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Effect of Garlic Extract on Blood Glucose Level and Lipid Profile in Normal and Alloxan Diabetic Rabbits

Wpływ wyciągu z czosnku na stężenie glukozy we krwi i profil lipidowy u królików zdrowych i chorych na cukrzycę wywołaną alloksanem

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article; **G** – other

Abstract

Objectives. Comparative hypoglycemic and hypolipidaemic activity of garlic (ethanol) extract and metformin was the aim of the study in 24 normal and diabetic rabbits.
Material and Methods. In group A of 12 rabbits, the influence of different doses (250, 300 and 350 mg/kg body weight) of garlic extract was evaluated, six of them were kept normal, while six were caused to be diabetic with alloxan (150 mg/kg body weight). In another group B of 12 rabbits, the influence of various doses of metformin (250, 375 and 500 mg/kg body weight) was also assessed in the similar grouping of six normal and six diabetic rabbits.
Results. The maximum hypoglycemic response was observed with highest doses of garlic extract (350 mg/kg body weight) in normal rabbits 4 h after garlic extract administration, while in diabetic rabbits, blood glucose level (270.3 ± 0.8 mg/dl) was significantly ($p < 0.05$) lowered as compared to the control level (303.8 ± 1.8 mg/dl). The levels of triglycerides (44.0 ± 0.9 mg/dl) and cholesterol (32.8 ± 0.7 mg/dl) also significantly ($p < 0.05$) decreased in normal rabbits after 4 h of extract administration as compared to that of 0 h samples (triglycerides 66.0 ± 1.5 mg/dl and cholesterol 47.5 ± 0.5 mg/dl). In diabetic rabbits, 0 h level of triglyceride and cholesterol was found to be 86.5 ± 1.1 mg/dl and 93.8 ± 0.9 mg/dl, respectively and levels seen in 4 h sample were 61.3 ± 1.2 mg/dl and 57.0 ± 1.8 mg/dl, respectively.
Conclusions. In normal as well as diabetic rabbits, garlic extract produced hypoglycemia as well as hypolipidaemia like metformin, but the hypoglycemic effect was more pronounced with metformin, whereas garlic extract was more effective in causing hypolipidaemia as compared to metformin (**Adv Clin Exp Med 2012, 21, 6, 705–711**).

Key words: garlic extract, rabbits, metformin, hypoglycemia, hypolipidaemia.

Streszczenie

Cel pracy. Porównanie działania hipoglikemicznego i hipolipidemicznego wyciągu z czosnku (etanol) i metforminy u 24 królików zdrowych i chorych na cukrzycę.
Materiał i metody. W grupie A 12 królików oceniono wpływ różnych dawek (250, 300 i 350 mg/kg masy ciała) wyciągu z czosnku, 6 utrzymywano bez leczenia, u pozostałych 6 wywołano cukrzycę za pomocą alloksanu (150 mg/kg masy ciała). W grupie B 12 królików oceniano wpływ różnych dawek metforminy (250, 375 i 500 mg/kg masy ciała) w podobnej grupie 6 zdrowych królików i 6 chorych na cukrzycę.
Wyniki. Maksymalną odpowiedź hipoglikemiczną zaobserwowano po podaniu największych dawek wyciągu z czosnku (350 mg/kg masy ciała) u zdrowych królików 4 godz. po podaniu ekstraktu z czosnku, a u królików chorych na cukrzycę stężenie glukozy we krwi (270,3 ± 0,8 mg/dl) znacząco ($p < 0,05$) zmniejszyło się w porównaniu z grupą kontrolną (303,8 ± 1,8 mg/dl). Stężenie triglicerydów (44,0 ± 0,9 mg/dl) i cholesterolu (32,8 ± 0,7 mg/dl) znacznie

(p < 0,05) zmniejszyło się u zdrowych królików po 4 godz. po podaniu ekstraktu z czosnku w porównaniu z próbkami z 0 godz. (triglicerydy 66,0 ± 1,5 mg/dl i cholesterolu 47,5 ± 0,5 mg/dl). U królików chorych na cukrzycę (0 godz.) stężenie triglicerydów i cholesterolu wynosiło 86,5 ± 1,1 mg/dl i 93,8 ± 0,9 mg/dl, a 4 godz. po podaniu stężenie wyniosło 61,3 ± 1,2 mg/dl i 57,0 ± 1,8 mg/dl.

Wnioski. U zdrowych królików i chorych na cukrzycę wyciąg z czosnku wywoływał hipoglikemię i hipolipidemię tak jak metformina, ale działanie hipoglikemiczne było większe w przypadku metforminy, a ekstrakt z czosnku był bardziej skuteczny w wywoływaniu hipolipidemii w porównaniu z metforminą (**Adv Clin Exp Med 2012, 21, 6, 705–711**).

Słowa kluczowe: wyciąg z czosnku, króliki, metformina, hipoglikemia, hipolipidemia.

There are several reports showing that hyperglycemia and hyperlipidaemia are linked to increased cardiovascular risk [1]. High levels of serum cholesterol, triglycerides, low-density lipoproteins and body mass index as well as low concentration of HDL are significantly associated with coronary heart disease [2].

For the treatment of type II diabetes, drug therapy (hypoglycemic agent and insulin), dietary therapy and recently spices and natural product therapy have been used [3].

Augasti [4] reported the therapeutic values of onion (*Allium cepa*) and garlic (*Allium sativum*). He observed several sulphur-containing active principles mainly in the form of cystein derivative, which are responsible for the various biological activities such as anti diabetic, antibiotic, hypocholesterolemic and fibrinolytic activity. Garlic (*Allium sativum*) is a member of *Liliaceae* family. Garlic, is a common food item used as flavor and spice and it is one of the herbs most commonly used in modern folkloric medicine. Strong odor of the garlic is largely due to sulphur-containing compounds like S-allycsteine sulphoxide, which are believed to account for most of its medicinal properties. Beside many other pharmacological activities such as anti-coagulant, anti-thrombotic, anti-oxidant anti-hypolipidaemic, garlic has been reported to possess sufficient hypoglycemic activity in animals.

Metformin, a biguanides, is well known for its hypoglycemic ability to control and maintain normoglycemia in type 2 diabetes mellitus, but it has been shown to possess hypolipidaemic activity as well in experimental animals. Metformin has been regarded as one of the best-tolerated drugs, particularly for cardiac patients. It exerts its hypoglycemic effects by reducing the release of glucose from liver glycogen stores and secondarily by provoking some increase in the cellular uptake of glucose in body tissues [5].

This study was designed to compare the hypoglycemic activity of garlic (ethanol) extract in normal and diabetic rabbits with that of metformin which is a hypoglycemic product prescribed widely for population with diabetes type 2.

Material and Methods

All the kits (Randox Laboratories, Ireland) for the estimation of various analytes were obtained from the local market (Irza Enterprises, Pakistan). Plasma glucose level was measured by using a Glucose Oxidase Kit. The plasma total cholesterol, triglyceride, HDL, and ALT and AST levels were evaluated by enzymatic test kits.

Experimental Animals

Animals under study were adult male rabbits (aged 4–6 months and weighing 1–2 kg) brought up in animal house of Gomal University, Dera Ismail Khan. These were housed in standard steel cages under standard laboratory conditions (light period 8:00 am to 8:00 pm, 21 ± 2°C temperature, relative humidity 55%, green fodder and water available *ad libitum.* The study protocol (Phar-2009-GU/119) was approved by the ethical Committee of the Department of Pharmacy, Gomal University, Dera Ismail Khan and was conducted in accordance with the USA guidelines for laboratory animal use and care.

Plant Material and Extraction Procedure

Plant material, tunicated buds of garlic (*Allium sativum*) were purchased from the local market (Metro, Multan, Pakistan); a botanist authenticated it and a voucher number was taken. These voucher specimens were deposited in the herbarium of Department of Botany, Gomal University, Dera Ismail Khan, Pakistan. Its ethanol extract was obtained using following procedure: One kg of tunicated buds of garlic was subjected to grinding in a high-speed grinder (Molinex-289, France) at room temperature. The ground material was suspended in 5 L of 95% ethanol for 15 days in airtight glass jar, shaking the suspension periodically 3 times a day. On the 16^{th} day, the suspension was filtered in muslin cloth to remove residue. Filtration was repeated 3 times to obtain clear filtrate. The filtrate was put into the flask of rotary evaporator (Eyela, Japan) batch wise in a volume of 500 ml keeping the bath temperature 40°C. The extract obtained (approximately 300 ml) was transferred to 500 ml beaker and subjected to further evaporation on water bath at 100°C to obtain ultimately a gel like mass weighing approximately 61 g.

Preparation of Dosage Form

Zero size hard gelatin capsule shells having a capacity to accommodate 500 mg of powder were used in the preparation of dosage form of garlic extract. The capsule shells were obtained from the local market (Irza Enterprises, Pakistan). The capsules were filled with extract manually adding 250, 300 and 350 mg in different capsule units.

Grouping of Animals, Drug Administration and Collection of Blood Samples

Twenty-four male healthy rabbits were divided into the two groups: Group A and B. Group A comprised of 12 normal rabbits. Eight days before the collection of blood samples for analysis, group B was rendered diabetic by giving intravenously alloxan 150 mg/kg (in 10% isotonic saline) body weight. Six (Group A1) of the normal rabbits (Group A) were given garlic extract 250 mg/kg body weight, 300 mg/kg body weight and 350 mg/ /kg body weight with an interval of 72 h, whereas six normal rabbits (Group A2) of group A2 were given 250 mg/kg body weight, 375 mg/kg body weight and 500 mg/kg body weight of metformin with the same interval of 72 h. Similarly, six (Group B1) diabetic rabbits (Group B) were given the same doses of garlic extract as administered to group Al and six diabetic rabbits (Group B2) from group B were given the same doses of metformin as were given to the rabbits in group A2 in the same time interval.

Samples from all the rabbits of group A and B for the estimation of blood glucose, triglycerides, and cholesterol, were taken from the marginal vein at 0 h (just before the administration of garlic extract), 2 h and 4 h after the administration of products.

Clotting of all samples was completed within 10 min after collection and serum was obtained by spinning the sample in centrifuge machine (Heraeus-Christ GHBH, Osterodeto, Germany) at 1000 × g. Each sample was labeled properly and put in the refrigerator for analysis, which was carried out on the same day.

Before the withdrawal of 0 h sample, all the rabbits were not allowed any food for at least 10 h; however, they were free to drink water. The samples were analyzed for glucose, triglyceride and cholesterol level.

Analytical Procedures

The blood samples were analyzed for the estimation of blood glucose, triglyceride and cholesterol using kits (supplied by Globe Diagnostics, Lahore, Pakistan) at the laboratory of Basic Medical Sciences, Faculty of Pharmacy, Gomal University, Dera Ismail Khan.

Statistics

Data was expressed as mean ± standard deviation (SD) and analyzed employing two-tailed Student's t-test, two-way ANOVA and Duncan's multiple comparison tests. The level of significance was set at 0.05. The software used was Statistical Package for the Social Sciences (SPSS), version 15.0.

Results

The results showing the levels of blood glucose, triglyceride and cholesterol of 24 rabbits before and after the administration of different doses of garlic extract and metformin are summarized in Table 1 and 2.

Table 1 shows the effect of garlic extract in a dose of 250, 300 and 350 mg/kg body weight in normal rabbits. Maximum response was seen by the end of 4 h after garlic extract administration when the blood glucose (68.8 ± 0.6 mg/dl), triglyceride (52.6 ± 1.5 mg/dl) and cholesterol (38.1 ± 0.7 mg/dl) levels were significantly ($p < 0.05$) lower than those seen in the 0 h sample (control levels). With the increase in dose to garlic extract 300 mg/ /kg body weight, 2 h samples showed a significant ($p < 0.05$) lowering in glucose, triglyceride and cholesterol (Table 1) levels as compared with the control one (glucose 74.1 ± 1.0 mg/dl, triglyceride 65.6 ± 1.2 mg/dl and cholesterol 45.6 ± 0.8 mg/dl). More significant ($p < 0.05$) effect was observed when the dose of garlic extract was increased to 350 mg/kg body weight and the level of fasting blood glucose, triglyceride and cholesterol were found to be 69.3 ± 0.7 mg/dl, 52.0 ± 1.5 mg/dl and 40.0 ± 1.5 mg/dl after two h and 55.6, ± 1.0 mg/dl, 44.0 ± 0.9 mg/dl and 32.8 ± 0.7 mg/dl after 4 h, respectively. After 2 and 4 h intervals, a decrease in the levels of all three parameters was statistically significant ($p < 0.05$) as compared with the control.

Table 1 shows the effect of increasing doses of metformin on the fasting blood glucose, triglyceride and cholesterol level in normal rabbits. After

Table 1. Effect of garlic extract on blood glucose, triglyceride and cholesterol level in normal rabbits. Samples were taken at 0 h (just before the administration of garlic extract), 2 h and 4 h after the administration of garlic extract. Each value is the mean and ± SEM of six observations

Tabela 1. Wpływ wyciągu z czosnku na stężenie glukozy we krwi, triglicerydów i cholesterolu u zdrowych królików. Próbki pobierano w 0 godz. (przed podaniem ekstraktu z czosnku), 2 godz. i 4 godz. po podaniu ekstraktu z czosnku. Każda wartość to średnia ± SEM 6 obserwacji

	Garlic extract 250 mg/kg body weight		
Samples (Próbki)	blood glucose level (mg/dl)	bloo blood triglyceride level (mg/dl)	blood cholesterol level (mg/dl)
0 h samples	73.3 ± 1.1	68.3 ± 1.6	43.0 ± 1.4
2 h samples	71.3 ± 1.1	58.1 ± 1.9	41.1 ± 1.3
4 h samples	*68.8 ± 0.6	* 52.6 ± 1.5	*38.1 ± 0.7
	Garlic extract 300 mg/kg body weight		
0 h samples	74.1 ± 1.0	65.6 ± 1.2	45.6 ± 0.8
2 h samples	*68.8 ± 0.8	*54.0 ± 1.2	*38.6 ± 1.1
5 h samples	*61.6 ± 1.8	* 49.0 ± 1.8	*34.8 ± 0.9
	Garlic extract 350 mg/kg body weight		
0 h samples	77.0 ± 1.1	66.0 ± 1.5	47.5 ± 0.5
2 h samples	*69.3 ± 0.7	*52.0 ± 1.5	*40.0 ± 1.5
4 h samples	*55.6 ± 1.0	*44.0 ± 0.9	*32.8 ± 0.7
	Metformin 250 mg/kg body weight		
0 h samples	68.3 ± 1.0	69.5 ± 1.0	46.0 ± 1.0
2 h samples	63.6 ± 1.5	* 57.0 ± 1.0	46.0 ± 0.85
4 h samples	*59.8 ± 1.2	*63.8 ± 1.3	44.0 ± 0.5
	Metformin 375 mg/kg body weight		
0 h samples	70.5 ± 1.0	67.3 ± 1.1	45.0 ± 0.8
2 h samples	*60.0 ± 1.6	66.3 ± 1.0	*41.0 ± 0.60
4 h samples	* 53.1 ± 2.9	64.3 ± 1.0	*41.0 ± 0.3
	Metformin 500 mg/kg body weight		
0 h samples	71.1 ± 0.7	65.0 ± 0.7	46.0 ± 0.7
2 h samples	*57.1 ± 2.1	64.0 ± 0.7	*41.5 ± 0.5
4 h samples	* 52. 0 ± 2.7	*62.3 ± 0.6	43.1 ± 0.4

* P < 0.05 as compared with values at 0 h samples.

* P < 0,05 w porównaniu z wartościami próbek pobranych w 0 godz.

administering metformin 250 mg/kg body weight, there was a non-significant ($p > 0.05$) decrease in the levels of blood glucose and triglyceride after 2 h but the decrease was significant ($p < 0.05$) for triglyceride as compared with the control levels (glucose 68.3 ± 1.0 mg/dl, triglyceride 69.5 ± 1.0 mg/dl and cholesterol 46.0 ± 1.0 mg/dl).

Three days after the administration of the 2nd dose, when the animals were ready for the 3rd dose, control levels (in 0 h samples) had the mean values 71.1 ± 0.7 mg/dl, 65.0 ± 0.7 mg/dl and 46.0 ± ± 0.7 mg/dl for glucose, triglyceride and cholesterol, respectively (Table 1). The 2 h samples after the administration of 3rd dose (500 mg/kg body weight), mean values were 57.1 ± 2.1 mg/dl, 64.0 ± ± 0.7 mg/dl and 41.5 ± 0.5 mg/dl for glucose, triglyceride and cholesterol, respectively. Whereas after 4 h of metformin administration, responses were still higher and mean values were 52.0 ± 2.7 mg/dl, 62.3 ± 0.6 mg/dl and 43.1 ± 0.4 mg/dl for glucose, triglyceride and cholesterol, respectively. The decrease in the blood glucose level was significant ($p < 0.05$) after 2 h and 4 h of metformin administration as compared with the control levels but the changes in the levels of triglyceride and cholesterol did not show any particular patron.

Table 2 shows the levels of glucose, triglyceride and cholesterol when the dose of metformin was increased to 375 mg/kg body weight. Just before metformin administration (zero level) the observed mean values were 305.1 ± 2.5 mg/dl, 82.3 ± 1.2 mg/dl and 92.3 ± 1.0 mg/dl for glucose, triglyceride and cholesterol, respectively, whereas in 2 h samples (2 h after metformin administration) these values were 298.0 ± 1.9 mg/dl, 79.5 ± 1.2 mg/dl and 89.0 ± ± 1.5 mg/dl non-significant ($p > 0.05$) decrease was seen in 2 h sample as compared with that of control, but in 4 h sample, significant ($p < 0.05$) decrease was seen for blood glucose (294.1 ± 1.8 mg/dl), triglyceride (79.5 ± 1.2 mg/dl) and cholesterol (88.1 ± 1.9 mg/dl).

Table 2. Effect of garlic extract on blood glucose, triglyceride and cholesterol level in diabetic rabbits (alloxan treated 150 mg/kg bodyweight). Samples were taken at zero h (just before the administration of garlic extract) at 2h and 4h after the administration of garlic extract. Each value is the mean and ± SEM of six observations

Tabela 2. Wpływ wyciągu z czosnku na stężenie glukozy we krwi, triglicerydów i cholesterolu u królików chorych na cukrzycę (leczonych alloksanem 150 mg/kg masy ciała). Próbki pobierano 0 godz. (tuż przed podaniem ekstraktu z czosnku), 2 godz. i 4 godz. po podaniu ekstraktu z czosnku. Każda wartość to średnia ± SEM 6 obserwacji

	Garlic extract 250 mg/kg body weight		
Samples (Próbki)	blood glucose level (mg/dl)	bloo blood triglyceride level (mg/dl)	blo blood cholesterol level (mg/dl)
0 h samples	307.0 ± 2.8	85.1 ± 0.9	91.0 ± 1.2
2 h samples	*290.5 ± 4.2	*77.5 ± 0.8	89.0 ± 1.5
4 h samples	*283.6 ± 4.0	*73.8 ± 0.7	*81.3 ± 0.9
	Garlic extract 300 mg/kg body weight		
0 h samples	300.8 ± 2.2	86.0 ± 0.9	95.0 ± 1.0
2 h samples	*286.3 ± 2.4	*74.0 ± 1.0	* 83.0 ± 1.6
5 h samples	* 280.8 ± 1.9	*68.5 ± 1.6	*68.1 ± 1.5
	Garlic extract 350 mg/kg body weight		
0 h samples	303.8 ± 1.8	86.5 ± 1.1	93.8 ± 0.9
2 h samples	*279.5 ± 1.9	*69.0 ± 2.1	*78.5 ± 1.0
4 h samples	*270.3 ± 0.8	*61.3 ± 1.2	*57.0 ± 1.8
	Metformin 250 mg/kg body weight		
0 h samples	308.5 ± 2.3	87.0 ± 0.9	92.0 ± 1.0
2 h samples	302.5 ± 1.7	87.0 ± 1.0	* 90.0 ± 1.0
4 h samples	302.6 ± 2.3	89.3 ± 1.1	*87.0 ± 1.7
	Metformin 375 mg/kg body weight		
0 h samples	305.1 ± 2.5	82.3 ± 1.2	92.3 ± 2.3
2 h samples	298.0 ± 1.9	79.5 ± 1.1	89.0 ± 1.6
4 h samples	*294.1 ± 1.8	79.5 ± 1.2	88.1 ± 1.9
	Metformin 500 mg/kg body weight		
0 h samples	301.3 ± 1.6	89.5 ± 0.8	95.0 ± 0.8
2 h samples	*280.1 ± 2.5	86.5 ± 0.8	93.0 ± 0.8
4 h samples	*275.5 ± 2.4	85.3 ± 0.6	*74.6 ± 1.2

* $P < 0.05$ as compared with values at 0 h samples.

* P < 0,05 w porównaniu z wartościami próbek pobranych o 0 godz.

With a higher dose of metformin 500 mg/kg body weight, a significant ($p < 0.05$) decrease in the blood glucose was in seen in the 2 h sample (280.1 ± 2.5 mg/dl) and the 4 h sample (275.5 ± 2.4 mg/dl) as compared with the control levels (301.3 ± 1.6 mg/dl). The mean value of triglyceride in 0.2 and 4 h were 89.5 ± 0.8 mg/dl, 86.5 ± 0.8 mg/dl and 85.3 ± 0.6 mg/dl, respectively. It can be seen from the values that a non-significant ($p < 0.05$) decrease was observed as a result of metformin administration. However, in the 4 h samples, the value of cholesterol was significantly ($p < 0.05$) lower (74.6 ± 1.2 mg/dl) as compared with the control (95.0 ± 0.8 mg/dl). In the 2 h samples, the mean values of cholesterol were found to be 93.0 ± 0.8.

Discussion

Garlic, like many other food additive, has gained sufficient importance among neutraceuticals, particularly in relation to its effects on blood glucose and lipid levels [4–6]. There have been attempts to assess the efficacy of garlic (ethanol) extract prepared by simple procedure in lowering blood levels of glucose, triglyceride and cholesterol in comparison with an established product metformin. In the present study, a dose related linear response has been observed with increasing dose of garlic extract in causing hypoglycemia and hypolipidaemia in rabbits. When garlic extract 250 mg/ /kg body weight was administered to normal rabbits, a hypoglycemic and hypolipidaemic response was seen maximally 4 h after the administration of garlic extract when the mean values of glucose, triglyceride and cholesterol decreased significantly ($p < 0.05$) as compared with control levels (Table 1). Hypoglycemic and hypolipidaemic response was apparently slow to appear, which could have been due to the delayed absorption of medicament in the present animals who were on the normal animal house diet as the changes in the blood levels of glucose, triglyceride and cholesterol were more prominent in the 4 h samples rather than in the 2 h samples. An almost similar pattern of hypoglycemic and hypolipidaemic response was seen when the doses were increased to 300 and 350 mg/kg body weight (Table 1). However, the magnitude of response was higher with the higher dose and the lowest levels of blood glucose (55.6 ± 1.0 mg/dl), triglyceride (44.0 ± 0.9 mg/dl) and cholesterol (32.8 ± 0.7 mg/dl) were seen in 4 h samples (Table 1). These levels were significantly ($p < 0.05$) low as compared to those seen in 0 h sample. The levels of glucose, triglyceride and cholesterol in 0 h samples were 77.0 ± 1.1 mg/dl, 66.0 ± 1.5 mg/dl and 47.5 ± 0.5 mg/dl, respectively.

In human trials, garlic as a food additive has shown hypolipidaemic as well as hypoglycemic effects [7–9]. The present data also reflects similar findings in normal rabbits as well as alloxan induced diabetic rabbits. To substantiate the present finding, a parallel administration of metformin was done in three different doses to another group of 12 rabbits. Six of them were normal and six were rendered diabetic. All normal rabbits showed a duly expected hypoglycemic and hypolipidaemic response to garlic extract as well as to metformin. In a number of studies, garlic has been found to be effective in lowering serum glucose level in STZ--induced as well as alloxan induced diabetic rats and mice and rabbits. Garlic is also said to lower serum cholesterol [4]. In a study by Alim et al. [9] the beneficial effects of garlic extract in controlling hyperlipidaemia in animals are attributed to the presence of various organosulfur compounds, mainly allicine in garlic.

When the present normal rabbits were administered 250 mg, 375 mg and 500 mg/kg body weight of metformin, blood glucose levels were 63.6 ± 1.5 mg/dl, 60.0 ± 1.6 mg/dl and 57.1 ± 2.1 mg/dl after 2 h and 59.8 ± 1.2 mg/dl, 53.1 ± 2.9 mg/dl and 52.0 ± 2.7 mg/dl after 4 h, respectively. With all the doses of metformin, decrease in glucose level was significant ($p < 0.05$) as compared with the control levels, which were 68.3 ± 1.0 mg/dl, 70.5 ± 1.0 mg/dl and 71.1 ± 0.7 mg/dl just before the dose 1, 2 and 3, respectively (Table 1).

Hyperglycemic action of metformin has been established in experimental animals as well as in human beings. Further work on the pharmacological activity of metformin has shown its hypolipidaemic effect [10]. These findings were in support of the present observation when the present animals were administered metformin in increasing doses. Table 1 shows the effect of garlic extract in lowering blood glucose, triglyceride and cholesterol in allxon induced diabetic rabbits. Allxon is poison for β-cells of the pancreas; it destroys β-cells of islets of Langerhans possibly by breaking the DNA strands. Allxon appears to do so as a result of a generation of free radicals and causes inactivation of essential sulfhydryl enzyme of cells. This results in diabetes commonly without damaging the α-cells or the acinar cells of the pancreas [11]. In the present study, significant ($p < 0.05$) lowering of blood glucose, triglyceride and cholesterol was seen as compared with control levels when the diabetic rabbits were administered garlic extract in a dose of 250, 300 and 350 mg/kg body weight. This response was almost of the same pattern as seen in the normal rabbits but apparently higher in magnitude. One possible explanation could be the fact that sugar levels in diabetic rabbits were quit higher as compared to the normal ones and changes in glucose level also correspond to initially high levels to certain extent. Concomitant rise of triglyceride and cholesterol level in 0 h samples of the diabetic rabbits compared with normal ones (Table 1) could be the outcome of de-arranged intermediary metabolism.

Although these changes in the blood glucose, triglyceride and cholesterol level were significant ($p < 0.05$) in the 4 h samples of diabetic rabbits as compared with 0 h levels, none of the doses (250, 300 and 350 mg/kg body weight) was able to decrease glucose level to the normal range (65–80 mg/dl), which could possibly be due to an obvious reason that most of the anti-diabetics either increase in insulin release from the β-cell or enhancement in tissue sensitivity towards insulin.

The present data shows the hypoglycemic and hypolipidaemic effect of garlic (ethanol) extract as well as of metformin in normal and diabetic rabbits. In diabetic animals, both of the treatments in three different doses caused a decrease in glucose, triglyceride and cholesterol to certain extent, but the decrease in all three parameters was significant ($p < 0.05$) with the higher dose in sample drawn 4 h after the garlic extract administration.

Comparing the efficacy of garlic extract and metformin in normal and diabetic rabbits, it can be inferred that garlic extract has sufficient potential as a therapeutic agent for maintaining normoglycemia in humans as their hypoglycemic effects remained comparable in normal as well as in diabetic rabbits whose β-cell have been virtually destroyed. Such a response could possibly be due to some peripheral action of metformin as well as of garlic extract in diabetic rabbits or the administered β-cell poison was not able to destroy completely the β-cells in the given dose.

In patients with type 2 diabetes, β-cells are still able to produce insulin. Metformin is being extensively used to produce normoglycemia by stimulating insulin. Similarly, garlic extract appears to have potential in maintaining normoglycemia in type 2 diabetic patients. Further work on garlic extract for isolation of active principal causing hypoglycemia may provide an excellent product, which could be a safe and low-cost antidiabetic agent for type 2 diabetic patients.

Present data reveals that garlic extract in proper formulation could be made to have sufficient potential as anti diabetic agent for the patient of type 2 diabetes mellitus. And further work on isolation of active principle from garlic extract would make this natural product more important for therapeutic purpose.

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