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The Effect on Plasma Glucose, Insulin and Glucagon Levels of Treatment of Diabetic Rats with the Medicinal Plant *Rhazya stricta* and with Glibenclamide, Alone and in Combination

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Abstract

Because many diabetic patients in the United Arab Emirates use medicinal plants as a supplement to treatment with insulin or oral hypoglycaemic agents, the effect on plasma glucose, insulin and glucagon concentrations of simultaneous treatment of streptozotocin-diabetic rats with *Rhazya stricta* extract and glibenclamide has been examined.

Treatment of control rats with the extract at oral doses of 0·5, 2·0 and 4·0 g kg^{-1} did not significantly affect the concentration of glucose, insulin or glucagon for up to 4 h after administration of the extract. The same doses in diabetic rats reduced the glucose level 1 h (2 and 4 g kg^{-1}) and 2 h (4 g kg^{-1}) after administration of the extract. This was accompanied by significant increases in insulin concentration 1, 2 and 4 h after administration of the extract at doses of 2 and 4 g kg^{-1}. Glibenclamide (2·5, 5·0 and 10·0 mg kg^{-1}) dose-dependently reduced glucose and glucagon levels, and increased that of insulin in normal and diabetic rats. Simultaneous treatment of normal and diabetic rats with the plant extract (0·5, 2·0 and 5·0 g kg^{-1}) and glibenclamide (5·0 mg kg^{-1}) significantly exacerbated the effects on glucose, insulin and glucagon induced by the extract or by glibenclamide when given separately. When the plant extract was given at doses of 0·5, 2 and 4 g kg^{-1} per day for 6 consecutive days the glucose level was reduced by approximately 6, 8 and 30%, respectively. No significant effect was seen on the levels of cholesterol or protein.

These results imply that co-administration of the extract with glibenclamide might adversely interfere with glycaemic control in diabetic patients.

In addition to the usual treatment with insulin or oral hypoglycaemic agents, many patients in our region take medicinal plants that are reputed to have an anti-hyperglycaemic effect (Al-Mugamar, personal communication). These plants are often given by herbalists or as self-medication. The therapeutic effectiveness of most of these plants in diabetic patients has not been scientifically evaluated in controlled trials, although the anti-hyperglycaemic action of several of these plants has been well documented in experimentally induced diabetes in laboratory animals, and the subject has been reviewed (Atta-Ur-Rahman & Zaman 1989; Bailey & Day 1989; Ivorra et al 1989; Marles & Farnsworth 1995). Despite the common use of medicinal plants to control diabetes, particularly in the third world, it is not known whether co-administration of the commonly used anti-hyperglycaemic drugs (insulin or oral hypoglycaemic agents) with any of the anti-diabetic medicinal plants would affect the control of the hyperglycaemia (which is the main feature of diabetes) or any of the other biochemical disturbances in the metabolism of carbohydrates, proteins or lipids that accompany diabetes.

In this work, therefore, we have investigated in control and streptozotocin-diabetic rats the interaction of *R. stricta* (a commonly used local medicinal plant reputed to be effective in diabetes) with a known and a commonly used oral hypoglycaemic agents, glibenclamide. *R. stricta* has been selected in this work because it is probably the local plant most commonly used for treatment of diabetes in this country (El Ghonemi 1993). In our laboratory we have previously studied the effect of the plant leaves in streptozotocin-diabetic rats (Wasfi et al 1994; Tanira et al 1996). Subchronic treatment (28 days) with *R. stricta* did not significantly affect plasma glucose or insulin concentrations in rats. However, treatment with the extract induced a significant increase in insulin concentration 0·5 and 1 h after treatment, accompanied by decreases in hyperglycaemia. In streptozotocin-diabetic rats administered glucose orally (1 g kg^{-1}) *R. stricta* induced a significant decrease in plasma glucose level (Tanira et al 1996).

Materials and Methods

Drugs and chemicals

The glibenclamide used was pure powder kindly supplied by Julphar (Ras-Al-Khiyma, UAE). Kits for insulin and glucagon determination were obtained from Dragonistic Product Corporation, LA and those for glucose, cholesterol and total proteins from Roche, Switzerland.

Animals

Locally bred male Wistar rats, 150–250 g, were obtained from the Animal Facility of the UAE University and housed in a room with controlled temperature (21 ± 2°C) and humidity (60–70%), on a 12 : 12 light/dark cycle (lights on at 0600 h). Rats were housed six in a cage (with raised wire bottom to prevent corpophagy) or were kept individually in metabolic cages for 5 days before, and until the end of the experiment, to facilitate collection of urine and faeces.

Unless otherwise indicated animals had free access to pelleted food (Abu Dhabi Flour and Animal Feed Factory) and tap water. Before experiments food, but not water, was withdrawn overnight. Animal weights, feed and water intake and faecal and urine output were measured daily in rats kept in metabolic cages.

Plant material and extraction procedure

The plant was collected from Umm Gafa, Al-Ain district in February 1996, and authenticated at the National Herbarium of the UAE University, where a voucher specimen was deposited.

The leaves were air-dried in the shade and coarsely pulverized. The resulting powder (200 g) was macerated with distilled water (3 L) for 16 h at room temperature, with occasional shaking. The extract was filtered and the filtrate was lyophilized by use of a freeze-dryer. The final lyophilized product constituted approximately 18·3% of the original material. Aqueous solutions were prepared freshly from the same lyophilized product and used in all tests. The aqueous extract was administered orally in a volume of 2 mL kg^{-1}.

Induction of diabetes

Diabetes was induced in rats by intraperitoneal (i.p.) injection of streptozotocin at a dose of 60 mg kg^{-1}. Streptozotocin was dissolved in 0·1 mM citrate buffer (pH 4·5) to give a concentration of 20 mg mL^{-1}. Control animals received the same volume of buffer alone by the same route. The diabetic state was assessed by measuring plasma glucose concentration before and 24 h and 48 h after streptozotocin treatment. Only rats with glucose concentration above 16 mM were considered to be diabetic. To overcome the hypoglycaemia which follows streptozotocin injection, during the first 24 h after streptozotocin administration diabetic rats were given 5% glucose solution to drink instead of tap water.

Blood collection

In most experiments blood was collected into heparinized capillary tubes by tail clipping. In other experiments rats were anaesthetized with thiopentone (30 g kg^{-1}, i.p.) before decapitation. Collected blood was centrifuged at 900 *g* for 15 min at 5°C to separate the plasma.

Treatment

Experiment 1. Rats (n = 36) were divided into six equal groups designated 1–6. Groups 1, 2 and 3 were kept as non-diabetic whereas groups 4, 5 and 6 were made diabetic with streptozotocin. Two days after treatment with streptozotocin or its vehicle the animals in groups 1, 2 and 3 were treated orally with *R. stricta* extract at doses of 0·5, 2 and 4 g kg^{-1}, respectively. Groups 4, 5 and 6 were treated with the same extract again at doses of 0·5, 2 and 4 g kg^{-1}, respectively. Blood was collected from all rats, by tail clipping, before treatment and 1, 2 and 4 h after extract administration for measurement of plasma glucose, insulin and glucagon concentrations.

Experiment 2. Rats (n = 36) were divided into 6 equal groups. As in Experiment 1, groups 1 to 3 were non-diabetic whereas groups 4 to 6 were diabetic. Group 1, 2 and 3, and groups 4, 5 and 6 were orally treated with glibenclamide at a doses of 2·5, 5 and 10 mg kg^{-1}, respectively. Blood was collected from all rats, by tail clipping, before treatment and 1, 2, and 4 h thereafter for measurement of glucose insulin and glucagon concentrations.

Experiment 3. Rats (n = 36) were divided into 6 equal groups and treated with *R. stricta* extract and glibenclamide simultaneously as follows: Group 1 (non-diabetic) treated with *R. stricta* (0·5 g kg^{-1}) and glibenclamide (5 mg kg^{-1}); Group 2 (non-diabetic) treated with *R. stricta* (2 g kg^{-1}) and glibenclamide (5 mg kg^{-1}); Group 3 (non-diabetic) treated with *R. stricta* (4 g kg^{-1}) and glibenclamide (5 mg kg^{-1}); Group 4 (diabetic) treated with *R. stricta* (0·5 g kg^{-1}) and glibenclamide (5 mg kg^{-1}); Group 5 (diabetic) treated with *R. stricta* (2 g kg^{-1}) and glibenclamide (5 mg kg^{-1}); Group 6 (diabetic) treated with *R. stricta* (4 g kg^{-1}) and glibenclamide (5 mg kg^{-1}).

Blood was collected from all the groups before treatment (zero time) and 1, 2 and 4 h thereafter and the plasma was used for glucose, insulin and glucagon measurement.

Experiment 4. In this experiment six groups (n = 6 per group) were used, and treated as follows: Group 1, control (non-diabetic) rats given distilled water; Group 2, non-diabetic rats given *R. stricta* (0·5 g kg^{-1} day^{-1}) for 6 days; Group 3, control (diabetic) rats treated as for group 1; Group 4, diabetic rats given *R. stricta* (0·5 g kg^{-1} day^{-1}) for 6 days; Group 5, diabetic rats given *R. stricta* (2 g kg^{-1} day^{-1}) for 6 days; Group 6, diabetic rats given *R. stricta* (4 g kg^{-1} day^{-1}) for 6 days.

Before the start of the experiment blood was collected by tail clipping to determine initial blood glucose, cholesterol and protein levels. Twenty-four hours after the last dose the rats were anaesthetized and decapitated. Blood was processed and plasma used for measurement of blood glucose, cholesterol and protein.

Biochemical analysis

Glucose, cholesterol and total protein concentrations were measured by automated methods using the Cobas Fara Autoanalyser (Roche, Switzerland) and reagents supplied by the manufacturer. The concentrations of the pancreatic hormones insulin and glucagon in the plasma were measured by radioimmunoassay. Insulin was determined by a modification of the method of Herbert et al (1965). Briefly, plasma samples (200 μL) were pipetted into the insulin-antibody-coated tubes and [^{125}I]-insulin (1·0 mL) was added to every tube which was then vortex-mixed. The samples were incubated at room temperature and decanted, before counting for 1 min in a Beckman gamma counter. Glucagon was determined by the double-antibody technique of Unger & Orci (1989). Briefly, plasma and controls (200 μL of each) were pipetted into the tubes provided and 100 μL of glucagon antiserum and [^{125}I]glucagon were added to the tubes which were then incubated for 24 h at 4°C. Precipitating solution (1·0 mL) was then added to all tubes and these were centrifuged for 15 min at 100 *g*. Radioactivity was counted for 1 min using a Beckman gamma counter. The minimum detection limits for insulin and glucagon assays were 1·2 μ int units mL^{-1} and 13 pg mL^{-1}, respectively. Results were analysed by Immunofit EIA/RIA analysis version 2·00.

Statistical analysis

Values reported are means ± s.e.m. with the number of observations given in parentheses. Differences between group means were assessed by one-way analysis of variance followed by the Scheffe test using the computer program Statview 5. $P < 0·05$ was considered as indicative of significance.

Table 1. The effect on plasma glucose concentration of acute treatment of normal and diabetic rats with *Rhazya stricta.*

Group	Status	Dose ($g\,kg^{-1}$)	Plasma glucose level (mM)			
			0 h	1 h	2 h	4 h
1	Normal	0·5	5·3 ± 0·2	5·5 ± 0·3	5·6 ± 0·3	5·6 ± 0·5
2	Normal	2·0	5·1 ± 0·3	5·3 ± 0·2	5·4 ± 0·3	5·6 ± 0·4
3	Normal	4·0	5·2 ± 0·4	5·3 ± 0·4	5·3 ± 0·4	5·4 ± 0·3
4	Diabetic	0·5	18·2 ± 1·9	14·3 ± 1·2	16·1 ± 2·1	16·1 ± 2·0
5	Diabetic	2·0	18·8 ± 1·7	12·8 ± 1·3*	15·1 ± 1·8	16·7 ± 1·9
6	Diabetic	4·0	18·9 ± 2·1	13·0 ± 1·3*	14·0 ± 1·4*	16·2 ± 1·7

Values are means ± s.e.m. (n = 6 rats). *R. stricta* extract was given orally to normal and streptozotocin-diabetic rats and plasma-glucose

Table 2. The effect on plasma insulin ($\mu g\,mL^{-1}$) and glucagon ($pg\,mL^{-1}$) concentrations of acute treatment of normal and diabetic rats with *Rhazya stricta.*

Group	Status	Dose ($g\,kg^{-1}$)	0 h		1 h		2 h		4 h	
			Insulin	Glucagon	Insulin	Glucagon	Insulin	Glucagon	Insulin	Glucagon
1	Normal	0·5	25·3 ± 3·1	121·3 ± 15·7	24·2 ± 3·4	118·9 ± 12·1	30·3 ± 4·2	121·3 ± 13·1	28·8 ± 3·2	120·2 ± 13·7
2	Normal	2·0	27·7 ± 3·3	124·9 ± 12·8	25·7 ± 3·2	120·7 ± 13·2	30·7 ± 5·1	120·7 ± 13·9	29·9 ± 3·9	123·7 ± 12·1
3	Normal	4·0	26·9 ± 3·2	130·1 ± 13·9	26·1 ± 3·1	130·2 ± 13·9	29·3 ± 3·9	129·3 ± 14·2	32·3 ± 4·8	133·2 ± 13·1
4	Diabetic	0·5	7·3 ± 2·1	120·7 ± 13·9	8·3 ± 0·9	131·2 ± 15·1	10·2 ± 2·1	123·3 ± 13·1	9·2 ± 1·1	127·1 ± 12·9
5	Diabetic	2·0	8·2 ± 1·3	123·2 ± 15·1	13·2 ± 1·6*	121·7 ± 12·1	17·7 ± 2·3*	127·3 ± 13·3	12·0 ± 2·1*	133·9 ± 15·1
6	Diabetic	4·0	7·9 ± 2·0	129·3 ± 14·1	16·2 ± 2·1*	130·3 ± 14·1	24·3 ± 3·1	129·9 ± 16·3	21·3 ± 2·0*	131·3 ± 16·1

Values are means ± s.e.m. (n = 6 rats). *R. stricta* extract was given orally to normal and streptozotocin-diabetic rats, and insulin and glucagon concentrations were measured before (0 h) and 1, 2 and 4 h after treatment. *$P < 0.05$, significant compared with the corresponding value at 0 h.

Table 3. The effect on plasma glucose concentration of acute treatment of normal and diabetic rats with glibenclamide.

Group	Status	Dose ($mg\,kg^{-1}$)	Plasma glucose level (mM)			
			0 h	1 h	2 h	4 h
1	Normal	2·5	5·5 ± 0·4	4·6 ± 0·5	4·5 ± 0·5	4·9 ± 0·5
2	Normal	5·0	5·3 ± 0·3	4·9 ± 0·5	4·3 ± 0·6*	4·2 ± 0·5*
3	Normal	10·0	5·4 ± 0·5	3·5 ± 0·3*	3·2 ± 0·5*	4·0 ± 0·4*
4	Diabetic	2·5	17·3 ± 1·8	11·3 ± 1·9*	10·32 ± 2·3*	8·7 ± 0·9*
5	Diabetic	5·0	19·9 ± 2·1	16·3 ± 2·0*	12·11 ± 2·1*	8·9 ± 1·2*
6	Diabetic	10·0	18·8 ± 1·9	9·2 ± 0·9*	9·9 ± 1·2*	8·7 ± 0·9*

Values are means ± s.e.m. (n = 6 rats). Glibenclamide was given orally to normal and streptozotocin-diabetic rats, and plasma glucose concentrations were measured before (0 h) and 1, 2 and 4 h after treatment. *$P < 0.05$, significant compared with the corresponding value at 0 h.

Results

Effect of R. stricta *on glucose, insulin and glucagon levels*

Treatment of control rats with *R. stricta* at doses of 0·5, 2·0 and $4·0\,g\,kg^{-1}$ did not significantly alter plasma glucose insulin or glucagon concentrations for up to 4 h after extract administration. Administration of the same doses to diabetic rats resulted in significant ($P < 0.05$) decreases in the glucose level 1 h (2·0 and $4·0\,g\,kg^{-1}$) and 2 h ($4·0\,g\,kg^{-1}$) after extract administration. This was accompanied by significant increases in the concentration of insulin (but not glucagon) measured 1, 2 and 4 h after administration of the extract (2·0 and $4·0\,g\,kg^{-1}$). These results are listed in Tables 1 and 2.

Effect of glibenclamide on glucose, insulin and glucagon levels

Treatment of rats with glibenclamide at oral doses of 2·5, 5·0 and $10·0\,mg\,kg^{-1}$ reduced, in a dose-related manner, blood glucose concentrations in both normo- and hyperglycaemic rats. Concomitantly, these reductions were accompanied, also in a dose-related fashion, by increases in insulin concentrations and decreases in glucagon concentrations in the plasma ($P < 0.05$). These results are listed in Tables 3 and 4.

Effect of R. stricta *and glibenclamide, given together, on glucose, insulin and glucagon levels*

Simultaneous oral treatment of normal and diabetic rats with *R. stricta* (0·5, 2·0 and $4·0\,g\,kg^{-1}$) and glibenclamide ($5·0\,mg\,kg^{-1}$) caused a significant reduction in plasma glucose concentrations. These reductions exceeded those induced by *R. stricta* and glibenclamide given alone by about 50% and 20%, respectively (Table 5). The results for insulin and glucagon concentrations closely paralleled those for glucose (data not shown).

Table 4. The effect on plasma insulin ($\mu g\,mL^{-1}$) and glucagon ($pg\,mL^{-1}$) concentrations of acute treatment of normal and diabetic rats with glibenclamide.

Group	Status	Dose ($mg\,kg^{-1}$)	0 h		1 h		2 h		4 h	
			Insulin	Glucagon	Insulin	Glucagon	Insulin	Glucagon	Insulin	Glucagon
1	Normal	2·5	24·8 ± 3·3	131·3 ± 15·9	29·7 ± 2·9	121·7 ± 12·9	29·8 ± 2·0	120·7 ± 14·7	28·3 ± 1·9*	122·7 ± 15·1
2	Normal	5·0	28·9 ± 4·1	142·7 ± 15·1	30·1 ± 1·9	133·7 ± 15·1	36·3 ± 2·0*	130·7 ± 15·7	33·9 ± 1·4*	133·2 ± 15·9
3	Normal	10·0	27·3 ± 3·7	139·8 ± 16·3	44·7 ± 2·1*	121·1 ± 12·1*	42·2 ± 1·9*	130·3 ± 13·9	35·7 ± 1·9*	139·2 ± 13·7
4	Diabetic	2·5	6·9 ± 0·8	129·3 ± 13·7	10·3 ± 1·2*	120·7 ± 13·7	14·2 ± 1·9*	118·7 ± 12·1	17·2 ± 2·2*	108·9 ± 11·1
5	Diabetic	5·0	8·3 ± 0·7	128·8 ± 14·1	13·3 ± 1·4*	117·3 ± 12·8	20·7 ± 2·9*	110·2 ± 12·7	22·1 ± 3·1*	106·6 ± 10·2
6	Diabetic	10·0	7·7 ± 0·6	133·3 ± 12·7	18·1 ± 1·9*	102·3 ± 11·3*	23·3 ± 3·1*	98·7 ± 11·3*	28·3 ± 3·1*	99·8 ± 12·1*

Values are means ± s.e.m. (n = 6 rats). Glibenclamide was given orally to normal and streptozotocin-diabetic rats, and insulin and glucagon

Table 5. The effect on plasma glucose concentration of acute treatment of normal and diabetic rats with *Rhazya stricta* and glibenclamide, given simultaneously.

Group	Status	Dose ($g\,kg^{-1}$)	Glibenclamide ($g\,kg^{-1}$)	Plasma glucose level (mM)			
				0 h	1 h	2 h	4 h
1	Normal	0·5	5	5·7 ± 0·3	4·3 ± 0·5	4·2 ± 0·4	4·8 ± 0·5
2	Normal	2·0	5	5·3 ± 0·4	4·4 ± 0·6	3·9 ± 0·4*	4·1 ± 0·4*
3	Normal	4·0	5	5·8 ± 0·5	3·2 ± 0·4*	3·0 ± 0·3*	4·2 ± 0·4*
4	Diabetic	0·5	5	19·3 ± 2·0	11·9 ± 19*	8·3 ± 0·8*	7·6 ± 0·7*
5	Diabetic	2·0	5	20·7 ± 2·3	12·0 ± 1·4*	8·0 ± 0·9*	6·3 ± 0·7*
6	Diabetic	4·0	5	18·7 ± 2·1	8·3 ± 0·8	7·1 ± 0·6*	6·0 ± 0·7*

Values are means ± s.e.m. (n = 6 rats). *R. stricta* and glibenclamide were administered orally simultaneously to normal and streptozotocin-diabetic rats, and plasma glucose levels were measured before (0 h) and 1, 2 and 4 h after treatment. *$P < 0·05$, significant compared with the corresponding value at 0 h.

Table 6. The concentrations of glucose, cholesterol and protein in the plasma of normal and diabetic rats treated orally with *Rhazya stricta* extract for 6 days.

Group	Status	*R. stricta* ($g\,kg^{-1}\,day^{-1}$)	Glucose (mM)	Cholesterol (mM)	Protein ($g\,L^{-1}$)
1	Normal	–	5·4 ± 0·3	3·2 ± 0·2	59·3 ± 6·1
2	Normal	2·0	5·3 ± 0·4	3·5 ± 0·4	60·2 ± 6·3
3	Diabetic	–	17·1 ± 1·3	3·7 ± 0·4	58·3 ± 6·1
4	Diabetic	0·5	16·0 ± 1·9	3·5 ± 0·5	59·7 ± 7·1
5	Diabetic	2·0	15·7 ± 1·8	3·5 ± 0·4	58·8 ± 7·0
6	Diabetic	4·0	13·2 ± 1·2*	3·2 ± 0·4	60·2 ± 6·9

Values are means ± s.e.m. (n = 6 rats). The extract was given to rats daily for 6 days; 24 h after the last day the animals were killed and plasma obtained for analysis. *$P < 0·05$, group 3 results significant compared with group 6 results.

Effect of treatment with R. stricta *on plasma glucose, cholesterol and protein levels in normal and diabetic rats*

Treatment of diabetic rats with 0·5, 2·0 and 4·0 $g\,kg^{-1}\,day^{-1}$ *R. stricta* for six consecutive days reduced glucose levels by 6·4%, 8·2% ($P < 0·01$) and 29·5% ($P < 0·05$), respectively. No significant effect was seen on the levels of cholesterol or protein. These results are listed in Table 6.

Discussion

Medicinal plants are often used to treat diabetes because of the firm belief in them by patients (especially in rural areas in the developing world), the inaccessibility of modern medicines, or for other reasons. Combining both medicinal plant preparations and modern therapeutic agents is commonly practised in this region (El Mugammer, personal communication). This work therefore investigated the effect of combining the extract of an 'antidiabetic' plant with glibenclamide. The results indicated that treatment of diabetic rats with relatively high doses of the plant extract alone moderately reduced hyperglycaemia. Within 1–2 h the effect decreased with time and within 4 h it had disappeared. These results accord with our previous observations (Tanira et al 1996) which indicated that the plant extract induced a 16–32% reduction in glucose level 0·5 and 1 h after a glucose load. Whereas *R. stricta* had no significant effect on insulin and glucagon concentrations in normal rats, it did significantly increase the concentration of insulin (but not glucagon) in a dose-related manner. Thus it seems that the short-lived decrease in glucose concentration after administration of the extract was caused by the rise in

insulin level. Previously we have shown that 0·5–1·0 h after extract administration there was a sharp and short-lived increase in insulin level in the plasma. However, when the extract was given for six consecutive days the insulin level was not affected. Among other factors, this was suggested to be because of a 'counter-regulatory' process which had taken place in the animals given the extract, after subchronic administration (Tanira et al 1996).

Glibenclamide administration induced its expected effect on glucose and pancreatic hormones levels. In both normal and diabetic rats simultaneous treatment with glibenclamide ($5\,mg\,kg^{-1}$) and the extract at doses of 0·5, 2·0 and $4·0\,g\,kg^{-1}$ increased the hypoglycaemic and insulin-activating effects of both compounds in an additive manner. These results suggest that combining the plant extract with glibenclamide might cause significant, albeit transient, interference in the control of glucose level in diabetic patients. However, the long-term effects of such combinations if given chronically are not known. These results highlight the potential problem which might arise if traditional treatments are given concomitantly with modern antidiabetic drugs. Management of diabetes might be particularly difficult in patients who medicate themselves with antidiabetic plants without informing their physicians. It should be mentioned that despite the relatively low toxicity of *R. stricta* (Tanira et al 1996) this plant was found to have psychoactive properties (e.g. sedation, antidepression and variable effects on endogenous MAO A and B inhibitor (tribulin); Ali et al 1995, 1996, 1997; Tanira et al 1997). It is conceivable that the claimed beneficial effect of the plant in diabetic patients might be related to some of its psychoactive properties.

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