

قسم مهارات تطوير الذات، عمادة السنة التحضيرية، جامعة حائل

الملخص: أجريت هذه الدراسة لتحديد استبدال الوجبات عالية الدهن بالوجبات منخفضة الدهون وعالية البروتين والمدعمة بمستويين من مسحوق الموز غير الناضج وقشوره في تغيير كمية الدهون، إنزيمات الكبد، هرمون الليبتين والجلوكوز في الفئران التي تعانى من السمنة. أستخدمت في هذه الدراسة مجموعتين أساسيتين من الفئران. المجموعة الرئيسية الأولى (٦ فئران) أستخدمت كمجموعة سلبية ضابطة تم تغذيتها على غذاء أساسي، في حين أن المجموعة الرئيسة الثانية (٤٢ فأراً) تم تغذيتها على غذاء عالي الدهن لمدة (٦ أسابيع) لإحداث السمنة في الفئران. تم تقسيم فئران المجموعة الرئيسية الثانية إلى سبع مجموعات فرعية كالتالي: المجموعة الفرعية (١) تم تغذيتها على غذاء عالي الدهن وأستخدمت كمجموعة موجبة ضابطة مصابة، المجموعة الفرعية (٢) تم تغذيتها على غذاء منخفض الدهن. المجموعة الفرعية (٣) تم تغذيتها على وجبة منخفضة الدهن ومرتفعة البروتين. المجموعات الفرعية (٤ و ٥) تم تغذيتها على وجبات منخفضة الدهن مرتفعة البروتين تحتوي على ٣٪ و ٦٪ مسحوق الموز غير الناضج، على التوالي. المجموعات الفرعية (٦ و٧) تم تغذيتها على وجبات منخفضة الدهن مرتفعة البروتين تحتوي على ٣٪ و ٦٪ مسحوق قشور الموز غير الناضج، على التوالي. أدت تغذية الفئران على وجبة مرتفعة الدهون إلى إحداث خلل في مستويات دهون الدم، هرمون الليبتين، جلوكوز الدم وإنزيمات الكبد. أحدثت تغذية الفئران المصابة بالسمنة على وجبات منخفضة الدهن مرتفعة البروتين والمحتوية على مستويين من مسحوق الموز غير الناضج وقشوره بنسب (٣٪ و ٦٪) تناقصاً معنوياً في النسبة المئوية للزيادة في الوزن وأيضاً مستويات (الكولسترول، الجلسريدات الثلاثية، كولسترول الليبوبروتينات منخفضة الكثافة والمنخفضة جداً، هرمون الليبتين، الجلوكوز وإنزيمات الكبد في سيرم الدم)، في حين أحدثت هذه المعاملات ارتفاعاً معنوياً في مستويات كولسترول الليبوبروتينات عالية الكثافة، مقارنة بكل من المجموعة الضابطة المصابة بالسمنة والمغذاة على غذاء مرتفع الدهن ومجموعة الفئران المغذاة على غذاء منخفض الدهن ومجموعة الفئران المغذاة على غذاء منخفض الدهن مرتفع البروتين. أشارت هذه النتائج إلى تغذية الفئران السمينة بعلائق منخفضة الدهون مرتفعة البروتين ومدعمة بمسحوق الموز غير الناضج وقشوره انقصت معنوياً زيادة للوزن ودهون الدم.

الكلمات المفتاحية: سمنة، موز غير ناضج، صورة دهون الدم، جلوكوز، ليبتين، إنزيمات الكبد.