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Almond oil for patients with hyperlipidemia: A randomized open-label controlled clinical trial

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ABSTRACT

Background: Cardiovascular diseases currently account for nearly half of non-communicable diseases. It was shown that enjoying a handful of nuts every day can significantly reduce the risk of developing heart diseases as they contain a variety of nutrients and other bioactive substances contributing to lowering the risk of heart diseases and controlling the cholesterol. The aim of this study was to determine the effect of almond oil on the lipid profile of patients with hyperlipidemia.

Methods: Ninety-seven patients were divided into the intervention (n = 49) and control (n = 48) groups. The intervention group received 10 ml of almond oil two times daily for 30 days. There was no intervention for the control group. The serum lipoproteins were measured before and after the study.

Results: The total cholesterol and LDL levels decreased significantly in the intervention group (treatment difference = -16.12 ± 26.16, P = 0.009; treatment difference = -20.88 ± 18.4, p < 0.001 respectively). But regular almond oil consumption did not significantly affect the triglyceride and HDL in this sample of hyperlipidemic patients.

Conclusion: Consumption of almond could reduce the total cholesterol and LDL in dyslipidemic patients.

1. Introduction

Coronary artery disease (CAD) currently accounts for nearly half of the non-communicable diseases[1] and has a high prevalence and morbidity in Iran.[2] Hyperlipidemia was reported as an important risk factor for CAD and metabolic syndrome.[1,3–5] An increase in the LDL level can initiate atherogenesis and promote atherosclerosis at every stage. Thus, lowering LDL can reduce the risk of subsequent coronary events, even in patients with advanced atherosclerotic diseases.[6,7] Despite the beneficial effects of pharmacologic therapy for dyslipidemia, patients often express a desire to rely on diets alone.[8] Frequent consumption of nuts was demonstrated to have an association with reduction in the incidence of CAD[9] as long term consumption of nuts was noted to be associated with lower atherogenic plasma lipid profile.[10] Nuts have a unique fatty acid profile and feature a proportionally higher content of monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) versus saturated fatty acid (SFA).[11] Thus, a high level of unsaturated fatty acid is likely to be an important contributing factor to the beneficial health effect of frequent nut consumption.[12] Nuts contain a variety of antioxidants including vitamin E, selenium, copper, and manganese.[13] It is now well documented that nuts can improve the blood lipid profile and reduce the risk of CAD.[14,15] This study was conducted to assess the effect of almond oil (*Prunus dulcis (Mill.) D.A.Webb*) on the lipid profile of hyperlipidemic patients.

2. Materials and methods

2.1. Study design

This prospective randomized open-label controlled clinical trial was conducted to assess the effects of almond oil consumption on lipid profiles of patients with dyslipidemia. No changes occurred in the

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methods after trial commencement.

2.2. Ethical issues

The study protocol was approved by the institutional review board of Shiraz University of Medical Sciences and the approval of the Ethics Committee was obtained before the study commenced. It was registered in Iranian registry of clinical trials (www.IRCT.IR) in April 2014 under the registration number of IRCT201411141525n4. All the participants gave their informed written consent.

2.3. Participants

The patients were recruited from Shiraz Healthy Heart House in Shiraz, Iran. Eligible participants had a clinical diagnosis of hyperlipidemia for at least 2 years, and were not smokers; they were 20–75 years old and had plasma triglyceride level between 200–400 mg/dL, total cholesterol level of more than 200 mg/dL, LDL less than 160 or HDL less than 50 mg/dL in females and less than 40 mg/dL in males. They did not have any history of renal, liver, kidney, heart and thyroid diseases; they also had no history of diabetes mellitus, allergy to nuts, asthma or atopic dermatitis. Exclusion criteria were breastfeeding and pregnancy, oral contraceptive pills consumption, alcohol consumption, and hospitalization during the study.

2.4. Intervention

Eighty five patients with hyperlipidemia were randomized into two study groups. The almond oil group subjects (n = 45) received 10 ml of Persian almond oil, two times per day, for 30 days. The control group subjects (n = 40) did not receive any intervention during the study period. Consumption of less than 70% of the drugs during the trial was considered as drug intolerance, and the patient was excluded from the trial. Almond oil was purchased from Cold-Pressing Company, Mashhad, Iran and subjected to gas chromatographic (GC) analysis.

2.5. GC–MS analysis of total fatty acid (FA)

To determine the fatty acid composition of the Almond oil, we used Methyl esterification method. 0.2 M KOH in methanol at 60 °C for 30 min was performed for fatty acid esterification. Formed FAMEs were extracted into 1 mL of hexane and analyzed directly by GC–MS. Fatty acid standards, a mixture of the saturated fatty acids from 9 to 20 carbons in length, were used to provide absolute quantification of FA.

FAMEs were separated by a BPX 70 column (50 m × 0.25 mm ID, 0.20 μm film thickness), helium as carrier gas with a constant flow of 1 mL/min and the following oven temperature program: initial temperature of 50 °C increased by 3 °C/min to 230 °C, and held for 10 min. The injection inlet temperature was 250 °C and injection volume was 0.5 μL with a split ratio of 1:30. The detection was performed by an Agilent 7000 GC/MS with the following settings: transfer line temperature of 250 °C, scanning mass range of 40–500 amu.

The findings revealed the presence of major components as oleic acid (70.1%), linoleic acid (20.8%), palmitic acid (6.9%), stearic acid (1.7%), and palmitoleic acid (0.4%). The patients in both groups were advised not to take any other forms of oil or change their diet style and habits. They were visited every 2 weeks during the study.

2.6. Outcome measures

In order to obtain the values for lipid profiles including total cholesterol, triglyceride, HDL, and LDL, we took the samples in 2 episodes (before starting the intervention and 30 days after the intervention). Baseline characteristics of the participants including age, gender, body mass index (BMI), blood pressure (BP), fasting blood sugar (FBS), drug history and history of any chronic or metabolic diseases were obtained by a date gathering form.

The serum triglyceride was measured by GPO-PAP method providing a normal upper limit of 200 mg/dL(2.3 mmol/L). The total cholesterol was also checked by GPA-PAP technique, which provided an upper limit normal value or 220 mg/dL(5.6 mmol/L). The HDL cholesterol was measured by dextran magnesium sulfate. The LDL cholesterol was derived according to the following formula: LDL = total cholesterol–(HDL + TG/5).

2.7. Safety assessment

In order to detect the potential possible patients' complaints in the follow up, we asked the patients about the presence of any allergic reaction, gastrointestinal problems and amount of almond oil that they used.

2.8. Randomization

Ninety-seven eligible patients were randomized in two parallel groups. Randomization was done using a computer-based random digit generator based on the registration number of the patients (on the order of referral). The staff involved in clinical care, and members collecting and analyzing data along with the randomization operator were blind to group allocation. Apart from the statistician, all of the staff involved in clinical center, and members collecting and analyzing the data were blinded to the intervention allocation.

2.9. Statistical methods

All statistical analyses were performed using the statistical Package for Social Sciences (version 17.0, SPSS Inc., Chicago, IL, USA). Data were presented as mean ± standard deviation (SD). The 95% confidence intervals for the means of data were calculated, and the significance of the differences between the two groups was assessed, using independent t-tests and x2 tests to compare the groups. Within group changes were assessed using paired sample T-test. A two-sided P value < 0.05 was considered as statistically significant.

3. Results

3.1. Study flow and baseline characteristics of the patients

One hundred volunteers were assessed for eligibility. Ninety-seven patients who met the inclusion criteria and agreed to participate in the study were divided into two groups. Forty nine patients were assigned into the intervention group and forty-eight to the control group. Fig. 1, is the flowchart of the groups' distribution, recruitment, intervention, follow up, and analysis.

The mean age of the participants in the trial was 49.4(± 12.02) and 50.19(± 9.87) years in Almond oil and control groups, respectively. This did not show any significant difference between the two groups of the study (P = 0.745). The other demographic data of the participants (gender, body mass index, systolic blood pressure, diastolic blood pressure) are shown in Table 1. None of the baseline clinical characteristics of the patients had significant difference(s) between the two groups of the trial, except for a significant difference observed between the study groups in terms of body mass index (26.475 ± 2.89 versus 28.5 ± 4.18p value = 0.013).

3.2. Clinical response

In the almond oil group, lipid profiles showed a significant decrease in total cholesterol levels from 224.95 ± 33.59 to 208.69 ± 28.89 mg/dl (P = 0.001), but in the control group, there was no significant difference. In the almond oil group, LDL level decreased from 138.76 ± 20.60 to 131.05 ± 17.84 mg/dl (P = 0.001), and in

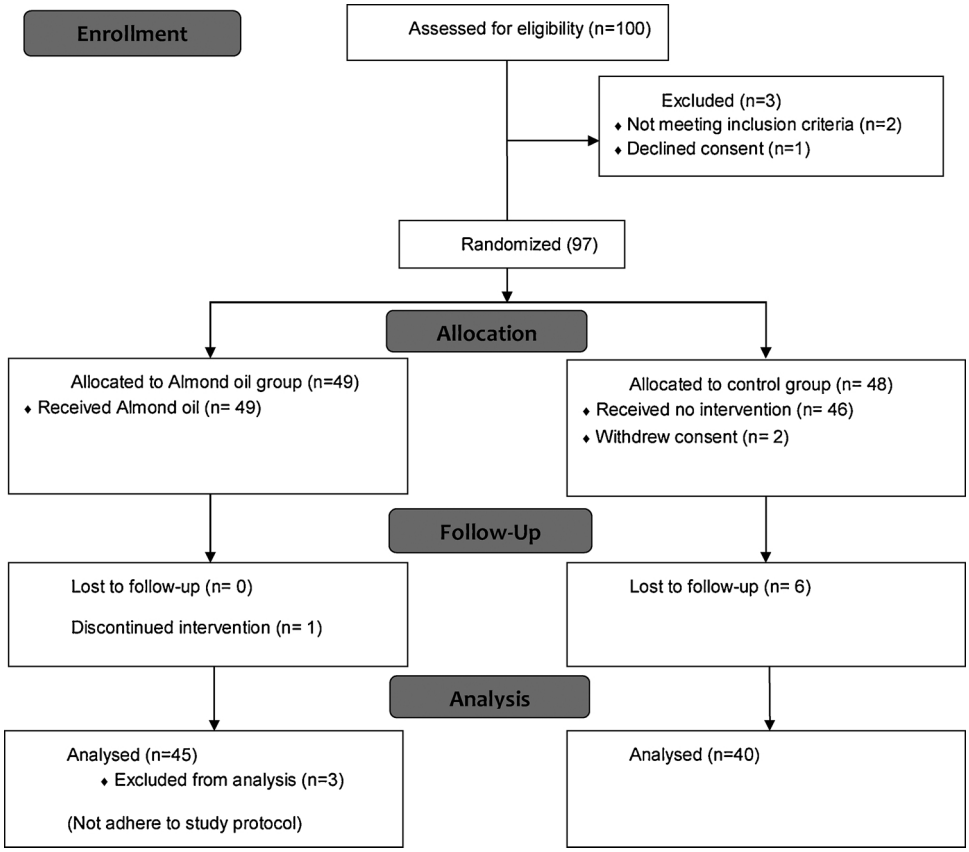

Fig. 1. Flow diagram of the groups' allocation, enrolment, intervention, follow-up, and the analysis in both groups of the study.

the control group it increased significantly from 131.98 ± 17.98 to 145.15 ± 29.57 (P = 0.001). In the almond oil group, the mean plasma triglyceride level decreased from 224.90 ± 57.93 to 219.55 ± 47.86 mg/dL after 30 days, which was not statistically significant (P = 0.219) and in the control group, there was a non-significant trend toward increase from 241.22 ± 73.40 to 245.88 ± 85.24 (P = 0.711). Also, mean HDL cholesterol increased in the almond oil group, but it was not statistically significant. HDL level significantly decreased in the control group from 48.86 ± 8.60 to 43.27 ± 5.90 (P = 0.001). The changes in all lipid profiles, except for HDL cholesterol and TG levels, were significant after the intervention. Table 2 presents the comparison of the changes in lipid profiles of the patients after the intervention in each group.

3.3. Safety and tolerability

All patients complied with the protocol of the study (consumption of daily volume of 10 mL almond oil, twice per day for 30 days). Almond oil was well tolerated by patients. No serious adverse effects were reported in the intervention group.

4. Discussion

The findings of our study demonstrated that the diet enriched with 10 ml of almond oil, 2 times per day for 30 days, significantly improved the lipid profiles (TC and LDL), but it did not significantly affect the TG and HDL in this sample of hyperlipidemic individuals.

CAD affects millions of people throughout the world and accounts for a million hospital stays each year. Numerous epidemiological surveys have shown an increase in the risk of atherosclerosis and CAD appearance with elevating serum lipid profile concentrations. Thus, hyperlipidemia is a well-known risk factor for cardiovascular diseases and its control should be emphasized.[13] Conventional medications to treat chronic diseases (including hyperlipidemia) have some adverse effects, and some people would rather use a natural remedy, instead.[16–18]

The findings of our study demonstrated that the diet enriched with 10 ml of almond oil 2 times per day for 30 days significantly improved lipid profiles (TC and LDL), but it did not significantly affect the TG and HDL in this sample of hyperlipidemic individuals. The findings on TC and LDL showed a significant correlation with those of previous studies, showing that taking almond could improve the lipid profiles.[19–25] Similar to our study, Jenkins et al. assessed the effect of consumption of almond on the lipid profile. They reported that almond consumption

Table 1
Baseline demographic data and clinical features of the trial participants.

Basic Characteristics	Almond oil group(n = 42)	Control group(n = 40)	P-value
Age (years)	49.4 ± 12.02	50.19 ± 9.87	0.745
Body mass index (BMI) (Kg/m^2)	26.475 ± 2.89	28.5 ± 4.18	0.013
Systolic Blood Pressure	133.16 ± 12.10	130.24 ± 14.05	0.325
Diastolic Blood Pressure	82.36 ± 8.52	83.09 ± 9.7	0.725

Table 2
Comparison of the changes in lipid profiles of patients after the intervention.

Lipid profiles	Almond oil group			Control group			Treatment difference	Treatment effect	P value
	Baseline	1 months	P-value	Baseline	1 months	P-value			
Total cholesterol	224.95 ± 33.59	208.69 ± 28.89	0.001	233.82 ± 39.91	233.68 ± 40.80	0.997	−16.12 ± 26.16	−7.0%	0.009
TG	224.90 ± 57.93	219.55 ± 47.86	0.219	241.22 ± 73.40	245.88 ± 85.24	0.711	−10 ± 57.73	−4.3%	0.441
LDL	138.76 ± 20.60	131.05 ± 17.84	0.001	131.98 ± 17.98	145.15 ± 29.57	0.001	−20.88 ± 18.41	−15.4%	< 0.001
HDL	41.80 ± 6.29	42.23 ± 5.67	0.491	48.86 ± 8.60	43.27 ± 5.90	0.001	6.01 ± 5.78	13.4%	< 0.001

decreased the LDL. Conversely, the result of this trial on TG and HDL was inconsistent with those of the previous studies, showing a significant decrease in TG and increase in HDL after using almond rich diet.[12,20–26] Hyson et al. reported that either whole almond or almond oil consumption for a six week period could decrease the TC, LDL and TG and increase the HDL levels. This difference is probably due to replacement of 50% of the daily intake of dietary fat with the fat from almond source; however, in our research, we added almond oil to the currently used diet.

The current data showed that regular nut consumption is associated with a variety of health promoting effects, and to date, there are no adverse effects reported even with high nut intakes. There is evidence that MUFA intake lowers the total and LDL cholesterol levels. Nuts are rich sources of antioxidants that have been demonstrated clearly for almonds. They not only are a rich source of USFA, but also contain several non-fat constituents such as plant proteins; fibbers; micronutrients (e.g. copper and magnesium); vitamins such as A, C and E; and plant sterol that may provide additional protective effects. In addition, the human body converts a-linolenic acid into EPA and DHA which are inversely associated with CRP, fibrinogen, IL6 and TNF. Almond was shown to be among the richest food source of vitamin E, too.[20–26]

4.1. Study limitations

This study had limitations diminishing the impact of the results, the most important of which is the small number of studied patients. Another limitation was the lack of information on the patients' lifestyle such as intake of total energy and total activity hours that can be the possible confounding factors. Lack of placebo group and short time period of the study were the other limitations of our study. In addition, this is an open-label study that may possibly have some bias.

5. Conclusion

Despite the trial's limitations, this randomized open-label controlled clinical trial provides evidence that regular almond oil consumption could improve the lipid profiles in hyperlipidemic patients and may, therefore, contribute to the reduction of cardiovascular disease risks. Future researchers should continue to investigate the role of almond oil and other nuts' oil on endothelial function and blood lipids in the population at risk of cardiovascular diseases.

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