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Effects of garlic extract consumption on blood lipid and oxidant/antioxidant parameters in humans with high blood cholesterol

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Abstract

Effects of garlic extract supplementation on blood lipid profile and oxidant/antioxidant status were investigated in volunteer subjects with high blood cholesterol. A total of 23 volunteer subjects with high blood cholesterol (>5.98 mmol/L) participated in the study. Of them, 13 patients were evaluated as a hypertensive group and the others a normotensive group. Before (first sample) and after (second sample) garlic extract consumption for 4 months, routine blood analyses including lipid parameters and liver and kidney function tests were performed. Additionally, blood oxidant (malondialdehyde [MDA], oxidation resistance [OR]), and antioxidant (antioxidant potential [AOP], nonenzymatic superoxide radical scavenger activity [NSSA]) parameters were measured. Serum total cholesterol, low-density lipoprotein (LDL) and very–low-density lipoprotein (VLDL) cholesterols, and triglyceride levels were found to be significantly lowered, but HDL high-density lipoprotein cholesterol level increased after the extract use. The total:HDL cholesterol ratio was also found to be significantly decreased after the extract use. There were no meaningful differences with regard to other routine biochemical parameters. Additionally, blood AOP, OR, and NSSA values were found increased and MDA level decreased in the second samples relative to the first ones. Systolic and diastolic blood pressure values were also found to be significantly lowered after extract supplementation in the hypertensive group, but no similar changes were observed in the normotensive group. We conclude that garlic extract supplementation improves blood lipid profile, strengthens blood antioxidant potential, and causes significant reductions in systolic and diastolic blood pressures. It also leads to a decrease in the level of oxidation product (MDA) in the blood samples, which demonstrates reduced oxidation reactions in the body.

Keywords: Garlic; Cholesterol; Antioxidant; Oxidation; Hypertension

1. Introduction

Cardiovascular disease is the leading cause of mortality and morbidity worldwide [1]. Oxidation of cholesterol fractions, in particular of low-density lipoprotein (LDL) cholesterol, has been accepted as playing an important role in atherosclerosis [2]. Cholesterol, cholesterol esters, and triglyceride components of the lipoprotein fractions can be oxidized by toxic radicals and can lose their chemical structures and cellular functions [3]. Lipid peroxidation is accepted to be a free radical process implicated in the formation of atherosclerosis [4], and the aldehyde products of lipid hydroperoxide breakdown to be responsible for the modification of LDL apoprotein [5]. An increased concentration of end products of lipid peroxidation is the evidence most frequently quoted for the involvement by toxic radicals in some human diseases including atherosclerosis [6]. The lipid-laden "foam cells" of atherosclerosis are macrophages, which are known to produce oxygen radicals in their microbicidal role [7]. In atherosclerotic complications, macrophages are held responsible for the oxidation of lipids or lipoproteins. It has been argued that oxidized sterols produced by monocyte-macrophages lead to necrosis and progression of the atherosclerotic lesion [7,8].

Although there are numerous studies to elucidate possible molecular mechanism(s) of atherosclerosis [9–13], no

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Table 1
Effects of garlic extract consumption on blood lipid profile

	TC (mmol/L)	HDL (mmol/L)	LDL (mmol/L)	VLDL (mmol/L)	TC/HDL	TG (mmol/L)
Before (n = 23)	6.97 ± 1.56	0.99 ± 0.13	4.55 ± 1.3	1.43 ± 0.16	7.1 ± 1.3	2.6 ± 0.51
After (n = 23)	5.23 ± 1.4	1.27 ± 0.16	3.07 ± 0.91	1.14 ± 0.13	4.6 ± 1.0	1.86 ± 0.4
P value	<0.01	<0.01	<0.05	<0.05	<0.01	<0.005

P value based on paired t test.

exact mechanism has yet been clarified. Similarly, various studies were performed to establish a possible protective role of garlic in the atherosclerotic process. In this regard, some properties such as antilipidemic [14–16], antioxidant [17–21], antiplatelet [15,22,23], hemostatic, and hemodynamic [24] activities of garlic were established. Relating to the antioxidant activity of garlic, Rahman et al. have demonstrated that components of aged garlic extract inhibit the in vitro oxidation of LDL by chelating Cu^{+2}, scavenging superoxide ions and thus inhibiting the oxidation of protein and lipid moiety of human LDL [20]. In another study, it has been reported that garlic supplementation in human subjects leads to increased resistance of LDL to oxidation, and it has been suggested that suppressed LDL oxidation may be one of the powerful mechanisms accounting for the anti-atherosclerotic properties of garlic [25]. As no exact molecular mechanisms on the protective function of garlic in the atherosclerosis have yet been clarified in detail, further studies need to be performed to establish the relation between garlic extract consumption, body oxidant/antioxidant status, and blood lipid profile.

The present study aims principally to investigate the possible effects of garlic extract consumption on blood lipid profile and oxidant/antioxidant status in normotensive and hypertensive subjects with high blood cholesterol levels.

2. Methods and materials

A total of 23 volunteer subjects with high blood cholesterol level (>5.98 mmol/L) participated in the study. Of them, 13 subjects were hypertensive (mean ± SD: 98.5 ± 22.3 mm Hg for diastolic and 148.3 ± 29.2 mm Hg for systolic blood pressure) and 10 normotensive (mean ± SD: 83.2 ± 13.2 for diastolic and 122.2 ± 15.4 for systolic pressure). Subjects with diastolic pressure value > 95 and systolic pressure value > 140 were evaluated in hypertensive group. Of the subjects 14 were male and nine female, ranging in age from 24 to 68 years (mean ± SD: 46.6 ± 18.2). The study subjects had no complaints other than high blood cholesterol and/or hypertension, and none had used medication for these problems during the study period. Subjects ingested garlic extract at the dose of 1 mL per kilogram of body weight per day (~10 g garlic/day) for 4 months.

In all analyses, blood serum samples were used. Before and after extract consumption, routine blood analyses including lipid parameters and liver and kidney function tests were performed. Additionally, blood oxidant, ie, malondialdehyde (MDA), oxidation resistance (OR), antioxidant potential (AOP), and nonenzymatic superoxide radical scavenger (NSSA) activity parameters as well as blood pressure values were measured. During the extract supplementation period, patients neither used medicine nor changed their dietary habits. Cholesterol and triglyceride analyses as well as liver and kidney function tests were carried out in a routine biochemistry laboratory. Blood AOP, MDA, NSSA, and OR analyses were performed as previously described [26–29].

Aqueous garlic extract (20 %, w/v) was prepared as previously reported [30] using a special kind of garlic (Kastamonu garlic). The antioxidant potential value of the extract as measured with the method described [26] was 596.4 nmol/mL/h, which is equivalent to the antioxidant potential value of approximately 1 g of ascorbic acid measured with the same method.

In the statistical analyses of the results, a paired t test was used. Values of $P < 0.05$ were considered to be significant.

3. Results

Results are given in Tables 1 and 2. As seen in Table 1, serum total, LDL and very–low-density lipoprotein (VLDL)

Table 2
Effects of garlic extract consumption on blood oxidant/antioxidant parameters

	AOP (nmol/mL/h)	NSSA (U/mL)	OR (nmol/mL/h)	MDA (nmol/mL)
Before (n = 23)	35.6 ± 8.5	8.4 ± 1.7	3.5 ± 0.68	1.40 ± 0.85
After (n = 23)	48.5 ± 9.6	13.2 ± 1.9	5.2 ± 1.20	0.98 ± 0.56
P value	<0.01	<0.01	<0.05	<0.05

P value based on paired t test.

Table 3
Correlations between some blood parameters established before and after garlic consumption

Parameter	Before	After
AOP-TC	−0.40	−0.50
AOP-HDL	+0.35	+0.40
AOP-LDL	−0.35	−0.35
AOP-VLDL	nc	nc
AOP-(TC/HDL)	−0.6	+0.7
AOP-TG	−0.30	−0.35
MDA-TC	+0.40	+0.30
MDA-HDL	−0.30	−0.45
MDA-LDL	+0.30	+0.30
MDA-VLDL	nc	nc
MDA-(TC/HDL)	+0.35	+0.30
MDA-TG	+0.60	+0.45

nc = no correlation.

cholesterol, triglyceride levels, and total/high-density lipoprotein (HDL) cholesterol ratios were found to be significantly lowered and after extract use, whereas HDL level was elevated after use. However, there were no meaningful differences in other routine biochemical parameters (AST, ALT, ALP, GGT, LDH, CK, bilirubin, urea, creatinine, protein, electrolytes, or calcium). Additionally, blood AOP, OR, and NSSA values were determined to be increased and MDA level decreased in samples taken after garlic extract use relative to samples before extract use. Blood pressure values (98.5 ± 22.3 *vs* 85.1 ± 12.4, $P < 0.05$ for diastolic pressure and 148.3 ± 29.2 *vs* 126.2 ± 15.6, $P < 0.05$ for systolic pressure) were also significantly lowered in the hypertensive group, whereas no changes (83.2 ± 13.2 *vs* 80.6 ± 10.8, $P > 0.05$ for diastolic pressure and 122.6 ± 15.4 *vs* 120.4 ± 12.8, $P > 0.05$ for systolic pressure) were observed in the normotensive group.

In the correlation analyses carried out between analyses parameters before and after extract use, some meaningful relations were observed. For example, there was negative correlation between AOP-TC (total cholesterol), AOP-LDL, AOP (TC/HDL), AOP-TG (triglyceride), and MDA-HDL values, and a positive correlation between AOP-HDL, MDA-TC, MDA-LDL, MDA-(TC/HDL), and MDA-TG values.

4. Discussion

Natural remedies have been investigated for centuries for a wide variety of ailments. Among them, garlic has received special attention for its beneficial effects [31–36]. However, there is no satisfactory data from randomized controlled trials linking supplementation of garlic in the diet with a reduction in the cardiovascular morbidity and mortality [37]. Although significant reductions in blood cholesterol and triglyceride levels were observed in some studies when garlic extract or powder were used, no satisfactory agreement has been reached on this kind of clinical and experimental data, as many of the trials have been limited by significant methodological shortcomings including inappropriate methods of randomization, poorly characterized subject groups, short duration, and insufficient statistical methods [38].

Despite some controversial evaluations of the protective role of garlic in the atherosclerotic diseases, it has long been suggested that garlic may have beneficial effects in the atherosclerotic process [39–42]. Although some unique properties of garlic such as antioxidant and antilipidemic potentials were investigated [43–45] and although considerable studies were performed to elucidate the mechanism of action [20,25,46,47], no further studies have been conducted to elucidate possible effects of garlic extract consumption on the relation between blood antioxidant parameters and lipid profile. The present study was designed to clarify these issues.

As seen from our results, garlic extract treatment can lower blood cholesterol level and can improve blood lipid profile to a significant extent. It also increases blood antioxidant potential and oxidation resistance and decreases MDA level, which is an important indicator of lipid peroxidation (Table 1). All of these results show that garlic extract exerts considerable antioxidant power *in vivo* as well, and protects cellular structures against peroxidation. The high antioxidant potential of garlic may be a result of its high content of sulfur compounds [19]. Because oxidation of cholesterol fractions (in particular, LDL) has been accepted as playing an important role in the atherosclerotic process [2], and because lipid peroxidation is a radical process implicated in this formation [4], it has been proposed that extracts such as garlic that are rich in antioxidant content may confer beneficial effects in this regard.

With respect to the cholesterol lowering property of garlic, it has been suggested that some constituents of garlic may act as inhibitors for some enzymes such as hydroxy methyl glutaryl CoA reductase, which participates in cholesterol synthesis [48,49]. Our results also show that garlic extract can lower blood pressure; however, it has not been established in detail whether there is a relationship between antioxidant activities and antihypertensive effects of garlic. In fact, some meaningful correlation was established between some parameters. The negative correlation established between AOP and some lipid parameters such as TC, LDL, and TG indicates an inverse relationship between antioxidant power and blood lipids. However, there was a positive correlation between MDA and the lipid parameters mentioned above, demonstrating a positive relationship between blood lipids and accelerated oxidation reactions in the blood. However, the positive relationship observed between AOP-HDL and the negative relation between MDA and HDL indicates that HDL has a protective function in the prevention of oxidation reactions and consumption of antioxidant potency. However, possible molecular mechanisms related to these events still need to be investigated further.

Our results show that increased blood antioxidant capacity and improved blood lipid profile due to garlic extract consumption may contribute to some of the beneficial effects of garlic with regard to atherosclerotic processes. Table 3

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