Role of *Momordica charantia* in maintaining the normal levels of lipids and glucose in diabetic rats fed a high-fat and low-carbohydrate diet

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ABSTRACT

This study aims to assess whether or not a methanol extract of *Momordica charantia* is able to normalise lipid and glucose levels in diabetic rats fed a high-fat and a low-carbohydrate diet. Different doses of the extract are administered orally for 45 days. The rats are bled at the beginning of the experiment and at 15-day intervals. Blood glucose, triglyceride, low-density lipoprotein (LDL), high-density lipoprotein (HDL) and cholesterol are estimated. Results showed that *M. charantia* extract normalised blood glucose level, reduced triglyceride and LDL levels and increased HDL level. The animals reverted to a diabetic state once the *M. charantia* extract was discontinued.

KEY WORDS: Blood glucose.
Cholesterol.
Diabetes.
Lipoproteins, HDL.
Lipoproteins, LDL.
Momordica charantia.
Triglycerides.

Introduction

Diabetes mellitus is a disease associated with disorders of carbohydrate metabolism whereby glucose transport to cells is limited by reduced insulin production or by insulin resistance caused by, for example, obesity or inherited factors. It is a major risk factor for stroke, heart disease and other blood vessel diseases, and studies have reported that hypertriglyceridaemia and hypercholesterolaemia are common in diabetic subjects who develop such conditions. High levels of circulating lipid is due to an increased turnover of fatty acid, as such molecules are used to generate energy via B-oxidation.[1]

People with diabetes mellitus may avoid or delay the onset of these diseases by reducing lipid stress by controlling risk factors such as weight and diet. Diet control involves reducing the fat content of the diet and supplementing it with fruits and vegetables.

Momordica charantia is a fruit commonly used in the Indian community across the African continent and also in India. In the Ayurvedic system of medicine, *M. charantia* is used in the treatment of inflammation, skin disease and diabetes, and a hypoglycaemic effect has been reported by many authors.[2–5] It also increases glucose level in hypoglycaemic rats as a result of its thyrogenic effect,[3] and polypeptide P in the extract is reported to have a hypoglycaemic property.[6]

Lipids are important macromolecules for the maintenance of cell structure and function. A carbohydrate-rich diet increases blood sugar level and a fat-rich diet may culminate in ketosis in diabetics; therefore, diet supplementation in this group should aim to address these problems.

M. charantia extract has a significant clearing effect on circulating glucose, low-density lipoprotein (LDL) and triglycerides in diabetic rats maintained on a normal diet.[7] Therefore, the present study aims to assess whether or not *M. charantia* extract produces the same results in diabetic rats fed a diet high in fat and low in carbohydrate.

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Materials and methods

M. charantia was obtained from local farmers and its authenticity was confirmed with the Herbarium section of the Department of Botany, University of Nairobi. The fruit was dried, crushed to a powder and extracted in 70% methanol and distilled under reduced pressure in a Buchi-type rotary evaporator. The concentrated extract was kept in a vacuum desiccator. The yield was 5% (w/w) of the total dry weight of the fruit.

Male albino rats (Horts Men strain), 200–250 g in weight, were used in all experiments and were kept in standard laboratory conditions. Diabetes was induced by injecting them with alloxan monohydrate, (60 mg/kg body weight) on two consecutive days. The animals had free access to water and food. Two types of feed were used during the experiment. The reference group was fed a normal diet and the diabetic rats were given a special diet containing 45% fat (90% saturated) and 30% carbohydrate. This is different from the usual prescribed diet for diabetics, which is 45% carbohydrate and 30% fat.

Kits for glucose, triglyceride, cholesterol, LDL and high-density lipoprotein (HDL) were used (Human Gesellschaft, Germany), and the manufacturer's guidelines were followed. Alloxan monohydrate was obtained from Sigma.

Table 1. Effect of termination of *M. charantia* extract treatment on diabetic rats fed a high fat, low carbohydrate diet.

	Group	Day 45	Day 60	Day 75
Glucose	A	100.34 ± 7.64	92.36 ± 6.63	101.39 ± 4.09
	DC	270.93 ± 3.26	281.34 ± 7.07	269.11 ± 8.76
	DE3	98.61 ± 6.53	120.43 ± 5.91	189.61 ± 7.06
Triglyceride	A	92.91 ± 4.63	95.76 ± 3.2	94.89 ± 5.05
	DC	263.73 ± 7.89	278.30 ± 3.9	280.73 ± 7.03
	DE3	103.01 ± 3.99	130.75 ± 7.8	173.60 ± 5.32
Total cholesterol	A	79.89 ± 4.34	75.35 ± 6.07	80.35 ± 5.95
	DC	148.75 ± 5.10	150.95 ± 8.11	155.76 ± 6.90
	DE3	81.34 ± 5.32	89.95 ± 6.02	110.95 ± 5.41
LDL	A	23.75 ± 2.83	21.73 ± 1.98	22.35 ± 1.73
	DC	39.75 ± 5.03	41.53 ± 2.05	38.60 ± 2.03
	DE3	19.63 ± 2.90	23.59 ± 2.15	28.69 ± 1.99
HDL	A	47.95 ± 5.12	46.35 ± 6.20	42.53 ± 3.99
	DC	16.90 ± 3.56	14.50 ± 3.01	14.75 ± 2.11
	DE3	49.95 ± 4.10	40.87 ± 3.71	28.95 ± 1.95

A: normal control rats, DC: diabetic control rats, DE3: experimental rats.

Results expressed as mean ±SE (mg/100 mL). Five in each group.

Twenty-five rats were used for the experiment, divided equally into five trial groups comprising the reference group (A), diabetic control group (DC) and three diabetic experimental groups (DE1, DE2 and DE3). Rats in the three DE groups were given different doses of the extract (80, 100 and 120 mg/kg body weight), while rats in the other two groups were given distilled water.

All the rats were bled on the day before the start of the experiment and on day 15, day 30 and day 45 of the experiment. Thereafter, all rats were returned to a normal diet. Rats in group DE3 were observed for a further 30 days and bled on day 60 and day 75 for assessment of glucose, triglyceride, cholesterol, LDL and HDL levels.

A tail-tip bleeding method was used in all the cases and serum was collected and stored in a freezer. Results were expressed as mean ± SE. Student's *t* test was used for statistical comparisons.

Results

Glucose

Blood glucose level showed a dose-dependent response to the *M. charantia* extract. The 80 mg/kg dose failed to produce a statistically significant reduction but the 100 and 120 mg/kg doses reduced glucose level to normal by day 15 (91.45 ± 6.23 mg/100 mL) and matched the levels in the reference group. This level stayed within the normal range up to day 45. In contrast, diabetic control rats fed the high-fat diet but not the *M. charantia* extract showed a gradual increase in glucose level (73.34 ± 7.60 mg/100 mL on day 0 and 299.64 ± 9.63 mg/100 mL on day 45). On return to a normal diet, glucose levels in group DE3 increased significantly by day 75 ($P<0.001$ compared with controls, Table 1).

Triglyceride

Triglyceride level showed a dose-dependent response to the *M. charantia* extract. Triglyceride concentration decreased as the extract dose increased. In the diabetic control rats, triglyceride level showed a three-fold increase. Return to a normal diet resulted in a significant increase in triglyceride level by day 75 in the DE3 group (Table 1).

Cholesterol

A significant difference was noted in the blood cholesterol level of rats in the DC and DE groups fed the high-fat diet. Levels were found to be significantly lower in rats in all three DE groups, and correlated well with levels in group A. Return to a normal diet resulted in an increase in cholesterol, but this was not statistically significant

Low-density lipoprotein

M. charantia had a dose-dependent effect on LDL levels. A significant difference was observed in LDL levels between the DC group and the DE groups. Levels were found to be low, even in the group on the 80 mg/kg dose, but the results showed greater significant with higher doses (120 mg/kg, $P<0.001$), with LDL levels lower than in group A. Return to a normal diet showed an increase in levels by day 75 ($P<0.05$; Table 1).

High-density lipoprotein
Blood HDL concentration decreased gradually and significantly in the DC group up to 45 days. However, a dose-dependent response was observed in the DE groups. The group that received extract at 120 mg/kg showed the most significant response ($P<0.001$). On return to a normal diet, a 40% decrease in HDL level was noted by day 75. (Table 1)

Discussion

High LDL levels in the blood of diabetic rat are due to low insulin levels. Insulin increases the number of LDL receptors at the cellular level; therefore, in an insulin-deficient state, a decrease in insulin receptors is expected, as is the consequent delay in LDL clearance.[8] Another reason could be the high level of glucose in the circulation. A two- to three-fold increase causes glycosylation of lysine in apoprotein B.[9] Thus, chemical modification of the lysine amino group might interfere with specific LDL-receptor binding and hence clearance.[9]

The present study shows that the daily administration of *M. charantia* extract to diabetic rats fed a diet high in lipid and low in carbohydrate normalises glucose and LDL level in the blood. The effect on glucose level might be due to the increase in glucose uptake by tissues, as it has already been reported that *M. charantia* enhances the *in vitro* rate of glucose uptake by diaphragm tissue.[2] This is due to the thyrogenic effect of the extract, as thyroid hormones are reported to increase basal and insulin-stimulated glucose uptake by skeletal muscle.[10] High glucose uptake is also reported in hyperthyroid rats.[10,11]

Termination of the use of *M. charantia* extract produced a return to diabetic conditions in the GE groups studied, as determined by the parameters measured, even though the rats were returned to a normal diet. This indicated that *M. charantia* plays an active part in the management of diabetes and that it does not have a cumulative effect.

In conclusion, it would appear that *M. charantia* can be included safely in a diet designed for diabetic patients. Furthermore, as *M. charantia* extract reduces lipid levels and increases HDL level, it would appear to have a positive impact on the factors responsible for heart disease and other related abnormalities. □

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