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Technical Note

Biochemical Action of *Balanites aegyptiaca* Fruits as a Possible Hypoglycemic Agent

The effect of Balanites aegyptiaca *as an anti-diabetic agent was investigated using adult albino rats. The rats were injected with alloxan to induce diabetes. Daily gain in body weight, daily food intake, food efficiency, serum protein, serum glutamic-oxalacetate transaminase (GOT) and glutamic pyruvate transaminase (GPT) activities and liver/body weight ratio were determined before and after 2, 10 and 20 days of alloxan injection. The addition of 10% whole or extracted pulp of* Balanites aegyptiaca *fruits at the expense of starch in the basal diet caused a considerable decrease in food intake and a gain in body weight and, consequently, food efficiency ratio, in the first 10 days compared with the negative control. In the second 10 days, rats fed on the basal diet, or the basal diet supplemented with 10% whole or extracted pulp, recovered their appetite for food and gained daily in body weight and food efficiency ratio. The liver/body weight ratio was not significantly affected. The addition of whole or extracted pulp also caused a highly significant decrease in serum glucose level and serum protein and inhibited the activities of GOT and GPT in alloxanized rats.*

INTRODUCTION

Balanites aegyptiaca is a tree which grows principally in West Africa, Sudan, Uganda, Tanzania, Palestine, Saudi Arabia and Egypt where it is to be found in El-Kharga and El-Dakhla Oases, in the eastern desert and southern Aswan. The fruit resembles the date in size and appearance and consists of a loose, thin, brownish-yellow skin, covering a brown sticky

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pulp, embedded in which is a hard woody shell enclosing a light yellowish kernel.

Many parts of the plant are used as food. The leaves are used as a vegetable and the pericarp is crushed and eaten cooked. The seeds are also used in making soup, bread and alcoholic beverages; the bark is used as a soup substitute in Sudan (Creach, 1940). The effect of *Balanites aegyptiaca* on many diseases has been studied by many authors. Creach (1940) observed that the bark of *Balanites aegyptiaca* was used as an anthelmintic in the treatment of syphilis and as a fish poison in Tanganika, French Sudan and the Lake Chad area. He also found that the Arabs used parts of the plant as a febrifuge (the mesocarp), as an anthelmintic (bark extraction), against lues chacre (the bark), as a liver remedy and to protect themselves against cold (the fruit). Moreover, it was also found that the bark yielded a washing liquid containing saponin and a fish poison. Many workers in the field of diabetes have sought a drug that may be curative for the disease. Plant and plant products are known to have antidiabetic effects, so the aim of the present investigation was to evaluate *Balanites aegyptiaca* fruit as a hypoglycemic agent.

MATERIALS AND METHODS

Samples

The whole pulp fruit was used for feeding rats. In another experiment the whole pulp fruit was extracted with 80% ethanol in a Soxhlet apparatus for 6 h, then the extracted pulp was also used in another feeding experiment.

Experimental animals

A total of 32 adult albino rats (four groups), 60 days old (average weight, 90 g) were fed on a basal diet consisting of casein, 15%; cottonseed oil, 10%, cellulose, 5%; salt mixture (Hegested *et al.*, 1941), 4%; vitamin mixture (Campbell, 1961), 1% and starch, 65%, for 8 days. Diet and water were supplied *ad libitum*. Each rat was kept separately in a well aerated cage, weighed every 2 days and its food consumption determined. Blood samples were withdrawn from orbital venous plexuses and blood glucose was determined. To induce hyperglycemia, rats were injected with

alloxan as described by Lazarow & Polay (1954) (150 mg per kilogram body weight). The fourth group was kept without injection and was fed on the basal diet only (negative control). The diabetic rats (24) were randomly assigned and divided into three groups. The first group was fed on the basal diet (positive control) whilst the second and third groups were fed on the basal diet supplemented with 10% whole and extracted pulp, respectively, at the expense of the starch. The supplemented diets were offered to the rats 48 h after alloxan injection. Blood sugar was determined using the modified method described by Asatoor & King (1954). Serum protein was determined according to the method of Gornall *et al.* (1949). The method of Ritmun & Frankel (1957) was used to determine serum transaminases (glutamic-oxalacetate transaminase (GOT) and glutamic pyruvate transaminase (GPT)). Statistical analysis was evaluated by using the analysis of variance (F-test) according to Snedecor & Cochran (1967).

RESULTS AND DISCUSSION

Table 1 shows means of daily gain in body weight, daily food intake and food efficiency ratio of rats before and after alloxan injection and feeding on whole and extracted pulp. From this table it is clear that, before alloxan injection, there are no differences between groups with regard to all mentioned parameters. Alloxan injection caused a considerable decrease in food intake in the first 10 days and two rats in every alloxanized group died. The decrease in the food intake was accompanied by a considerable decrease in daily gain in body weight and consequently a decrease in food efficiency ratio which reached zero for all groups injected with alloxan. In the second 10 days rats in groups 2 and 3 (positive control and those fed on the basal diet supplemented with 10% whole pulp) recovered their appetite for food, while the fourth group, fed on the basal diet supplemented with 10% extracted pulp, also followed the same trend, but the increase was non-significant. The daily food intake was high and was followed by an increase in daily gain in body weight but this was still lower than the values obtained at the beginning of the experiment (Fig. 1). The liver/body weight ratio was non-significantly affected.

Table 2 shows the blood glucose level of the rats at the beginning of the experiment, then 2, 10 and 20 days after alloxan injection. Injection of

TABLE 1

Means of Daily Gain in Body Weight, Daily Food Intake, Food Efficiency and Liver/Body Weight Ratios in Rats, on Different Diets Before and After Alloxan Injection

Rats	*Experimental time*									
	Beginning of the experiment			*10 days after injection*			*20 days after injection*			*Liver/ body weight ratio*
	Daily gain in body weight (g)	*Daily food intake (g)*	*Food efficiency*	*Daily gain in body weight (g)*	*Daily food intake (g)*	*Food efficiency*	*Daily gain in body weight (g)*	*Daily food intake (g)*	*Food efficiency*	
Group 1 Negative control	2·1	9·95	0·213	2·4	10·1	0·237	2·31	10·1	0·231	0·039
Group 2 Positive control	1·8	9·41	0·192	0·06	7·3	0·008	1·73	9·05	0·190	0·044
Group 3 Hyperglycemic rats + whole pulp	2·0	9·58	0·207	0·00	7·4	0·000	1·50	10·1	0·164	0·046
Group 4 Hyperglycemic rats + extracted pulp	1·9	9·35	0·205	−0·21	7·5	−0·030	0·63	7·9	0·077	0·049

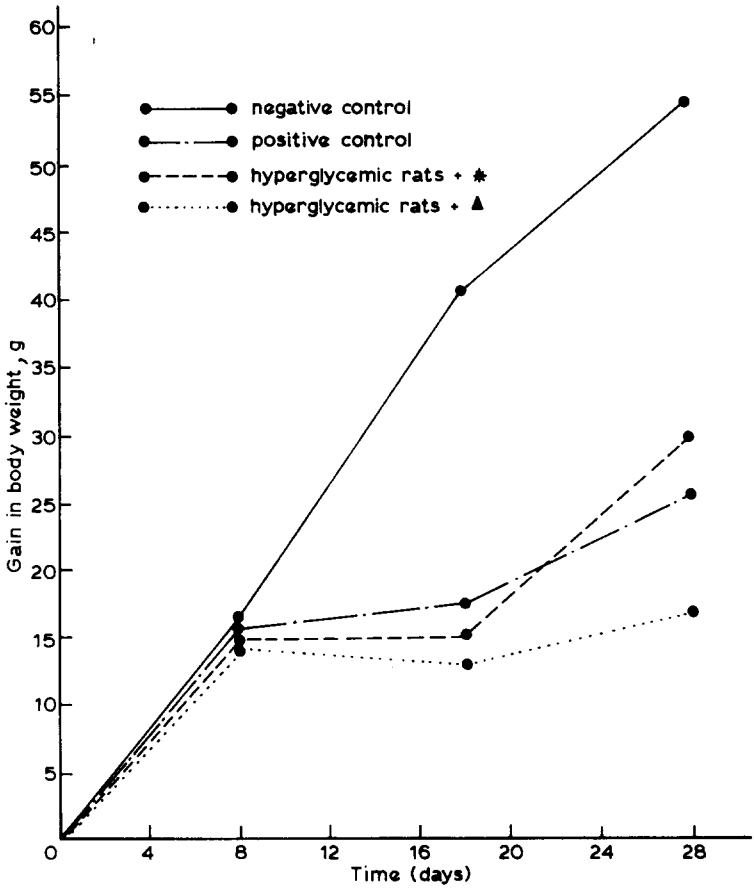

Fig. 1. Daily gain in body weight of the hyperglycemic rats fed whole and extracted pulp compared with positive and negative controls. (✱, whole pulp; ▲, extracted pulp.)

alloxan caused a highly significant increase of blood glucose level for all the injected groups. Alloxan may have increased hepatic glycogenolysis or gluconeogenesis or decreased the rate of removal of glucose from the blood by the tissues. These influences are due to the absence of an adequate amount of insulin. The alloxan acts directly, promptly and specifically on the β-cells of the pancreatic islets.

Administration of whole and extracted pulp reduced the elevated blood glucose levels of diabetic rats compared with corresponding positive control and the decrease continued and reached 192 and 213 mg/100 ml, respectively at the end of the experiment. These levels, however, were still

higher (highly significant) than those of the negative control. It should be emphasized, also, that the rates of reduction of blood glucose levels in the extracted pulp-fed animals were less than in animals given whole pulp.

Fritz & Siegmund (1926) found that saponin decreased blood sugar. In addition, Kenji (1923) observed that injections of 1 % saponin caused no hyperglycemia in starved animals. In this connection, Tankono (1933) mentioned that the administration of saponin with adrenalin caused no changes in blood sugar. They concluded that the pulp of *Balanites aegyptiaca* fruits may increase cellular utilization of glucose. The hypoglycemic effect of pulp of *Balanites aegyptiaca* fruits may be due to

TABLE 2
Mean of Blood Glucose Level

Rats	*Blood glucose (mg/100 ml)*			
	Before the experiment	*After 48 h*	*After 10 days*	*After 20 days*
Negative	91·92	91·92	96·67	101
Positive	96·83	298·75	372·78	364·2
Whole pulp	96·67	378·98	242·73	192
Extracted pulp	93·50	281	247·97	213·83
LSD 0·05	ns	65·1808	41·2899	44·3830
LSD 0·01		88·8971	56·3134	60·5319

ns, not significant.

the occurrence of active principles which may be similar to insulin in its action and enable cells to achieve better utilization of glucose.

As previously discussed, the mode of action of the hypoglycemic agents of *Balanites aegyptiaca* fruits differs from that of tolbutamides. The principal action of tolbutamides is to stimulate the release of insulin to the β-cells of the islets of Langerhans, then reduce blood glucose levels. Thus, it is ineffective in alloxan-induced diabetes (Jain & Vyas, 1974). However, *Balanites aegyptiaca* fruits have hypoglycemic activity when insulin secretion by the pancreas is almost stopped. The hypoglycemic action of the fruits may enable cells to utilize glucose.

Effect of *Balanites aegyptiaca* fruits on serum protein

Table 3 shows that protein serum level was increased in alloxanized diabetic rats compared with normal animals. Whole or extracted pulp caused a significant decrease in serum protein content compared with alloxanized diabetic rats. The increase in serum protein levels in diabetic

TABLE 3
Means and Standard Deviations of Serum Protein, GOT and GPT Activity in Normal and Alloxanized Diabetic Rats

Rats	*Serum protein in alloxanized rats*	*GOT*	*GPT*
Negative control	$7{\cdot}13 \pm 0{\cdot}40$	$38{\cdot}6 \pm 2{\cdot}6$	$10{\cdot}3 \pm 0{\cdot}44$
Positive control	$11{\cdot}7 \pm 0{\cdot}54$	$65{\cdot}4 \pm 4{\cdot}15$	$30{\cdot}0 \pm 2{\cdot}1$
Whole pulp	$10{\cdot}3 \pm 0{\cdot}75$	$30{\cdot}5 \pm 3{\cdot}65$	$17{\cdot}4 \pm 0{\cdot}78$
Extracted pulp	$10{\cdot}9 \pm 0{\cdot}94$	$34{\cdot}5 \pm 5{\cdot}82$	$19{\cdot}7 \pm 1{\cdot}25$

Means: Average of six rats in each group.
Serum protein: mg/100 ml.
GOT and GPT activity: IU (International Units).

animals may be due to the disturbance of hormonal regulation in glucose metabolism, and this was then restored by hypoglycemic agents of *Balanites aegyptiaca* fruits. Activities of glutamic-oxalacetate transaminase (GOT) and glutamic pyruvate transaminase (GPT) were estimated in serum and the results are also given in Table 3. The diabetic rats give high values for GOT and GPT activities. The addition of hypoglycemic agents (whole or extracted pulp) caused a highly significant decrease in serum GOT and GPT activities in diabetic rats but the values were still higher than those of normal rats (negative control). The present data are in agreement with those of Cohn & Joseph (1960) who reported that there was more urinary urea nitrogen excretion in alloxanized diabetic rats than in their corresponding normal animals. Also, alloxanized diabetic rats had an increase in their ability to convert several amino acids (aspartic, glutamic and leucine) to lipids as compared with a negative control.

The present results of serum protein levels confirm the GOT and GPT findings and suggest that alloxan elevated the blood sugar levels; these results correspond to the activation of transaminase enzymes (GOT and GPT) while both hypoglycemic agents (whole pulp or extracted pulp) decrease the blood sugar levels in diabetic rats. The decreases of blood sugar levels were paralleled by the inhibition of GOT and GPT activities, which inhibited glycogenolysis.

Accordingly, some of the amino acids were deaminated and the amino nitrogen excreted as urea. More work is needed, however, to elucidate the qualitative and quantitative changes in protein metabolism resulting from the hypoglycemic agents.

REFERENCES

Asatoor, A. M. & King, E. J. (1954). Simplified colorimetric blood sugar method. *Biochem. J.*, **56**, 44.

Campbell, I. A. (1961). *Methodology of protein evaluation.* RAG Nutr. Document R. 101 add. 37. June meeting, New York.

Cohn, C. & Joseph, D. (1960). Comparison of 'meal eating' and 'nibbling' on severity of alloxan diabetes. *Proc. Soc. Expt. Biol. Med.*, **105**, 575.

Creach, P. (1940). *Balanites aegyptiaca* and its various uses in Tchad territory. *Rev. Botan. Appl. Agr. Trop.*, **20**, 578. *Chem. Zenter*, **1**, 651 c (1943). (*cf Chem. Abst.*, **38**, 3777, 1944).

Fritz, L. & Siegmund, B. (1926). Resorption experiments on the surviving isolated intestine. II. The effect of saponin on the resorption of sugar solutions. *Biochem. Z.*, **172**, 422. (*cf Chem. Abst.*, **20**, 3493).

Gornall, A. G., Bradawell, G. J. & David, M. M. (1949). Determination of serum protein by means of the biuret reaction. *J. Biol. Chem.*, **177**, 751.

Hegested, D. M., Mills, R. C., Elvehjem, C. A. & Hart, E. B. (1941). Choline in the nutrition of chicks. *J. Biol. Chem.*, **138**, 459.

Heikila, R. E. & Cabbat, F. S. (1980). The prevention of alloxan induced diabetes by amygdalin. *Life Sci.*, **27**(8), 659. (*cf Chem. Abst.*, **93**, 197711).

Jain, R. C. & Vyas, C. R. (1974). Garlic in alloxan-induced diabetic rabbits. *Am. J. Clin. Nutr.*, **28**(7), 684.

Kenji, T. (1923). The variations in blood sugar in internal asphyxia due to blood poisons. *Biochem. Z.*, **141**, 85. (*cf Chem. Abst.*, **18**, 1530, 1924).

Lazarow, A. & Polay, B. (1954). *Experimental diabetes and its relation to the disease. A symposium.* Blackwell Scientific Publications, Oxford.

Ritmun, S. & Frankel, S. (1957). A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminase. *Amer. J. Clin. Path.*, **28**, 56.

Snedecor, G. W. & Cochran, W. G. (1967). *Statistical methods* (6th edn) Iowa State Univ. Press, Ames, Iowa, USA, 393 pp.

Tankono, I. (1933). Influence of the peroral administration of saponin with adrenaline, ephidrine and insulin on the contents of sugar and inorganic phosphorus in the blood. *Japan J. Med. Sci.* **IV**. *Pharmacol.* 7(1) *Proc. Japan, Pharmacol. Sci.* **IV**. *Pharmacol.* 7(1), *Proc. Japan, Pharmacol. Soc.* 54.

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