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ORIGINAL ARTICLE

The effect of banana peels supplemented diet on acute liver failure rats

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Abstract Peel of vegetables and fruits are of the most important part that helps in protecting the body from diseases, getting rid of the free radicals, as they contain vitamins and minerals which are antioxidant, in addition to phenols. Previous studies have proved the existence of vitamin C, E, and B6 in banana peels, especially vitamin C that can act as an antioxidant.

The present study was performed to examine the effect of fresh and dried banana peels consumption on liver function (albumin, GPT, GOT, LDH, GGT and ALP) and lipid profiles cholesterol, triglycerides, low-density lipoprotein (LDL), high-density lipoprotein (HDL) and very low-density lipoprotein (VLDL) on acute liver failure rats induced by carbon tetrachloride. The chemical constituents, vitamins, minerals and fiber were determined for the tested fresh and dried banana peels.

This work was carried out on 40 adult male white albino rats randomly classified into eight groups (each of 5 rats). The first group was fed on basal diet as a "negative control". The other seven groups were injected by carbon tetrachloride to induce liver failure. The second group fed on basal diet as acute liver failure rat's untreated "positive control", the third into five groups fed on basal diet containing 5%, 10% and 15% fresh banana peels while the six into eight groups fed on basal diet containing of 5%, 10% and 15% dried banana peels for a period of four consecutive weeks.

Results revealed that all acute liver failure groups administrated with different levels of fresh banana peels (5%, 10% and 15%) had significant decrease in liver function, total cholesterol, triglycerides, LDL-c and VLDL-c cholesterol comparing with the positive control group. On the other hand, significant increase in HDL-c was recorded in all acute liver failure groups administrated with dried banana peels 5% and 10% comparing with control positive group. It was suggested that, consumption of fresh and dried banana peels may modify the risk of acute liver failure patients.

Introduction

Liver is unique to the subphylum Vertebrata and varies little among the classes. It is the largest organ of the body, occupies

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a strategic position between the intestinal tract and the rest of the body. Liver plays a crucial role in maintaining metabolic homeostasis. Its functions include the processing of dietary amino acids, carbohydrates, lipids, and vitamins; phagocytosis of particulate materials in the portal circulation; synthesis of serum proteins; biotransformation of circulating metabolites and detoxification and excretion of endogenous waste products and pollutant xenobiotics into the bile (Crawford, 1999).

Acute liver failure (ALF) is a complex multisystemic illness that evolves after a catastrophic insult to the liver manifesting in the development of a coagulopathy and encephalopathy within a short period of time. ALF is a heterogenous condition incorporating a range of clinical syndromes, principally determined by the underlying etiology, the age of the patient, and the duration of time over which the disease evolves (Harry et al., 2002). There are a number of classifications of ALF in use but in the UK the terms such as hyperacute, acute, and subacute are used to define the onset of encephalopathy within 7 days, 8–28 days, and more than 28 days, respectively. The natural history of the condition is very variable within this range and survival rates without transplantation range from 10% to 90% for different cohorts. Integrated multidisciplinary protocols that use liver transplantation are now achieving considerably improved survival rates in the range from 40% to 90% depending on the underlying etiology (Grady et al., 2013).

ALF is common complication of viral hepatitis, occurring in 0.2–4% of cases depending on the underlying etiology (Grady, 2000). The risk is lowest with hepatitis A, but it increases with the age at time of exposure. Hepatitis B can be associated with ALF through a number of scenarios. The commonest are de novo infection and spontaneous surges in viral replication, while the incidence of the delta virus infection seems to be decreasing rapidly (Bernal, 2003). Vaccination should reduce the incidence of hepatitis A and B, while antiviral drugs should ameliorate replication of hepatitis B. Hepatitis C is rarely recognized as the sole cause of ALF. Hepatitis E is common in parts of Asia and Africa and the risk of developing ALF increases to over 20% in pregnant women, being particularly high during the third trimester (Strauss et al., 2001). Unusual causes of viral ALF include herpes simplex 1 and 2, herpesvirus-6, varicella zoster, Epstein–Barr virus, and cytomegalovirus. Seronegative hepatitis is the commonest presumed viral cause in some parts of the western world, although there is little evidence to implicate a viral infection. Middle aged women are most commonly affected and it occurs sporadically. The diagnosis is one of exclusion (Murphy et al., 2004).

Banana should be considered to be a good source of natural antioxidant for foods and functional food source against cancer and heart disease (Someya et al., 2002). Therefore, attention in recent times has been focused on the isolation, characterization and utilization of natural antioxidants, especially growing interest in polyphenols as potential disease preventing agents. As these compounds are predominantly found in most of fruit tissues, it would be worthwhile investigating the nature of polyphenols that are present in banana peel. Fruits and vegetables however, contain many different antioxidant and antimicrobial components. The majority of the antioxidant capacity of a fruit or vegetable may be from compounds such as other vitamin C, vitamin E or β-carotene. Bananas are one of the most popular fruits in the world and it well be known that fruits contain various antioxidants compounds such as gallocatechin and dopamine (Mokbel and Hashinaga, 2004). Since the banana fruits are widely available, they have been used as food without apparent toxic effect. The peel could be a potential source of antioxidant and antimicrobial activities. Ethyl acetate and water soluble fractions of green banana peel displayed high antimicrobial and antioxidant activities. Most of the compounds isolated from green peel, β-sitosterol, malic acid, 12-hydroxystearic acid and succinic acid, showed significant antibacterial activities and low antioxidant activities, while those compounds isolated from water soluble extracts, glycoside and monosaccharide components, displayed significant antioxidant and low antimicrobial activities (Matook and Fumio, 2005).

Banana peel represents about 40% of total weight of the fresh fruit (Anhwange et al., 2008). The total amount of phenolic compounds in banana peel has been ranged from 0.90 to 3.0 g/100 g dry weight and gallocatechin is identified at a concentration of 160 mg/100 g dry weight; Someya et al. (2002). Other phytochemicals such as anthocyanin, delphinidin, cyaniding; Seymour, and catecholamines have been identified (Kanazawa and Sakakibara, 2000) in ripe banana pulp and peel. Recent studies demonstrated that banana peel generally includes higher phenolic compounds than those of banana pulps; Kondo et al. (2005) and Sulaiman et al. (2011). Subagio et al. (1996) identified carotenoids such as β-carotene, α-carotene and different xanthophylls in the range of 300–400 μg lutein equivalents/100 g. of banana peels. Gonzalez-Montelongo et al. (2010) studied the extraction conditions that produce maximum antioxidant activity (Acetone: water (1:1), 25 °C, 120 min). Moreover, the number of extraction steps, temperature and time, have been reported as the most effective factors associated with antioxidant properties of banana peel, respectively. According to the study by Someya et al. (2002) total phenolics are more abundant in peel (907 mg/100 g dry wt.) than in pulp (232 mg/100 g dry wt.) in Musa cavendish.

Mohamed and Fatma (2011) showed that the extract of some fruits and vegetables peels (apple APME, banana BPME, red beet RBPME and potato PPME) especially methanol extract has a significant protective effect against acute hepatotoxicity induced by CCl4 in rats, which may be due to its free radical scavenging effect and its ability to increase antioxidant activity.

This study aimed to investigate the effect of fresh and dried banana peels consumption on liver function and lipid profiles.

Materials and methods

Materials

Source of samples

Banana (Musa Acuminate) was purchased from local market in Egypt.

Chemicals and drugs

2 ml (v/v) carbon tetrachloride/kg Shibate et al. (1999) all chemicals were obtained from El-Gomhoria Company for chemicals, Cairo, Egypt.

Banana peels preparation

The peels were removed from the flesh and submitted to the following processes:

1. Fresh peels: banana fresh peels were washed with water and cut into small pieces.
2. Dried peels: peel samples were dried at 50 °C in a hot air oven for 12 h and ground to obtain the particle size of less than 1.0 mm (Adejuyitan et al., 2008).

Experimental animal design. A total of 40 male healthy rats, weighing between (140–150 g) were divided into 8 groups. 35 rats were subcutaneous injected by carbon tetrachloride as 2 ml/kg body weight to induce acute liver failure. And 5 rats considered negative control group. Basal diet consisted of protein (14%), fat (4%), salt mixture (3.5%), vitamin mixture (1%), choline (0.25%), and cellulose (5%) and the remainder was corn starch (Reeves et al., 1993). All rats were fed basal diet for one week as an adaptation period. Body weight gain was calculated through and after the experiment for a period of four consecutive weeks. The groups are designed as follows:

Group (1): containing 5 rats fed on basal diet as a "negative control".

The other 35 rats were injected by carbon tetrachloride to induce acute liver failure and divided into 7 subgroups each group contained 5 rats as follows:

Group (2): basal diet as acute liver failure rats "positive control".
Group (3): basal diet (acute liver failure rats) containing 5% fresh banana peel.
Group (4): basal diet (acute liver failure rats) containing 10% fresh banana peel.
Group (5): basal diet (acute liver failure rats) containing 15% fresh banana peel.
Group (6): basal diet (acute liver failure rats) containing 5% dried banana peel.
Group (7): basal diet (acute liver failure rats) containing 10% dried banana peel.
Group (8): basal diet (acute liver failure rats) containing 15% dried banana peel.

At the end of experiment (4 weeks), rats were starved for 12 h, and then sacrificed under ether anesthesia. Blood samples were collected from the aortic vein into clean dry centrifuge tubes and stored at room temperature for 15 min, put into a refrigerator for 2 h, and then centrifuged for 10 min at 3000 rpm to separate serum. Serum was carefully aspirated and transferred into dry clean Man-Wasser tubes by using a Pasteur pipette and kept frozen at (−205 °C) till analysis. Liver, kidney spleen and heart were removed, blotted on filter paper and weighed separately (Ilwy, 2003).

Methods

Chemical analysis

Samples of banana peels were analyzed chemically for protein, fat, moisture and ash contents using the methods described by A.O.A.C. (2005). Total dietary fiber was determined by enzymatic and gravimetric method according to A.A.C.C. (2000). Carbohydrates were calculated by difference.

Mineral and vitamin analysis. The mineral and vitamin composition of the banana peels was determined according to the methods of the A.O.A.C. (2005).

Biological analysis

Plasma lipids were determined spectrophotometrically according to the method of Schmit (1964). The triglycerides in plasma were estimated spectrophotometrically according to the method of Wahlefeld (1974). The method of Allian et al. (1974) was used to determine total cholesterol. Plasma HDL-Cholesterol was determined according to the study by Gordon and Amer (1977).

LDL-cholesterol and VLDL-cholesterol were estimated from quantitative measurements of total and HDL-cholesterol and plasma triglycerides (TG) using the empirical relationship of Friedewald et al. (1972).

The activities of plasma transaminases (GOT and GPT) and Albumin were measured using the method of Reitman and Frankel (1957). Plasma alkaline phosphatase (ALP) and lactate dehydrogenase activities (LDH) were determined according to the study by Res-GSCC (DGKC) (1972). Glutamyl transferase activity (GGT) was measured as described by Szasz (1969).

Statistical analysis

Statistical analysis of results was statistically analyzed using computer program (SPSS, 2010). One-way analysis of variance (ANOVA), low significant differences (LSD) and Duncan were used, and the difference was considered significant at p-value < 0.05 according to the study by Zar (1984).

Results and discussion

Banana peels (BP) contain several important nutrients such as potassium, calcium, sodium, iron and manganese. It contain almost numerous essential amino acids (leucine, valine, phenylalanine and threonine) as well as crude fat and polyunsaturated fatty acids (particularly linoleic and α-linolenic acid) at appreciable levels thereby making it an important basal material in animal feeding. Upon ripening, several degradative reactions caused by endogenous enzymes are believed to affect starch and hemicelluloses composition of the peels and this explains its elevated sugar content. This chemical conversion process makes biodegradation of BP easy when needed for other biotechnological activities. Moreover, pectin quality of the peels is promising since it contained important simple sugars (glucose, rhamnose, arabinose and xylose) (Saheed et al., 2012).

Chemical Analysis

Data presented in Table 1 show the chemical composition of fresh banana peels which was 10.04 ± 0.04, 5.32 ± 0.72, 54.01 ± 1.03, 21.96 ± 0.25, 8.23 ± 0.04 and 50.25 ± 0.04 g/100 g for protein, fat, carbohydrates, moistures, ash

Table 1 The chemical composition of banana peels.

Chemical composition (g)/100 g	Banana peels (mean ± SD)	
	Fresh	Dried
Protein	10.04 ± 0.04	7.25 ± 0.37
Fat	5.32 ± 0.72	4.81 ± 0.94
Carbohydrates	54.01 ± 1.03	79.87 ± 0.26
Moistures	21.06 ± 0.25	6.73 ± 1.05
Ash	8.23 ± 0.04	1.34 ± 1.05
Total dietary fiber	50.25 ± 0.04	44.28 ± 0.04

The data were presented as mean ± S.D. of three independent analyses.

and total dietary fiber respectively. On the other hand, the values of protein, fat, carbohydrates, moistures, ash and total dietary fiber in dried banana peels were 7.25 ± 0.37, 4.81 ± 0.94, 79.87 ± 0.26, 6.73 ± 1.05, 1.34 ± 1.05 and 44.28 ± 0.04 g/100 g respectively. Happi Emaga et al. (2007) showed that the banana peel had higher fat, ash, and total dietary fiber content, but lower protein and starch content than those of the banana peels at stage 1 of ripeness (4.2, 12.8, 37.3, 3.6 and 9.5 g/100 g dry matter, respectively). This might be due to the differences in types or due to geographical factors. Figuerola et al. (2005), Llobera and Canellas (2007) and Marin et al. (2007) reported by had lower total dietary fiber content than fiber obtained from different sources of fruit industrial by-products (60–78 g/100 g dry matter).

Table 2 shows that mineral and vitamin contents of banana peels. The mean values of K and V.A were higher in the fresh banana peels (78.10 ± 0.04 mg/100 g and 3.12 ± 0.03ug/g) and Fe and V.E were lower in the dried banana peels than in fresh peels (0.15 ± 0.12 mg/100 g and 0.18 ± 0.14 mg/g). On the other hand, the mean values of V.C. and V. B6 were higher in the fresh banana peels (1.86 ± 0.34 mg/g and 2.93 ± 0.04 mg/g) and lower in the dried banana peels (0.94 ± 0.23 mg/g and 1.23 ± 0.12 mg/g). Adlin (2008) and Faigin (2001) reported that the content of a banana peel was 55.59%, calcium 0.36%, Phosphor 0.10% and gross energy 3727 kcal/kg. Banana peel also contains vitamins C, E, and B6. Vitamin C can act as an antioxidant, while serotonin is thought to play an anti-depressant so as to increase feed intake and body weight on heat stress conditions.

Biological analysis

Results in Table 3 showed that the feed intake and body weight gain in the studied groups. The feed intake was the highest in the group (6) 15.23 g/day and the lowest in the group (5) 12.84 g/day. No significant differences ($p \leqslant 0.05$) were observed in the body weight gain% between negative control (group 1) and those fed on either diet supplemented with 5% and 10% fresh banana peel (groups 3 and 4) or 10% and 15% dried banana peel (group 7 and 8). However, there was a significant difference in body weight gain between negative control and positive control groups. Dhanabal et al. (2005) proved that banana peels supplemented diet caused varying percentage weight gains in all groups, which were not statistically significant when compared to the control. However the percentage weight gain reduced after the induction of hepatotoxicity. The consumption of banana peels which did not significantly affect the weight of the animals could be as a result of unavailability of nutrients especially carbohydrate and protein contained in banana peels. Also, liver damage could affect body weight by interfering with its function of processing of nutrients and making them unavailable for growth.

Table 4 indicates the relative organs weight of rats in the studied groups where the relative weight of liver and kidney was higher in group (7) (3.91 ± 0.15 g and 0.69 ± 0.01 g).

Table 3 Body weight gain and feed intake of acute liver failure rats fed on banana peels supplemented diet.

Groups	Parameters	
	Feed intake (g/day)	Body weight gain (%)
Group (1) negative control	14.09	$36.14^{a} \pm 3.17$
Group (2) positive control	13.13	$15.40^{c} \pm 2.26$
Group (3) 5% fresh banana peel	14.21	$33.34^{ab} \pm 0.37$
Group(4) 10% fresh banana peel	13.64	$35.12^{a} \pm 0.50$
Group (5) 15% fresh banana peel	12.84	$27.25^{b} \pm 2.83$
Group (6) 5% dried banana peel	15.23	$32.11^{b} \pm 1.78$
Group (7) 10% dried banana peel	14.27	$33.54^{a,b} \pm 2.37$
Group (8) 15% dried banana peel	13.52	$37.21^{a} \pm 0.51$

The data were presented as mean ± S.D. Means with different superscripts significantly differ ($p \leqslant 0.05$) according to "Duncan" and the mean values were arranged in a descending order from "a": "d".

Table 2 Mineral and vitamin content of banana peels.

Mineral (mg/100 g)	Banana peels (mean ± SD)		Vitamin (mg/g)	Banana peels (mean ± SD)	
	Fresh	Dried		Fresh	Dried
K	78.10 ± 0.04	62.81 ± 0.14	[a]V.A	3.12 ± 0.03	1.14 ± 0.12
Ca	19.20 ± 0.04	16.75 ± 0.14	V.C	1.86 ± 0.34	0.94 ± 0.23
Na	24.30 ± 1.37	22.34 ± 0.34	$V.B_1$	1.79 ± 0.04	0.45 ± 0.14
Fe	0.61 ± 1.27	0.15 ± 0.12	$V.B_6$	2.93 ± 0.04	1.23 ± 0.12
Mg	76.20 ± 0.04	65.14 ± 0.37	V.E	1.03 ± 0.04	0.18 ± 0.14

The data were presented as mean ± S.D. of three independent analyses.
[a] ug/g.

Table 4 Relative organs weight of acute liver failure rats fed on banana peels supplemented diet.

Groups	Parameters (g)			
	Relative weights of liver	Relative weights of kidney	Relative weights of spleen	Relative weights of heart
Group (1) negative control	$3.47^{a} \pm 0.20$	$0.55^{b} \pm 0.07$	$0.41^{b,c} \pm 0.03$	$0.35^{b} \pm 0.11$
Group (2) positive control	$3.64^{a} \pm 0.09$	$0.67^{a} \pm 0.07$	$0.38^{c} \pm 0.03$	$0.39^{a} \pm 0.03$
Group (3) 5% fresh banana peel	$3.24^{b} \pm 0.03$	$0.69^{a} \pm 0.05$	$0.42^{b} \pm 0.03$	$0.34^{b} \pm 0.11$
Group(4) 10% fresh banana peel	$2.96^{c} \pm 0.07$	$0.65^{b} \pm 0.04$	$0.38^{c} \pm 0.07$	$0.34^{b} \pm 0.12$
Group (5) 15% fresh banana peel	$3.25^{b} \pm 0.09$	$0.62^{b} \pm 0.04$	$0.42^{b} \pm 0.07$	$0.36^{a} \pm 0.01$
Group (6) 5% dried banana peel	$3.16^{b} \pm 0.07$	$0.59^{b} \pm 0.01$	$0.44^{b} \pm 0.06$	$0.35^{b} \pm 0.01$
Group (7) 10% dried banana peel	$3.91^{a} \pm 0.15$	$0.69^{a} \pm 0.01$	$0.48^{a,b} \pm 0.04$	$0.34^{b} \pm 0.11$
Group (8) 15% dried banana peel	$3.21^{b} \pm 0.17$	$0.66^{a,b} \pm 0.04$	$0.54^{a} \pm 0.15$	$0.37^{a} \pm 0.11$

The data were presented as mean ± S.D. Means with different superscripts significantly differ ($p \leq 0.05$) according to "Duncan" and the mean values were arranged in a descending order from "a": "d".

On the other hand, the relative weight of spleen was higher in group (8) (0.54 ± 0.15 g) and the relative weight of heart was higher in positive group (0.39 ± 0.03 g). The relative weight of liver and kidney in group (4) and (6) decreased significantly than the positive group. On contrary, the relative weight of spleen and heart was increased significantly in group (8) than the positive group. The results are in accordance with the study by Iweala et al. (2011) who found that relative organ weights did not differ among the groups supplemented with lignin, pectin, cellulose, hemicellulose and mineral as Fe, Zn and banana peels were a good feed material for rat and poultry.

Data in Table 5 showed plasma total lipids of rats in the studied groups. The serum of total lipids and triglycerides was higher in group 3 (337.11 ± 13.41 and 72.50 ± 1.36 mg/dL) than the experimental groups although total cholesterol was higher in group 6 (116.65 ± 4.38 mg/dL) than the experimental groups. The serum of total lipids, total cholesterol and triglycerides was decreased significantly in group (5) compared to positive group. Bowry and Stocker (1993) indicate that the animals in the hepatotoxic groups fed 10% peels of *Musa paradisiaca*-supplemented diet had a high value of cholesterol. Gould et al. (1998) proved that increase in cholesterol level is a risk factor associated with arteriosclerosis and cardiovascular disease (Cooper et al., 2007). Nikkila (1984) showed that the triglyceride concentration was significantly increased ($p < 0.05$) in the hepatotoxic groups and hepatotoxic group fed 10% peels of *M. paradisiaca*-supplemented diet, respectively. High levels of triglycerides, LDL-Cholesterol and VLDL-Cholesterol have been associated with heart disease.

Results in Table 6 revealed cholesterol fractions of rats in the studied groups where the serum of HDL-cholesterol was higher in group (6) (55.40 ± 1.34 mg/dL) and serum of LDL-cholesterol and VLDL-cholesterol was lower in group (5) (23.92 ± 5.99 and 5.36 ± 0.11 mg/dL) than the positive group. The ratio of HDL/LDL-cholesterol was higher in group (3) (1.87 ± 0.0.3) but was lower in positive group (0.33 ± 0.34). On the other hand, all acute liver failure groups administrated with different levels of fresh and dried banana peel (5%, 10% and 15%) levels had significant decrease in serum low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) comparing with control positive, while acute liver failure groups administrated with fresh and dried banana peels (5% and 10%) had significant increase in serum high-density lipoprotein comparing with control positive. These results are in accordance with the study by Someya et al. (2002) who found that banana peel extract contains higher levels of antioxidant compounds than the pulp promising a wider range of application of the peels in food and nutraceuticals. The potential applications of banana peels depend on its chemical composition, and the important functional components of banana peel are the resistant starch (RS) and dietary fiber (Emaga et al., 2008). RS has attracted interest because of its positive effects in the human

Table 5 Plasma total lipids of acute liver failure rats fed on banana peels supplemented diet.

Groups	Parameters (mg/dL)		
	Total lipids	Total cholesterol	Triglycerides
Group (1) negative control	$202.27^{c} \pm 11.84$	$62.74^{b} \pm 3.01$	$63.50^{b} \pm 0.05$
Group (2) positive control	$472.06^{a} \pm 51.19$	$158.50^{a} \pm 3.11$	$90.75^{a} \pm 1.61$
Group (3) 5% fresh banana peel	$337.11^{b} \pm 13.41$	$106.50^{a,b} \pm 1.31$	$72.50^{a} \pm 1.36$
Group(4) 10% fresh banana peel	$304.79^{b} \pm 9.71$	$96.24^{b} \pm 2.44$	$39.25^{b} \pm 1.19$
Group (5) 15% fresh banana peel	$301.42^{b} \pm 5.21$	$65.23^{b} \pm 4.08$	$32.75^{c} \pm 1.54$
Group (6) 5% dried banana peel	$327.11^{b} \pm 10.41$	$116.65^{a} \pm 4.38$	$67.00^{a} \pm 2.51$
Group (7) 10% dried banana peel	$314.79^{b} \pm 8.71$	$87.13^{b} \pm 1.11$	$42.50^{b} \pm 2.01$
Group (8) 15% dried banana peel	$311.42^{b} \pm 5.21$	$81.01^{b} \pm 2.34$	$35.25^{b,c} \pm 2.01$

The data were presented as mean ± S.D. Means with different superscripts significantly differ ($p \leq 0.05$) according to "Duncan" and the mean values were arranged in a descending order from "a": "d".

Table 6 Cholesterol fractions of acute liver failure rats fed on banana peels supplemented diet.

Groups	Parameters (mg/dL)			
	HDL-cholesterol	LDL-cholesterol	(HDL/LDL)-cholesterol	VLDL-cholesterol
Group (1) negative control	25.63^{b} ± 0.16	18.10^{e} ± 4.30	1.42^{a} ± 0.03	11.90^{b} ± 0.39
Group (2) positive control	32.13^{a} ± 0.31	98.90^{a} ± 6.13	0.33^{b} ± 0.34	17.30^{a} ± 0.34
Group (3) 5% fresh banana peel	34.63^{a} ± 0.94	29.13^{d} ± 1.40	1.87^{a} ± 0.13	13.71^{a} ± 0.30
Group(4) 10% fresh banana peel	42.63^{a} ± 1.87	39.63^{b} ± 5.23	1.08^{b} ± 0.31	6.85^{b} ± 1.04
Group (5) 15% fresh banana peel	29.13^{b} ± 2.73	23.93^{b,c} ± 3.99	1.22^{b} ± 0.34	5.36^{b} ± 0.11
Group (6) 5% dried banana peel	35.40^{a} ± 1.34	42.13^{b} ± 3.14	1.31^{a} ± 0.04	12.28^{a,b} ± 1.31
Group (7) 10% dried banana peel	41.13^{a,b} ± 1.23	31.76^{b} ± 2.04	1.29^{b} ± 0.04	7.32^{b} ± 0.23
Group (8) 15% dried banana peel	28.13^{b} ± 2.63	39.43^{b} ± 8.16	0.71^{a} ± 0.12	5.86^{b} ± 0.23

The data were presented as mean ± S.D. Means with different superscripts significantly differ ($p \leq 0.05$) according to "Duncan" and the mean values were arranged in a descending order from "a"; "d".

Table 7 Liver function of acute liver failure rats fed on banana peels supplemented diet.

Groups	Parameters					
	Albumin	GPT	GOT	LDH	GGT	ALP
Group (1) negative control	4.21^{a} ± 0.12	40.02^{a} ± 8.52	49.01^{a,b} ± 28.92	122.2^{a,b} ± 6.91	5.14^{a,b} ± 0.23	135.3^{b} ± 0.26
Group (2) positive control	3.15^{a,b} ± 0.13	47.60^{a} ± 12.97	96.20^{a} ± 32.66	145.7^{a} ± 2.41	6.51^{a} ± 0.34	168.2^{a} ± 0.18
Group (3) 5% fresh banana peel	2.99^{a} ± 0.34	38.20^{a} ± 7.36	37.40^{b} ± 25.18	113.5^{b} ± 3.42	4.56^{b} ± 0.25	119.2^{c} ± 0.18
Group(4) 10% fresh banana peel	2.84^{b} ± 0.23	40.84^{a} ± 11.48	35.00^{b} ± 26.38	109.3^{b} ± 2.01	4.21^{b} ± 0.31	124.2^{b} ± 0.14
Group (5) 15% fresh banana peel	2.76^{b} ± 0.12	39.43^{a} ± 8.33	35.60^{b} ± 17.99	107.2^{b} ± 3.42	4.21^{b} ± 0.31	120.3^{b} ± 0.14
Group (6) 5% dried banana peel	3.09^{a,b} ± 0.03	38.45^{a} ± 7.36	39.00^{b} ± 28.922	119.4^{b} ± 3.42	5.06^{b} ± 0.25	129.1^{b} ± 0.18
Group (7) 10% dried banana peel	2.98^{b} ± 0.12	40.41^{a} ± 11.48	33.20^{b} ± 32.66	110.6^{b} ± 2.01	5.11^{b} ± 0.34	123.5^{b} ± 0.14
Group (8) 15% dried banana peel	2.85^{b} ± 0.13	42.43^{a} ± 8.33	37.40^{b} ± 25.18	108.7^{b} ± 3.42	4.91^{b} ± 0.34	123.6^{b} ± 0.14

The data were presented as mean ± S.D. Means with different superscripts significantly differ ($p \leq 0.05$) according to "Duncan" and the mean values were arranged in a descending order from "a"; "d".

colon and implications for health (Langkilde et al., 2002). 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. The amount of dietary fiber in banana is relatively constant during banana ripening (Sampath et al., 2012).

Data in Table 7 revealed that the serum Albumin, LDH and GGT were lower in group (5) (2.76 ± 0.12, 107.2 ± 3.42 and 4.21 ± 0.31 U/L) than the positive group. On the other hand, serum GPT and ALP was lower in group (3) (38.20 ± 7.36 and 119.2 ± 0.18 U/L) and serum of GOT was lower in group (7) (33.20 ± 32.66 U/L) than the positive group. From the data shown in the same table it could be observed that all acute liver failure groups administrated with different levels of fresh and dried banana peel (5%, 10% and 15%) levels had significant decrease in serum Albumin, GPT, GOT, LDH, GGT and ALP comparing with control positive. Iweala et al. (2011) proved that the liver enzymes were not significantly altered except AST that was significantly increased ($p < 0.05$) in the hepatotoxic control group. The liver enzymes, AST and ALT play a role in the metabolism of amino acids. An increase in level of both enzymes may indicate hepatocellular disease, active cirrhosis and metastatic liver. Showed that was a significant increase of AST level in the hepatotoxic control. Conversely, there was a reduction of AST in the non-hepatotoxic groups fed 10% peels of *M. paradisiaca*-supplemented diet. This shows that peels of plantain may possess protective effects on the liver.

Conclusion

From the previous results it could be concluded that supplementation diet with fresh or dried banana peel may be useful for acute liver failure patients, and it could be develop the retarded liver function and lipid profile of them, especially with fresh banana peel.

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