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# Histopathologic Effects of Methanolic Extract of *Momordica charantia* L. Leaves on the Liver of Wistar Rats

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**Abstract:** Histopathologic assessment of the effects of 500 mg $kg^{-1}$ methanolic extract of the leaves of *Momordica charantia* on liver of wistar rats was carried out. Forty wistar rats of eqnal sex weighing between 140-250 g were randomly categorised into eight experimental groups of five wistar rats per group. One main control group M and seven treatment groups A1, A2, B1, B2, C1, C2 and D. A1, A2, B1 and B2 groups were treated with alloxan intraperitoneally. However, while A1 group received 500 mg $kg^{-1}$ (2 mL) of extract treatment, A2, B1 and B2 had no extract treatment. A2 received 2 mL of methanol. C1 group were normoglycaemic rats with no alloxan treatment, but were given 500 mg $kg^{-1}$ (2 mL) of extract treatment orally. C2 group (also normoglycaemic without alloxan treatment) received 2 mL of methanol in place of extract treatment. The D group had 500 mg $kg^{-1}$ (2 mL) of extract treatment intraperitoneally without alloxan treatment. Histopathologic assessment revealed acute congestion of the liver with fluid, enlarged portal triad, pericentral vein haemorrhage and centrilobular necrosis in the A1 treatment. A similar but lesser lesion in D treatment was noticed and essentially normal tissues was observed in all other treatments including the C1 tissues that had extract via the oral route. Significant difference ($p<0.05$) were observed in the Serum Alkaline Phosphatase, L-alanine aminotransferase, L-aspartate aminotransferase, total bilirubin and conjugated bilirubin in the treated rats of the various groups; but the cholesterol levels was not significantly different ($p>0.05$) from control. The results generally indicate that methanolic extract of the leaves of *Momordica charantia* Linn is relatively safe when used orally, but parenteral administration suggests need for caution on indiscriminate use because of its potentially hazardous effect on tissues like the liver; especially on long term use.

**Key words:** Histopathologic, methanolic extract, *Momordica charantia*, liver, wistar rats

## INTRODUCTION

Plants have always been very useful source of remedy to several ailments owing to its easy availability and affordability in traditional setting. Some of these plants that exhibit medicinal properties have been known to help in stabilizing different internal organs in animals, while others have had side effects on the organs probably due to the varying amonnts or quantity of toxic matter present in such plants. Sofowora (1993) posit that toxicity testing in animals is carried out on a new drug to identify potential hazard. It helps in determining the upper limits of administration. Not all contents of the plant's extract usnally have such medicinal property (Kim *et al*., 1999). In this study, *Momordica charantia*-a herbal plant used traditionally in treatment of hyperglycaemic condition is the focus. The histopathologic effects observable from its oral or parenteral use is also assessed. This study was necessitated by the fact that the plant called ugbebhe in Esan and ora language meaning "A goat killer" is almost indiscriminately ingested orally by the Esan and owan

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people of Edo state, Nigeria for the traditional management of diabetes mellitus. The indigenes of these areas had long observed frequent cases of sudden deaths amongst the goats that graze on the parts of *Momordica charantia* namely-the leaves, fruits and seeds. The animals were reported to foam from their mouths, with spontaneous episodes of diarrhoea preceding their deaths.

Amongst the mechanism of action of *Momordica charantia* advanced is that it supports the immune system through its nitric acid scavenging abilities (Jagetia and Baliga, 2004) and it has also been shown to act like insulin by forcing amino acid uptake into skeletal muscle (Cummings *et al*., 2004). It has been shown in animal studies to decrease body fat (Chen and Chan, 2003) and lower the level of liver triglyceride (Senanayake *et al*., 2004). That *Momordica charantia* is safe and has anti-inflammatory properties is not in doubt; but there is still the need for more research to totally authenticate this position (Virdi *et al*., 2003; Ou *et al*., 2003). How much of the plant should be taken? Are there any side effects? Scientific literature suggests that users of *Momordica charantia* be cleared by a physician prior to use (Basch *et al*., 2003).

Rivera (1942) reported that high dose of an alcoholic extract of *Momordica charantia* led to eulargement and ulcers in the gallbladder and development of yellow areas in the liver. Other previous studies in this regard such as Salawn *et al*. (2004) also observed mild to moderate congestion of the liver, kidney, spleen, stomach and intestines with methanolic extract of the leaves of *Momordica charantia*.

This study aims at eliciting possible histopathologic effects observable from indiscriminate use of the herbal plant; particularly as it affects the liver which is a key organ involved in metabolism and detoxification.

## MATERIALS AND METHODS

### Collection, Harvesting and Preparation of *Mormordia charantia* Linn

The leaves of *Momordica charantia* L. were collected from the premises of the University of Benin, Benin City, Edo State, Nigeria in December, 2004. It was identified botanically using a handbook on West African weeds (Akobundu and Agyakwa, 1988). Identification was authenticated by Professor M. Idu of Botany Department, University of Benin, Benin City, Nigeria with herbarium number BTN 142 assigned. The leaves were washed and air-dried for five days, cleaned of debris and kept in the oven to dry at 40°C for 3 h. The dried leaves were ground to powdered form at the Department of Pharmacognosy, University of Benin, Benin City. Three hundred milligram of powdered sample was subjected to methanolic extraction and 16.3% yield was obtained for use.

### Phytochemical Screening of *Momordica charantia* Linn Leaves

Ten kilograms of powdered sample was weighed and stored in a moisture free airtight container for use. Phytochemical screening for the presence of tannins, flavonoids, saponins, alkaloids and Anthraquinones in the plant extract was done following the procedures of Odebiyi and Sofowora (1973) and Sofowora (1993) in the department of Pharmacognosy, university of Benin, Benin City.

### Experimental Animals

Forty wistar rats of eqnal sex weighing between 140-250 g were kept in cages in animal house of Faculty of Pharmacy and Anatomy department of the University of Benin. The experimental animals were kept in separate cages. They were all allowed to acclimatize for three weeks before treatment was commenced during which period they were fed on standard mouse cubes obtained from Pfizer Livestock feeds (Nig) Ltd., Benin City. They were supplied with water *ad libitum* in standard drinking

bottles. The rats were randomly categorized for experimental purpose into different treatment groups of five rats per group. One main control group (M) and seven treatment groups A1, A2, B1, B2, C1, C2 and D with each group consisting of five rats ascribed the suffix Ma, Mb, Mc, Md and Me for the control group M and A1a, A1b, A1c, A1d and A1e for the treatment group A1. The same categorization thus applies to all the groups.

The duration of experiment was twelve weeks conducted from May 12 to August 11, 2005. The main control group M was given Pfizer feeds and water *ad libitum* throughout the period. The A1 group was alloxan-treated intraperitoneally to induce hyperglycaemia and after overnight fasting were given intraperitoneal 500 mg $kg^{-1}$ (2 mL) of alcoholic (methanol) extract of the treatment plant for toxicity testing. A2 group was also alloxan-treated and received the same volume as in A1 but of methanol without extract treatment. The decision to administer 500 mg $kg^{-1}$ of extract was made by the need to use a possibly toxic dose since 500 mg $kg^{-1}$ in a previous preliminary investigation proved toxic to thyroid tissue (Panda and Kar, 2000). The B1 group was induced with alloxan but not treated with extract before sacrificing. B2 group was alloxan-treated but was sacrificed before evidence of induced diabetes. The C1 group was also administered 500 mg $kg^{-1}$ of extract orally without alloxan treatment i.e., they were normoglycaemic rats. C2 group was also normoglycaemic without alloxan treatment but were administered the same volume as in C1 of methanol as a negative control in place of extract treatment. The D group was given 500 mg $kg^{-1}$ of extract intraperitoneally, but had no alloxan treatnent.

About 2.5 g of extract were diluted in 10 mL of alcohol to give 250 mg $mL^{-1}$. Alloxan was prepared as 50 mg $mL^{-1}$ in distilled $H_2O$ and administered intraperitoneally at a dose of 150 mg $kg^{-1}$ to get the volume equivalent thus:

$$\frac{X \times 150}{50}$$

Where,
X = Weight in kg

The Histopathologic effects of the leaf extract of treatment plant were assessed with daily administration of 500 mg $kg^{-1}$ of extract for twelve weeks before sacrificing. The method of sacrificing was by cervical dislocation.

**Chemicals and Reagents**

All chemicals were of analytical grade. Potassium oxalate, sodium fluoride, benzene, hydrochloric acid, lead acetate, methanol, acetone, potassium chloride, haematoxylin and eosin were obtained from BDH chemicals Ltd., (Poole UK). Alloxan monohydrate was obtained from Sigma Aldrich Inc. USA. Ammonia was from Merck (Germany). Glucose oxidase kit and glucose strips (Accu Chek) were from Roche Diagnostics Gmbh, Manheim, Germany. Chloroform was from May and Baker Ltd, Dagenham, England and sodium hydroxide was from Avondale Laboratories, Banbury, Oxon, England. Alkaline Phosphatase reagent set, a commercially available test kit for colorimetric endpoint determination of ALP was obtained from Teco diagnostics, 1268 N. Lakeview Ave. Anaheim, CA 92807. The L-alanine aminotransferase ALT, L-aspartate aminotransferase AST, total and conjugated bilirubin as well as total cholesterol determination kits used were products of Randox Laboratories Ltd., UK.

**Histopathology**

**The Isolated Liver Organ Was Processed as Follows**

Fixation in formal saline, after which tissue was, dehydrated through different alcohol concentrations 50, 70, 90% and absolute alcohol. Removal of alcohol in xylene was done and tissues

were embedded in paraffin and mounted on chuck. Sectioning was at 5 microns using the rotary microtome. The sectioned tissue (ribbons) were floated in water and picked with glass slides in preparation for staining with haematoxylin and eosin following the following steps: Sections were dewaxed in xylene (3-5 min), hydrated through the following grades of alcohol concentration: 100, 90, 70 and 50% spending 1 min on each stage.

Section was rinsed in water and stained with haematoxylin (10-15) min; Differentiated in 1% acid alcohol for 10 sec and then blued in running tap water for 5 min. Thereafter counterstaining was done in 1% Eosin for 3-5 min. Section was finally dehydrated through 50, 70, 90 and 100% of alcohol impregnation, dropped in xylene and mounted on Distrene (a polystrene) a plasticizer (tricresyl phosphate) and xylene (DPX).

**Statistical Analysis**

Data, expressed as the mean±Standard Error of Mean (SEM) was tested for significant difference using the table of analysis of variance. Means were separated using least significant difference. The analysis was carried out using (Genstat release 8.1 PC/Windows 2000), Genstat eight edition; a computer software.

## RESULTS

The methanolic extract was water soluble and gave a yield of 16.3. Treated rats showed reduced food intake, weight loss and sluggishness when administered over a long while, but there was no death of animal recorded even with the high dose used.

From Table 1 significant variation was observed in the means of AST values of experimental animals with A1 group (alloxan-induced and intraperitoneally treated with extract) having the highest value 141.24±17.94 compared to control M with 52.44±4.40.

From Table 2 the mean value of ALT was highest in the A1 treatment group compared to the control group (M). The values in the other treatment groups showed no such marked difference from control.

Table 1: Means of AST values in ($U\,L^{-1}$) of treatment groups and analysis of variance

| Group | Means±SEM* |
|---|---|
| M | 52.44±4.40$^{b}$ |
| A1 | 141.24±17.94$^{a}$ |
| A2 | 51.26±2.84$^{b}$ |
| B1 | 52.28±2.93$^{b}$ |
| B2 | 55.74±3.31$^{b}$ |
| C1 | 61.38±3.05$^{b}$ |
| C2 | 58.96±3.26$^{b}$ |
| D | 66.86±9.52$^{b}$ |

*Means with different alphabetic remarks are significantly different at 5% probability level

Table 2: Means of ALT values in ($U\,L^{-1}$) of treatment groups and analysis of variance

| Group | Means±SEM* |
|---|---|
| M | 57.94±4.05$^{b}$ |
| A1 | 84.50±11.51$^{a}$ |
| A2 | 50.36±1.96$^{b}$ |
| B1 | 54.90±4.63$^{b}$ |
| B2 | 55.68±2.56$^{b}$ |
| C1 | 65.14±4.91$^{b}$ |
| C2 | 60.46±2.95$^{b}$ |
| D | 54.26±3.49$^{b}$ |

*Means with different alphabetic remarks are significantly different at 5% probability level

It was observed from Table 3, that though there were some variations in the mean values of cholesterol amongst the groups, there is no marked difference in any of the treatment groups compared to control group.

From Table 4, significant variations were observed amongst the groups in the mean level of ALP values. There was also significant difference between A1 group with 145.78±19.26 compared to the control M group with 51.72±0.92. This was followed by the values in D group, C1 group, B1, A2, M, B2 and C2 groups in decreasing order of magnitude.

From Table 5 significant variations was observed from amongst the groups with A1 group having the highest value compared to control group M.

From Table 6, significant variation in the mean values of conjugated bilirubin was observed among the groups with A1 group having the highest compared to control group M.

Table 3: Mean values of cholesterol (mg $dL^{-1}$) of treatment groups and analysis of variance

| Group | Mean±SEM* |
|---|---|
| M | 132.64±1.89$^{a}$ |
| A1 | 124.84±3.84$^{b}$ |
| A2 | 121.30±2.25$^{b}$ |
| B1 | 137.18±3.05$^{a}$ |
| B2 | 122.20±1.62$^{b}$ |
| C1 | 126.58±3.72$^{b}$ |
| C2 | 125.68±2.80$^{b}$ |
| D | 125.26±1.59$^{b}$ |

*Means with different alphabetic remarks are significantly different at 5% probability level

Table 4: Mean ALP values in (U $L^{-1}$) of treatment groups and analysis of variance

| Group | Mean±SEM* |
|---|---|
| M | 51.72±0.92$^{c}$ |
| A1 | 145.78±19.26$^{a}$ |
| A2 | 52.56±3.41$^{c}$ |
| B1 | 60.94±4.59$^{c}$ |
| B2 | 50.10±2.19$^{c}$ |
| C1 | 63.52±6.63$^{c}$ |
| C2 | 48.56±2.33$^{c}$ |
| D | 94.32±22.22$^{b}$ |

*Means with different alphabetic remarks are significantly different at 5% probability level

Table 5: Mean total bilirubin values (mg $dL^{-1}$) of treatment groups and analysis of variance

| Group | Mean±SEM* |
|---|---|
| M | 0.1980±0.01$^{b}$ |
| A1 | 0.3060±0.04$^{a}$ |
| A2 | 0.1540±0.01$^{b}$ |
| B1 | 0.2020±0.02$^{b}$ |
| B2 | 0.1580±0.02$^{b}$ |
| C1 | 0.2140±0.02$^{b}$ |
| C2 | 0.1640±0.01$^{b}$ |
| D | 0.1880±0.02$^{b}$ |

*Means with different alphabetic remarks are significantly different at 5% probability level

Table 6: Mean conjugated bilirubin values (mg $dL^{-1}$) of treatment groups and analysis of variance

| Group | Mean±SEM |
|---|---|
| M | 0.04±0.01$^{b}$ |
| A1 | 0.12±0.03$^{a}$ |
| A2 | 0.05±0.01$^{b}$ |
| B1 | 0.07±0.01$^{b}$ |
| B2 | 0.05±0.01$^{b}$ |
| C1 | 0.08±0.01$^{b}$ |
| C2 | 0.04±0.01$^{b}$ |
| D | 0.05±0.01$^{b}$ |

*Means with different alphabetic remarks are significantly different at 5% probability level

## DISCUSSION

The liver of the A1 treatment group showed areas of normal hepatocytes interspersed with regions of degenerative changes and centrilobular necrosis. Infiltration by inflammatory cells especially in the vicinity of the portal tracts, acute congestion with enlarged portal triad and some areas of haemorrhage and fluid are the characteristic findings (Fig. 1A and B). These lesions were present but less marked in the D treatment group (Fig. 2). The liver of the C1 was essentially as that of the control, (Fig. 3) with no abnormality detected. Features in the A1 treatment especially, reflect acute hepatic failure due to massive oedema and possibly hepatotoxic materials. That these findings were not consistent throughout the treatment groups is somewhat likened to report on *Momordica charantia* fruit juice and seed extract's effect on liver of Sprague-Dawley rats by Kamani *et al.* (1994); who found that the prevalence of dilatation and/or congestion of the central vein sinusoidal system appeared twice as high in the group treated with fruit juice than the seed extract treated and distilled water treated groups. In this experiment, hyperglycaemia and intraperitoneal route of administration of the extract may have influenced the findings.

The serum L-aspartate aminotransferase value (Means±SEM) was 141.24±17.94 U $L^{-1}$ in the A1 treatment, which was very significantly different from control with 52.44±4.40 U $L^{-1}$ ($p<0.05$) and other treatments. Serum L-alanine aminotransferase value for A1 was 84.50±11.51 U $L^{-1}$ and 57.94±4.05 U $L^{-1}$ for control. Its value in the rest groups, were not significantly different from the control. Alanine aminotransferase is a cytoplasmic enzyme found in very high concentration in the

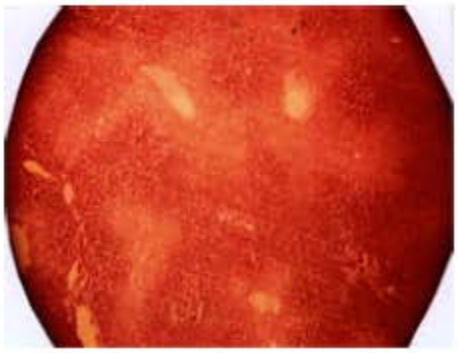

Fig. 1A: Liver parenchyma with degenerative changes and necrosis

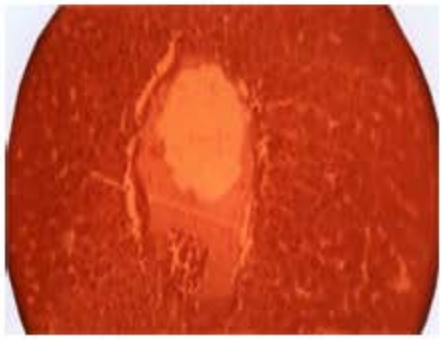

Fig. 1B: Acute congestion of the liver, enlarged portal Triad with pericentral vein hemorrhage

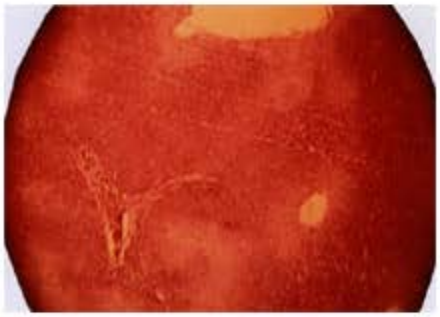

Fig. 2: Areas of necrosis as in A1

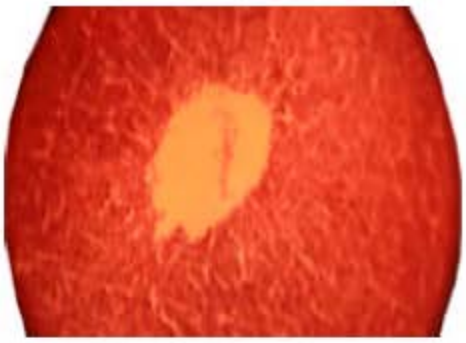

Fig. 3: Normal hepatocytes and central vein

liver, while Aspartate aminotransferase is present in cytoplasm and mitochondria as well, but a less specific enzyme than Alanine aminotransferase as an indicator of hepatic damage (Wilkinsons, 1976). Similarly, the serum values of Alkaline Phosphatase was significantly raised in the A1 treatment 145.78±19.26 U $L^{-1}$ and minimally raised in D treatment 94.32±22.22 U $L^{-1}$ compared to control 51.72±0.92 U $L^{-1}$ ($p<0.05$). Alkaline Phosphatase is an enzyme found in liver bile duct and bone cells. Its level can be markedly raised in cholestasis and minimally raised in chronic hepatocellular disease (Wilkinson, 1976). The elevated levels of these enzymes L-aspartate aminotransferase (AST), L-alanine aminotransferase (ALT) and Alkaline Phosphatase (ALP) in mostly the A1 treatment is understandable from the lesions observed in the liver. Price and Stevens (1993) have shown that ALT and AST are useful in diagnosis of liver disease. The increased levels of these enzymes are consistent with other studies (Schmidt and Schmidt, 1996). This also may have accounted for the elevated levels of bilirubin total of 0.3060±0.04 mg $dL^{-1}$ and conjugated 0.12±0.03 mg $dL^{-1}$ in the A1 treatment group compared to control of 0.1980±0.01 and 0.04±0.01 mg $dL^{-1}$ for the bilirubin total and conjugated, respectively. The serum assay levels of cholesterol remained not significantly different in both the normoglycaemic and alloxan-treated rats compared to control. That the values were not exaggerated in diseased tissues may have been supported by previous study (Jayasooriya *et al*., 2000) that *Momordica charantia* lowers serum cholesterol.

Although one cannot attribute any observed toxicity in these tissues to be exclusively due to the applied methanolic leaf extract of *Momordica charantia* since alloxan was used, no detectable histopathologic changes however, were observed in B1 and B2 rats treated with alloxan without *Momordica* extract treatment; thus suggesting that alloxan may have had negligible interference with

findings. Rivera (1942) had previously reported that high dose alcoholic extract of *Momordica charantia* is injurious to the liver and the gallbladder. Also, the observed lesions in the tissues with intraperitoneally administered extract were non-diffused i.e., not generalised, but rather locular and non consistent. This may be attributable to the presence of flavonoids as in catechin related compounds in this extract having some protective effect against its toxicity (Kim *et al*., 2003). Similar observation (Kamani *et al*., 1994) led to the remark that *Momordica charantia* may either contain hepatotoxins capable of causing cellular damage at the molecular level, without causing significant histopathological changes; or the plant may have an enzyme inducing effect.

The situation is quite different in the group C1 rats which received oral administration of the extract. The enzymes AST, ALT and ALP levels, together with the serum bilirubin total and conjugated levels as well as the serum cholesterol levels showed no significant difference from the control M group ($p>0.05$). This goes a long way to explain the non acutely toxic nature and relative safeties in the oral route administration of the extract (Matsumura, 1975; Corbett *et al*., 1984); as well as its preference to the parenteral route, hence the widespread use orally in the management of hyperglycaemic condition (Karunanayake *et al*., 1984; Welihinda *et al*., 1986; Ahmed *et al*, 2004; Miura *et al*., 2004).

Thus it can be concluded that while *Momordica charantia* may have a wide safe therapeutic margin on oral use, very high dose of methanolic leaf extract of *Momordica charantia* on parenteral administration might be potentially dangerous and could be deleterious to the liver.

## REFERENCES

Ahmed, I., E. Adeghate, E. Cummings, A.K. Sharma and J. Singh, 2004. Beneficial effects and mechanism of action of *Momordica charantia* juice in the treatment of streptozotocin-induced diabetes mellitus in rat. Mol. Cell Biochem., 261: 63-70.

Akobundu, 1.O. and C.N. Agyakwa, 1988. A Handbook on West African Tropical Weeds. IITA Publication, Ibadan, Nigeria, pp: 420.

Basch, S., E. Gabardi and C. Ulbright, 2003. Bitter melon (*Momordica charantia*): A review of efficacy and safety. Am. J. Health Syst. Pharm., 60: 356-359.

Chen, O. and L.L. Chan, 2003. Bitter melon (*Momordica charantia*) reduces adiposity, lowers serum insulin and normalises glucose tolerance in rats fed a high fat diet. J. Nutr., 133: 1088-1093.

Corbett, J.R., K. Wright and A.C. Baille, 1984. The Biochemical Mode of Action of Pesticides. 2nd Edn., Accademic Press, London and New York, 1984.

Cummings, E., H.S. Hundal, H. Wackerhage, M. Hope, M. Bello, E. Adeghate and J. Singh, 2004. *Momordica charantia* fruit juice stimulate glucose and amino acid uptakes in L6 myotubes. Mol. Cell Biochem., 1: 99-104.

Jagetia, G.C. and M.S. Baliga, 2004. The evaluation of nitric oxide scavenging activity of certain Indian medicinal plants *in vitro*: A preliminary study. J. Med. Food, 7: 343-348.

Jayasooriya, A.P., M. Sakono, C. Yukizaki, M. Kawano, K. Yamamoto and N. Fukuda, 2000. Effects of *Momordica charantia* powder on serum glucose levels and various lipid parameters in rats fed with cholesterol-free and cholesterol-enriched diets. J. Ethnopharmacol., 72: 331-336.

Kamani, H.T., S. Jeevathayaparan, P. Angunawala, E.H. Karunanayake and K.S.A. Jayasinghe, 1994. Effect of *Momordica charantia* on key hepatic enzymes. J. Ethnopharmacol., 44: 93-97.

Karunanayake, E.H., J. Welihinda, S.R. Sirimanna and G. Siunadorai, 1984. Oral hypoglycaemic activity of some medicinal plants of Sri Lanka. J. Ethnopharmacol., 11: 223-231.

Kim, C.H., J. Heweh and S.L. Moreberry, 1999. Anti-proliferation activity of plants from genera used in traditional Chinese medicine. Ethnobotany, 11: 85-91.

Kim, M.J., G.R. Ryu and J.S. Chung, 2003. Protective effects of epicatechin against the toxic effects of streptozotocin in rat pancreatic islets: *In vivo* and *in vitro*. Pancreas, 26: 292-299.

Matsumura, F., 1975. Toxicology of Insecticides. Plenum Press, New York, pp: 24-26.

Miura, T., Y. Itoh, N. Iwamoto, M. Kato and T. Ishida, 2004. Suppressive activity of the fruit of *Momordica charantia* with exercise on blood glucose in type 2 diabetic mice. Biol. Pharm. Bull., 2: 248-250.

Odebiyi, O.O. and A. Sofowora, 1973. Phytochemical Screening of Nigeria Medicinal Plants. Lloydia, 41: 234-246.

Ou, L., L.Y. Kong, X.M. Zhang and M. Niwa, 2003. Oxidation of ferulic acid by *Momordica charantia* peroxidase and related anti-inflammation activity changes. Biol. Pharm. Bull., 11: 1511-1516.

Panda, S. and A. Kar, 2000. Excess use of *Momordica charantia* extract may not be safe with respect to thyroid function and lipid peroxidation. Curr. Sci., 79: 222-224.

Price, C.M. and L. Stevens, 1993. Fundamentals of Enzymology. 2nd Edn., Oxford: Science Publications, pp: 451-475.

Rivera, G., 1942. Preliminary chemical and pharmacological studies on cudeamor *Momordica charantia* L. Part 11. Am. J. Pathol., 114: 72-87.

Salawu, O.A., E.O. Ezekiel, O. Adaudia and H.O. Kwanashie, 2004. Toxicological evaluation of methanolic extract of *Momordica charantia* leaves in rats. West Afr. J. Pharmacol. Drug Res., 20: 15-21.

Schmidt, E. and F.W. Schmidt, 1996. Brief Guide to Practical Enzyme Diagnosis. 2nd Edn., Mannheim. Boetirnger Mannheim Gmbh.

Senanayake, G.V., M. Maruyama, K. Shibuya, M. Sakono and N. Fukuda *et al*., 2004. The effects of bitter melon (*Momordica charantia*) on serum and liver triglyceride levels in rats. J. Ethnopharmacol., 91: 257-262.

Sofowora, A., 1993. Medicinal Plants and Traditional Medicine in Africa. Spectrum Books Ltd., Ibadan, pp: 58-196.

Virdi, J., S. Sivakam, S. Shahani, A.C. Suther M.M. Banavalikar and M.K. Biyani, 2003. Antihyperglycaemic effects of three extracts from *Momordica charantia*. J. Ethnopharmacol., 88: 107-111.

Welihinda, J., E.H. Karunanayake, M.H.R. Sheriff and K.S.A. Jayasinghe, 1986. Effect of *Momordica charantia* on the glucose tolerance in maturity onset diabetes. J. Ethnopharmacol., 17: 277-282.

Wilkinson, J.H., 1976. The Principal and Practice of Diagnostic Enzymology. Edward Arnold (Publisher) Ltd., London, pp: 305-348.