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# Effect of Garlic and Lemon Juice Mixture on Lipid Profile and Some Cardiovascular Risk Factors in People 30-60 Years Old with Moderate Hyperlipidaemia: A Randomized Clinical Trial

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## Abstract

### Background:

This study was performed to effects of garlic and lemon juice mixture on lipid profile and some cardiovascular risk factors in people 30–60 years old with moderate hyperlipidemia.

### Methods:

In a parallel-designed randomized controlled clinical trial, a total of 112 hyperlipidemic patients 30–60 years, were recruited from Isfahan Cardiovascular Research Center. People were selected and randomly divided into four groups. Control blood samples were taken and height, weight, and blood pressure were recorded. (1) Received 20 g of garlic daily, plus 1 tablespoon lemon juice, (2) received 20 g garlic daily, (3) received 1 tablespoon of lemon juice daily, and (4) did not receive garlic or lemon juice. A study technician was done the random allocations using a random numbers table. All participants presented 3 days of dietary records and 3 days of physical activity records during 8 weeks. Blood samples were obtained at study baseline and after 8 weeks of intervention.

### Results:

Results showed a significant decrease in total cholesterol (changes from baseline: 40.8 ± 6.1, $P < 0.001$), low-density lipoprotein-cholesterol (29.8 ± 2.6, $P < 0.001$), and fibrinogen (111.4 ± 16.1, $P < 0.001$) in the Group 1, in comparison with other groups. A greater reduction in systolic and diastolic blood pressure was observed in Group 1 compared with the Groups 3 and 4 (37 ± 10, $P = 0.01$) (24 ± 1, $P = 0.02$); respectively. Furthermore, a great reduction in body mass index was observed in the mixed group compared with the lemon juice and control groups (1.6 ± 0.1, $P = 0.04$).

### Conclusions:

Administration of garlic plus lemon juice resulted in an improvement in lipid levels, fibrinogen and blood pressure of patients with hyperlipidemia.

**Keywords:** Cardiovascular disease, garlic, hypercholesterolemic patient, lemon juice

## INTRODUCTION

Cardiovascular diseases (CVDs) are multifactorial disorders which are characterized by multiple metabolic dysfunctions. Epidemiologic studies indicate that increased serum lipids profiles, elevated plasma fibrinogen, and coagulation factors play critical roles.[1] CVDs are the major cause of mortality and morbidity in the world. Unfortunately, they lead to 17 million deaths every year. It has been estimated that this number will reach 24.8 million people in 2030 worldwide.[2] CVDs are considered to be the most common cause of death (25–45% mortality) and the fifth most common cause of disability.[3] According to the World Health Organization statistics, the most important risk factors include tobacco usage, high blood pressure, alcoholism, high cholesterol, low fruit, and vegetable consumption, lack of appropriate physical activity and obesity.[1] Iran is the fifth country, throughout the world in terms of having high blood pressure related diseases.[4] High blood pressure and risk factors in CVDs are the main causes of death and mortality in Iran and according to the report of Iranian Health Profile Survey in 1999, the prevalence of blood pressure in adults over 30 years increased by 12–45%.[5] Previous studies showed that 46% of the total deaths in 18 provinces of Iran were caused by CVD.[6] Approximately, 6.6 million people between the ages of 25–64 have high blood pressure, and it is estimated that 12 million persons between 25 and 46 years of age are at increased risk of CVD.[7] Oxidative stress has a pathological role in CVD, particularly its effects on low-density lipoprotein-cholesterol (LDL-C) oxidation, and eventually leads to inflammation status.[8] Dietary factors show a key role in the management of CVD. Epidemiologic studies noticed that diets rich in vegetables and fruits are affiliated with a lower risk of mortality, particularly cardiovascular diseases related deaths.[9,10] It has also been indicated that the benefits of vegetable and fruit intake appear to be related to CVD.[11] These food groups contain different phytochemicals which can demonstrate anti-inflammatory properties. One of the most well-known sources of anti-CVD phytochemicals is garlic, which plays an effective role in the suppression and treatment of CVDs.[12] Even though pharmacological interventions cause a significant reduction in high blood pressure and dyslipidemia, lifestyle modification and correcting the dietary regime can be a key step in the management of CVD.[13] Among foods which are effective in reducing inflammation status and ultimately cardiovascular parameters, the use of garlic and lemon juice is common. Garlic is used in various forms such as raw garlic, powdered garlic tablets, or extracted oil. Lipid levels, blood pressure, reactive oxygen species, and other cardiovascular risk factors affected by garlic will decline that has been confirmed by several studies.[14] Epidemiological studies have demonstrated that increased consumption of polyphenols such as flavonoids and phenylpropanoids phytochemicals that are present in fruits and vegetables are associated with reduced risk of CVD. Lemon juice is high in erycosytryn and hesperidin flavones. Animal studies showed that erycosytryn and hesperidin have antioxidant properties, and they can decrease oxidative stress.[12] Several studies have been conducted concerning the relationship between garlic and lemon juice in reducing inflammatory biomarkers and lipid levels in patients with CVD, separately. However, the effects of garlic and lemon juice mixture on the indicators of CVDs have not yet been analyzed. Regarding the increasing prevalence of these diseases, we examined the effects of garlic and lemon juice mixture on some CVD risk factors such as total cholesterol (TC), LDL-C, systolic blood pressure (SBP), and diastolic blood pressure (DBP) and fibrinogen in people 30–60 years old with moderate hyperlipidemia.

## METHODS

### Participants

In a parallel-designed randomized controlled clinical trial, hyperlipidemic patients 30–60 years were recruited from Isfahan Cardiovascular Research Center (ICRC) from November to December 2013. Considering the proposed formula for parallel-design randomized trials, given the Type I error of 5%, the study power of 90% considering TC as the key variable. The sample size calculation was determined,[15] we needed 120 patients to be enrolled. Subjects were eligible if they had a fasting TC and LDL-C levels between 200–240 mg/dl and 100–160 mg/dl, respectively. Participants were excluded if they were suffering from any other chronic diseases, including heart diseases, kidney failure, lung dysfunction, thyroid disorders, gastrointestinal disorders, rheumatoid arthritis, and other liver diseases such as hepatitis or fatty liver. Participants that were pregnant lactating, or that smoked were also excluded. In addition, participants' body weight should not have changed in the last 2 months. Subjects were excluded if they were on medication which affected blood sugar, lipid profile, blood pressure, or anti-inflammatory markers. Participants should not have had any food allergy or sensitivity to garlic or lemon juice consumption. Individuals with a history of following any special diet (vegetarian/vegan, etc.) were excluded as well. From the revision of the medical records available in ICRC, 800 patients were chosen. These subjects were invited for screening as they met nearly all of the inclusion criteria. After the screening process, 120 eligible volunteers enrolled into the study and were randomly allocated to four groups: (1) Mixed with garlic and lemon juice group, (2) garlic group, (3) lemon juice group and (4) control group. Of the 120 subjects randomly assigned to treatment, two subjects in the control group in the beginning of intervention were dropped out from the study because of their busy schedule and over the duration of the study, two subjects in the mixed group because of pregnancy and three subjects because of the gastric problem were eliminated from this study. One subject in the garlic group because of pregnancy and two subjects because of travel were eliminated. Finally, 112 subjects continued until the end of the study. The participant flow diagram is shown in Figure 1. All participants provided informed written consent. This trial was approved by the Isfahan University of Medical Sciences (392436) and was registered in clinical trials center's website address (www.irct.ir) (Code: IRCT2015020720986N1).

## Study design

In a parallel-designed randomized controlled clinical trial, professor of biostatistics did the random allocations. In this study, group blinding was not possible because the intervention involved taking or not taking garlic or lemon juice. However, laboratory personnel analyzing results were blinded. During of the intervention, subjects were allowed to continue performing daily diet and activities. Group 1 received 20 g of raw garlic daily plus 1 tablespoon of lemon juice ($n$ = 30), Group 2 received 20 g garlic daily ($n$ = 30), Group 3 received 1 tablespoon of lemon juice daily, 2 h after dinner ($n$ = 30), and Group 4 did not receive garlic, or lemon juice ($n$ = 30) for 8 weeks. Participants were asked to use garlic and lemon juice for 8 weeks. When the participants were given packets of garlic and bottle of lemon juice, we were wanted not to change their lifestyle, physical activity, or diet during the study. Participants were asked to bring back the empty packets and bottles at the final session to help assure compliance.

## Variables assessment

They were instructed to avoid change in diet and physical activity, so their diet and physical activity were similar, and it was checked by researchers and their records. All participants provided 3 physical activity records (3 days) and 3 dietary records (3 days) during the intervention at 0, 4, and 8 weeks. They provided 3 days of physical activity records and 3 days of dietary records (1 weekend day and 2 weekdays) to certify they preserved their usual diet and activity levels during the intervention. The presented portion sizes in the dietary records were changed to grams. The average amount (g) of food intake data, based on 3, 3 days of dietary records, was joined with Nutritionist IV software (N-Squared Computing, Cincinnati, OH, USA) to conclude nutrient intake data. The nutrient database of Nutritionist IV software was based on the United States Department of Agriculture food composition table, reclaimed for Iranian foods. Physical activity was declared as metabolic equivalents per hour per day. To quantify measures of blood sampling and metabolic profiles were carried out at study baseline and after 8 weeks of intervention.

After overnight fasting, blood samples were collected from patients between 7 and 10 am. After centrifuging at 4°C at 500 × *g* for 10 min, tubes were frozen at −80°C until analysis.). Fibrinogen was determined by latex immunoturbidimetric assay (Bionic, Iran). TC, triglyceride (TG), high-density lipoprotein (HDL) were measured by photometric enzyme assay (Pars Azmoon, Iran) and LDL were measured. Both intra- and inter-assay coefficients of variation were <5% for all of the used measurement kits. Biochemical parameters were measured at baseline and after 8 weeks of the intervention. When participants were in the comfortable seat position, after 10 min rest, blood pressure was measured on the left arm using electronic blood monitor. Body weight and height were measured with light clothing and without shoes to the nearest 0.1 kg and 0.1 cm, respectively and body mass index (BMI) was calculated. Except height, other physical characteristics and blood pressure were measured 2 times, in study week 0, 8, respectively.

### Statistical analysis

Data were analyzed using SPSS (version 18, SPSS, Chicago, IL, USA), and a two-sided $P < 0.05$ was considered to be significant. To quantify measures of metabolic profiles, blood sampling was done at the beginning of the study to establish a baseline and after 8 weeks of intervention. To ensure the normal distribution of variables, we applied the Kolmogorov–Smirnov test. For main effect analysis, the difference between the four groups based on outcome variables such as dietary intake, physical activity, and metabolic profile were compared using ANCOVA test controlling for a baseline of these variables and age/gender. Baseline general characteristics were examined using Chi-square for categorical variables and one-way ANOVA for continuous variables. We used Tukey's *post hoc* comparisons to identify pairwise differences when we reached a significant finding in ANOVA.

## RESULTS

From the review of the medical records available in ICRC, 800 patients were selected. These subjects were called for screening as they met almost all of the inclusion criteria. After the screening process, 120 eligible volunteers enrolled into the study. After randomization, 8 person withdrew due to travel ($n = 2$), gastric problem ($n = 3$), and pregnancy ($n = 3$). Thus, 112 subjects completed the study. The mean age of the participants was 42.46 ± 8.11 years. None of them were consume any nutritional supplement and no one on specific medication. The distribution of participants in terms of sex, weight, BMI was not significantly different between the four intervention groups. The baseline characteristics of the 112 subjects are listed in Table 1. Comparison of baseline metabolic profiles such as serum TC, LDL-C, HDL-C, triglyceride and fibrinogen levels, SBP and DBP revealed no significant difference between the groups. No significant differences were found between groups regarding food groups, carbohydrates, saturated fatty acids, or the majority of micronutrients as derived from the food record. Participants' physical activity level was generally moderate and did not have any strenuous exercise. They were instructed to avoid change in their physical activity and were checked by researchers. We did not find any significant difference in the physical activity levels between the four intervention groups. Energy, nutrient intake, food groups, and physical activity during the intervention period were shown in Table 2.

Changes of all variables within mixed and garlic groups were significant before and after intervention ($P < 0.001$). The effects of intervention within groups on general characteristics and metabolic profiles are shown in Table 3. We found a significant decrease in TC, LDL-C and fibrinogen in the mixed group in comparison with other groups ($P < 0.001$). No significant changes were observed regarding serum HDL and TG concentration in the mixed group in comparison with garlic and lemon juice groups ($P = 0.08$) but this change was significant in mixed group compared with control group ($P = 0.02$) ($P = 0.001$); respectively. A greater reduction in systolic and diastolic blood pressure was observed in the mixed group compared with the lemon juice and control groups ($P = 0.01$) ($P = 0.02$); respectively. Also a great reduction in BMI was observed in the mixed group compared with the lemon juice and control groups ($P = 0.04$). No significant differences in BMI, systolic and diastolic blood pressure between mixed and garlic groups were observed.

The effects of a mixture of garlic and lemon juice, garlic and lemon juice on general characteristics and metabolic profiles are shown in Table 4.

## DISCUSSION

Much research has concentrated on garlic for preventing atherosclerosis. Multiple useful cardiovascular effects have been discovered including enhancement of fibrinolytic activity, lowering of blood pressure, reduction in cholesterol, and triglyceride.[14] The results showed that combination of garlic and lemon juice significantly reduced serum TC, LDL-C, and blood pressure. Garlic, such as many other food additives, gained substantial interest due to its effects on lipid levels.[16,17,18] Moderate garlic intake causes few adverse effects. Allergic contact dermatitis can happen.[19] Many human and animal studies have investigated the effects of garlic on lipid levels, fasting blood sugar, BMI, fibrinogen, and SBP and DBP but no studies have yet been performed on the effects of a combination of garlic and lemon juice consumption on these biomarkers. Since 1993, 25 clinical trials have been published that have investigated the hypolipidemic effects of garlic. Eleven of the studies showed that garlic reduced serum cholesterol levels, but fourteen studies showed no effect on lowering cholesterol.[10] In addition, different extracts of garlic alone have been demonstrated to lower serum cholesterol, triglycerides, and LDL in rodents and humans.[20,21] Maha and Khalil showed that adding 8% raw garlic along with 2% cholesterol to the diet of rats decreased plasma TC and LDL-C.[22] A number of human studies have shown that raw garlic favorably affects important risk factors for CVD. Consumption has been shown to decrease total and LDL-C and triglyceride levels. An intake of the half to one clove of garlic per day lowers cholesterol levels approximately 10%.[23,24] Mechanisms that explain the observed effects of garlic include a decrease in cholesterol absorption, cholesterol, and fatty acid synthesis.[25] However, there is some evidence that garlic powder does not lower cholesterol levels, which may reflect a loss of active compound(s) during processing.[26] The formation of these active compounds is impressed by crushing garlic, a period of the drying process, the temperature at which garlic is dried, and humidity.[27] Therefore, we used raw garlic in this study. Direct measurements of enzyme activity have demonstrated that garlic and various constituents prohibit human 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase and squalene monooxygenase, enzymes required in cholesterol biosynthesis.[28,29,30,31,32] This prohibition of HMG-CoA reductase by garlic has also been supported in a recent study.[33] In addition, LDL-C reduction by garlic extract may be owing to decreases of hepatic 3-hydroxy-3-methylglutaryl-CoA reductase, cholesterol 7α-hydroxylase, pentose-phosphate pathway activities,[34] cholesteryl ester transfer protein activity,[35] microsomal triglyceride transfer protein,[36] enhanced bile acid excretion,[37] and prohibition of hepatic fatty acid synthesis[38] by allicin and/or other components.[28] It should also be emphasized that certain garlic preparations (e.g., garlic oils) do not indicate the degree of cholesterol lowering seen with specific powdered formulations.[39] In this study, we did not observe significant changes in HDL-C levels between groups. Aouadi showed that adding 10% fresh crushed garlic and 2% cholesterol to diet led to significant reduction in LDL-C levels, and increased HDL-C levels in rats.[40] The present study showed that fasting blood glucose showed no significant change due to consumption of a combination of garlic and lemon juice. However, in the lemon juice group after the intervention, we observed a significant increase in fasting blood glucose compared with other groups. Mohammadi and Abbas showed that fasting blood glucose levels decreased in garlic group compared with hypercholesterolemia group, but this decrease was not significant.[41] Ali *et al.*[42] reported that garlic administration has no effect on blood glucose, similar to this study. In our study, there was a significant reduction in mean SBP and DBPs in the garlic plus lemon juice group when compared with control and lemon juice groups. Since 1993, some studies have been published on the effects of garlic on blood pressure.[43,44,45,46] In one study has been reported to be moderately reduced in blood pressure by garlic alone.[47] In contrast of this, a meta-analysis published in 2001 represented that garlic has no considerable effects on blood pressure.[48] The moderate subside of blood pressure with garlic may be because of increased nitric oxide production and a more vasodilators state.[49] G-glutamylcysteines are compounds discovered in garlic, and these may lower blood pressure as illustrated by their ability to prohibit angiotension-converting enzyme *in vitro*.[50] In this study, we observed a significant reduction in triglycerides in the mixed group compared with control group. However, no significant changes were observed in the mixed group compared with the garlic and lemon juice groups. In our study, we observed a significant reduction in fibrinogen in the mixed group compared with other groups. In some studies, it has been reported that garlic causes a significant reduction in fibrinogen.[51,52] Contrarily, a study published in 1998 concluded that garlic has no effects on fibrinogen.[53] Previous studies regarding the effect of garlic alone have focused on lipid levels. One important difference between our study and these other studies was the combination of garlic and lemon juice. Even though the subjects were instructed to consume only 20 g garlic and 1 tablespoon of lemon juice, some significant effects were seen for the mentioned variables. In the present study, we provided garlic and lemon juice for participants and did not recommend a specific diet. This limitation should be considered in interpreting the findings of this research. We analyzed patient food records. The present study has some other potential limitations; it cannot suggest appropriate doses of garlic and lemon juice for people with hyperlipidemia. To establish this, other studies examining the effects of different doses of garlic and lemon juice are required.

## CONCLUSIONS

In conclusion, a combination of garlic and lemon juice resulted in an improvement in lipid levels and blood pressure of people with hyperlipidemia. Further studies to determine the appropriate doses of garlic and lemon juice for these patients are warranted. In addition, the effect of a combination of garlic and lemon juice might be different based on the degree of hyperlipidemia. Therefore, studies are needed to examine the effects of garlic plus lemon juice according to the degree of hyperlipidemia.

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### Conflicts of interest

There are no conflicts of interest.

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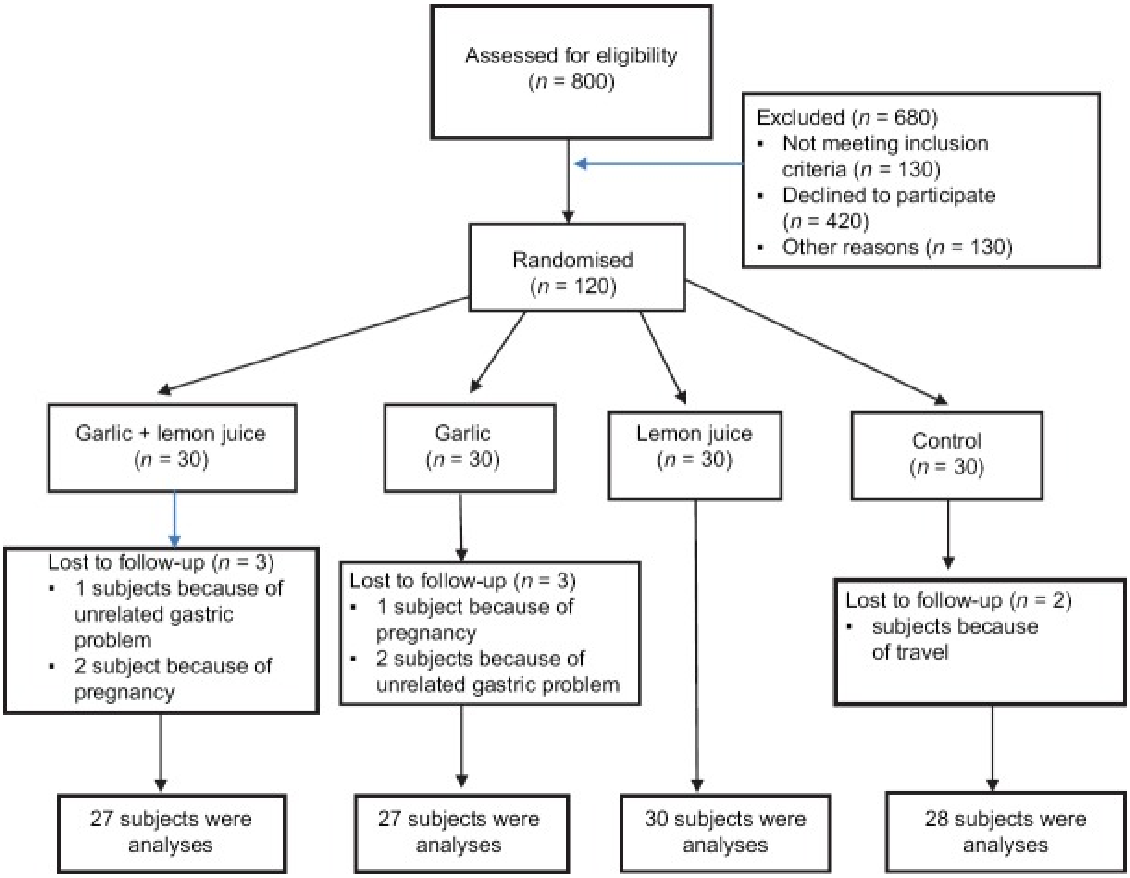
## Figures and Tables

## Figure 1




Study flow diagram

## Table 1

| | Group 1 Mix (*n*=27) | Group 2 Garlic (*n*=27) | Group 3 Lemon juice (*n*=30) | Group 4 Control (*n*=28) | *P* |
|---|---|---|---|---|---|
| Age (year) | 43.9±7.8 | 45. 3±9.3 | 41.8±8.1 | 39.3±6.2 | 0.21 |
| Weight (kg) | 83.6±14.4 | 78.7±16.2 | 75.4±10.2 | 76.8±11.1 | 0.61 |
| BMI (kg/m$^2$) | 29.7±3.7 | 28.1±5.9 | 27.7±3.7 | 27. 2±3.2 | 0.52 |
| Men, *n* (%) | 15 (55) | 14 (52) | 15 (50) | 16 (57) | 0.96 |
| TG (mg/dl) | 176.8±87.1 | 195.9±123.7 | 163.4±71.8 | 135.6±64.9 | 0.07 |
| TC (mg/dl) | 235.4±18.2 | 234.4±26.5 | 222.6±17.2 | 239±18.8 | 0.65 |
| LDL (mg/dl) | 124±18.7 | 119.9±26.8 | 121.9±23.0 | 119.2±19.0 | 0.85 |
| HDL (mg/dl) | 40.2±7.3 | 37.2±7.4 | 40.9±7.3 | 41.4±6.5 | 0.12 |
| Fibrinogen (mg/l) | 279.6±34.4 | 271.1±63.7 | 275.7±54.4 | 293.8±19.4 | 0.27 |
| SBP (mmHg) | 134±21 | 128±12 | 122±21 | 122±32 | 0.31 |
| DBP (mmHg) | 86±21 | 81±12 | 80±11 | 72±21 | 0.60 |

All values are mean±SD.TG=Triglyceride, TC=Total cholesterol, LDL=Low-density lipoprotein-cholesterol, HDL=High-density lipoprotein-cholesterol, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, SD=Standard deviation, BMI=Body mass index

Baseline characteristics of study participants

## Table 2

| Variable | Group 1 | Group 2 | Group 3 | Group 4 | P* |
|---|---|---|---|---|---|
| Dietary intake | | | | | |
| Energy (kJ) | 7657.6±3652.3 | 7688.6±3524.5 | 7943.3±3654.7 | 7654.9±3456.6 | 0.89 |
| Carbohydrate (g) | 316±53 | 327±48 | 314±62 | 319±49 | 0.68 |
| Protein (g) | 73±27 | 75±19 | 73±31 | 76±12 | 0.82 |
| Total fat (g) | 90±21 | 88±25 | 91±19 | 92±23 | 0.75 |
| Saturated fat (g) | 4.3±3.6 | 4.6±3.7 | 4.2±3.6 | 4.4±3.6 | 0.56 |
| Poly unsaturated fat (g) | 5.4±2.7 | 6.5±3.3 | 5.5±3.8 | 5.5±2.8 | 0.11 |
| Mono unsaturated fat (g) | 7.8±4.5 | 8.4±5.5 | 7.6±4.4 | 7.9±5.5 | 0.17 |
| Cholesterol (g) | 126.2±52.1 | 125.7±68.3 | 128.2±56.3 | 126.6±71.1 | 0.22 |
| Fat group (g) | 16.5±18.6 | 17.6±15.4 | 16.4±17.4 | 18.5±15.7 | 0.85 |
| Meat group (g) | 96.3±45.3 | 110.3±37.5 | 97.2±42.3 | 116.5±32.5 | 0.73 |
| Fruit group (g) | 412.3.3±261.2 | 334.5±231.3 | 351.2±241.4 | 305.3±221.4 | 0.21 |
| Grain group (g) | 534.3±142 | 521.4±132.1 | 491.3±128 | 513.5±131.2 | 0.62 |
| Vegetables group (g) | 335.3±312.6 | 286.2±220.5 | 228.4±227.2 | 326.5±310.3 | 0.64 |
| Physical activity (MET-h/day) | 32.2±2.3 | 31.2±3.1 | 29.8±2.3 | 31.5±3.4 | 0.76 |

All values are means±SD. *P value is related to the mean difference change between four groups. SD=Standard deviation, MET=Metabolic equivalent of task

Nutrient intake and physical activity of study participants throughout the study

## Table 3

| | Group 1 Mix | | | Group 2 Garlic | | | Group 3 Lemon juice | | | Group 4 Control | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before | After | P | Before | After | P | Before | After | P | Before | After | P |
| BMI (kg/m$^2$) | 29.7±3.7 | 28.±3.7 | <0.001 | 28.1±5.9 | 27.4±5.6 | <0.001 | 27.7±3.7 | 27.6±3.8 | 0.34 | 27. 2±3.2 | 27.5±3.3 | 0.59 |
| SBP (mmHg) | 134±21 | 97±11 | <0.001 | 128±12 | 95±11 | <0.001 | 122±21 | 121±13 | 0.21 | 122±32 | 122±25 | 0.18 |
| DBP (mmHg) | 86±21 | 62±11 | <0.001 | 81±12 | 63±08 | <0.001 | 8±11 | 8±2 | 0.60 | 72±21 | 71±13 | 0.17 |
| TC (mg/dl) | 235.4±18.2 | 194.6±24.3 | <0.001 | 234.4±26.5 | 215.3±23 | <0.001 | 222.6±17.2 | 247.1±18.4 | 0.14 | 239±18.8 | 243.1±14.2 | 0.19 |
| TG (mg/dl) | 176.8±87.1 | 138.5±72.7 | <0.001 | 195.9±123.7 | 162±98.6 | <0.001 | 163.4±71.8 | 152.6±62.8 | 0.10 | 135.6±64.9 | 151.1±67.1 | 0.07 |
| LDL (mg/dl) | 124±18.7 | 94.2±21.3 | <0.001 | 119.9±26.8 | 105.1±23 | <0.001 | 121.9±23.0 | 110.9±23.6 | 0.21 | 119.2±19.0 | 127.2±22.1 | 0.09 |
| HDL (mg/dl) | 40.2±7.3 | 45.4±8.7 | <0.001 | 37.2±7.4 | 41±8.6 | <0.001 | 40.9±7.3 | 40.6±6.4 | 0.30 | 41.4±6.5 | 41.3±7.8 | 0.86 |
| Fibrinogen (mg/l) | 279.6±34.4 | 168.2±50.5 | <0.001 | 271.1±63.7 | 263.4±61.3 | <0.001 | 275.7±54.4 | 267.7±54.2 | 0.24 | 293.8±19.4 | 293.1±18.6 | 0.85 |

All values are mean±SD. *P value is related to the mean difference change within groups. TG = Triglyceride, TC = Total cholesterol, LDL = Low density lipoprotein-cholesterol, HDL = High-density lipoprotein-cholesterol, SBP = Systolic blood pressure, DBP: Diastolic blood pressure, SD = Standard deviation, BMI = Body mass index

The effect of intervention on metabolic profiles and anthropometric measurements within groups

## Table 4

| | Group 1 Mix Change | Group 2 Garlic Change | Group 3 Lemon juice Change | Group 4 Control Change | $P^d$ |
|---|---|---|---|---|---|
| BMI (kg/m$^2$) | 1.6±0.1[a] | 0.7±0.3 | 0.1±0.1 | 0.1±0.1 | 0.04 |
| SBP (mmHg) | 37±10[a] | 33±1 | 1±8 | 0±4 | 0.01 |
| DBP (mmHg) | 24±1[a] | 18±4 | 0±9 | 1±8 | 0.02 |
| TC (mg/dl) | 40.8±6.1[b] | 21.1±3.5 | 14.5±1.2 | 4.1±4.6 | <0.001 |
| TG (mg/dl) | 38.3±14.4[c] | 24±27 | 20.2±9 | 15.5±2.1 | 0.02 |
| LDL (mg/dl) | 29.8±2.6[b] | 14.8±3.8 | 11±0.6 | 8±3 | <0.001 |
| HDL (mg/dl) | 5.1±1.4[c] | 3.4±1.2 | 2.3±0.9 | 0.1±1.3 | 0.001 |
| Fibrinogen (mg/l) | 111.4±16.1[b] | 7.7±2.4 | 8.±0.2 | 0.6±0.8 | <0.001 |

[a]Those in comparison of Group 1 with Group 3 and 4 were significant, [b]Those in comparison of Group 1 with other groups were significant, [c]Those in comparison of Group 1 with Group 4 were significant, [d]Obtained from ANOVA. BMI=Body mass index, SBP=Systolic blood pressure, DBP: Diastolic blood pressure, TG=Triglyceride, TC=Total cholesterol, LDL=Low-density lipoprotein-cholesterol, HDL=High-density lipoprotein-cholesterol

The comparison on changes of metabolic profiles and anthropometric measurements between four groups