

Nutritional Intervention Study with Argan Oil in Man: Effects on Lipids and Apolipoproteins

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Key Words

Nutritional intervention study · Argan oil · Olive oil · Lipids · Cardiovascular diseases

Abstract

Aim: To evaluate whether the consumption of virgin argan oil (VAO) is associated with a change in serum lipids and reduces the risk of cardiovascular disease in healthy Moroccans. **Methods:** Sixty volunteers consumed butter (25 g/day) during 2 weeks (stabilization period) and were randomly divided into two groups: the treatment group received 25 g/day of VAO during 3 weeks (intervention period), and the control group received 25 g/day of extra virgin olive oil (EVO). Throughout the study, weight, blood pressure, and daily food intake were measured. Serum total cholesterol and low- and high-density lipoprotein cholesterol, triglycerides, and apolipoproteins A-I and B were measured at the end of each diet period. **Results:** Analysis of food intake showed that the daily diet is isocaloric for the butter regimen ($2,537 \pm 244$ kcal/day) as well as for the VAO and EVO regimens ($2,561 \pm 246$ and $2,560 \pm 253$ kcal/day, respectively). Analysis of the lipid intake showed a reduction in saturated fatty acids with VAO and EVO regimens (27 ± 1.4 and $26.4 \pm 3.4\%$, respectively) as compared with the stabilization

period ($41.6 \pm 2.4\%$). The analysis of serum lipids showed a significant increase in high-density lipoprotein cholesterol and apolipoprotein A-I in both VAO group (8.4%, $p = 0.012$, and 5.2%, $p = 0.027$, respectively) and EVO group (17.3%, $p = 0.001$, and 5.9%, $p = 0.036$, respectively). However, low-density lipoprotein cholesterol and apolipoprotein B (13.8%, $p = 0.037$, and 7.8%, $p = 0.039$, respectively) decreased significantly only in EVO group as compared with the stabilization period, while triglycerides decreased significantly by 17.5% ($p = 0.039$) only in VAO group. **Conclusion:** These results confirm the cholesterol-lowering effect of EVO and show for the first time the triglyceride-lowering effect of VAO in men.

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Introduction

The role of dietary intake in the development of cardiovascular diseases (CVD) has been subject of many studies [1, 2]. As far as food lipids are concerned, the influence of the ingested quantities was often highlighted [3]. Examples through trials based on animal models have strengthened the concept that the decrease in food lipid intake is associated with a reduction of the blood cholesterol level as well as with a decrease of the risk of CVD

[2, 4–6]. It is known that saturated fatty acid consumption increases the risk of coronary artery diseases, while unsaturated fatty acid consumption reduces this risk [6–8]. Indeed, it is assumed that there is a linear relationship between an overconsumption of saturated fatty acids and atherogenesis, promoting CVD as a primary cause of mortality in industrialized countries. Recommendations in these countries are based on a collection of experimental, epidemiological, or nutritional data published during the last 20 years, showing that the CVD incidence is positively correlated with the total cholesterol (TC) concentration and negatively correlated with the high-density lipoprotein (HDL) threshold and that a low plasma apolipoprotein (apo) A-I concentration is associated with a high CVD risk [9, 10].

Virgin argan oil (VAO) is the extract of the pit of arganier which is the hard core of the fruit of *Argania spinosa*, an endemic tree growing in southwestern Morocco. This comestible oil is rich in unsaturated fatty acids (oleic and linoleic) and other compounds (tocopherols, polyphenols, and sterols) [11]. The quality of its fatty acids suggests a possible role in the nutritional prevention of CVD. Furthermore, the abundance of phenolic and tocopherol compounds provides a powerful antioxidant effect. The pharmacological and dietary properties of VAO have apparently never been investigated before in human beings. For this reason, our objective was to assess the effect of argan oil consumption on the lipid metabolism by studying the lipid and lipoprotein profiles through a nutritional interventional study in 60 healthy male volunteers.

Subjects and Methods

Subjects

Sixty-six male students of nursery from the Institute of Formation to Health Careers (Meknès, Morocco), aged 20–43 (mean 23.4 ± 3.8) years and having a normal body mass index (BMI; 22 ± 2.2 kg/m²) and a normal blood pressure, were recruited. All participants presenting a metabolic disease (hypercholesterolemia, hypertriglyceridemia, diabetes), a coronary, hepatic, cardiac, or renal insufficiency, and taking lipid-profile-affecting drugs were excluded from this study. All participants signed written informed consent that has been approved by the local ethics committee. The final study population consisted of 60 participants (30 by group). The lifestyle of the participants such as physical activities, number of working hours, and sleeping time have not changed throughout this study.

Experimental Protocol

In this nutritional intervention study, there were two diet periods. During diet period I (baseline diet), all subjects consumed

Table 1. Chemical composition of VAO and EVO used in the study [11]

| | VAO | EVO |
|-------------------------------|-------|---------|
| Fatty acids, % | | |
| C16:0 | 13.4 | 10.4 |
| C18:0 | 5.1 | 2.76 |
| C18:1 n-9 | 44.8 | 71.0 |
| C18:2 n-6 | 33.7 | 12.9 |
| C18:3 n-3 | 0.1 | 1.04 |
| Sterols, mg/100 g oil | | |
| Schottenol | 142 | 0 |
| Spinasterol | 115 | 0 |
| Stigmasta-8,22-dien-3β-ol | 9 | 0 |
| β-Sitosterol | 0 | 156 |
| Campesterol | 0 | 12 |
| Others | 29 | 151 |
| Total | 295 | 319 |
| Tocopherols, mg/kg oil | | |
| α | 35 | 190 |
| δ | 122 | 42 |
| γ | 480 | 26 |
| Total | 637 | 258 |
| Phenolic compounds, μg/kg oil | | |
| Vanillic acid | 67 | 359 |
| Syringic acid | 37 | 0 |
| Ferulic acid | 3,147 | 51 |
| Tyrosol | 12 | 19,573 |
| Others | – | 773,000 |
| Total | 3,263 | 792,983 |

25 g/day of butter pasted with the bread at breakfast during 2 weeks. During diet period II, the subjects were randomized into two diet groups: one group of 30 subjects who substituted butter by consuming 25 ml/day of VAO (VAO group) taken in a single oral dose with bread at breakfast and the control group of 30 subjects consuming 25 ml/day of extra virgin olive oil (EVO group) at breakfast during 3 weeks. Daily control of the food intake was required. The chemical composition of VAO and EVO used in this study is presented in table 1. Nutritional contributions and calculations of total energy of the three diets have been estimated using the Ciqual standard tables of food composition [12] and are shown in table 2.

Clinical Examination

Before allocation to each diet period, the participants underwent a medical examination, allowing the determination of anthropometric parameters and other variables: BMI and systolic and diastolic blood pressure (SBP and DBP, respectively).

Lipid Profile

At the end of each diet period, venous blood was collected into dry tubes after a 12-hour fasting period. Serum was obtained by centrifugation at 4,000 rpm for 12 min at 4°C. The blood samples were immediately stored at –80°C until analysis.

Table 2. Dietary consumption analysis of butter, VAO and EVO diets (mean \pm SD)

| | Butter diet | VAO diet | p (comparison between butter and VAO diets) | EVO diet | p (comparison between butter and EVO diets) |
|------------------------|-------------------|------------------|---|-----------------|---|
| Total energy, kcal/day | 2,537 \pm 244.2 | 2,561 \pm 246 | 0.620 | 2,560 \pm 253 | 0.805 |
| Proteins | | | | | |
| g/day | 85.7 \pm 15.6 | 84.8 \pm 15 | 0.535 | 84.7 \pm 15 | 0.535 |
| % | 13.5 \pm 1.9 | 13.2 \pm 2 | | 13.3 \pm 1.9 | |
| Carbohydrates | | | | | |
| g/day | 339.4 \pm 44.2 | 391.7 \pm 46.1 | 0.902 | 390.3 \pm 48 | 0.902 |
| % | 62 \pm 12 | 60.9 \pm 2.9 | | 61 \pm 2.8 | |
| Fats | | | | | |
| g/day | 68.9 \pm 12 | 73.3 \pm 11.5 | 0.097 | 72.7 \pm 11.5 | 0.097 |
| % | 24.5 \pm 3.6 | 25.8 \pm 3.6 | | 25.7 \pm 3.5 | |
| % SFA | 41.6 \pm 2.4 | 27 \pm 1.4 | 0.001 | 26.4 \pm 3.4 | 0.001 |
| % MUFA | 30.2 \pm 1.9 | 36.4 \pm 1.4 | 0.001 | 43.9 \pm 1.2 | 0.001 |
| % PUFA | 28.2 \pm 3.6 | 36.5 \pm 4.5 | 0.011 | 29.7 \pm 3.9 | 0.383 |

SFA = Saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

Serum TC and triglyceride (TG) levels were measured using enzymatic kits (Bioword and Spinreact, respectively) adapted for a spectrophotometer (Heyios). Serum HDL cholesterol was enzymatically measured by phosphotungstic acid and magnesium chloride precipitation (Biosystems) adapted for a spectrophotometer (Heyios). Low-density lipoprotein (LDL) cholesterol was calculated by the formula of Friedewald et al. [13]. Serum apos A-I and B were measured by means of immunoturbidimetric assays using a commercial kit (Roche) adapted for a Cobas autoanalyzer (Roche).

Statistics

The results are presented as mean values \pm SD. The Mann-Whitney U test was used for comparisons between VAO and EVO groups during each diet period. Differences in lipid and anthropometric parameters between baseline and 3 weeks after the diets in VAO and EVO groups were analyzed by the Wilcoxon signed-rank test. $p < 0.05$ was considered statistically significant. The Statistical Package for the Social Sciences was used (SPSS version 11.0).

Results

Diets

Table 2 shows the dietary consumption analysis of the butter, VAO, and EVO diets. The total energy intake was isocaloric for the butter diet (2,537 \pm 244.2 kcal/day) and for both VAO and EVO diets (2,561 \pm 246 and 2,560 \pm 253 kcal/day, respectively). These contributions were according to the recommended standards reported by the World Health Organization [Report 724, 1985]. However, the global distribution of fatty acids changed between diet phases. The unsaturated fatty acid contributions were higher in the VAO and EVO diets (>73%) than in the butter diet (58%).

Anthropometric Parameters

Our results show that body weight, BMI, and SBP and DBP of all participants remained unchanged after VAO and EVO interventional diets (table 3) when compared with baseline values. In the same way, we did not observe any significant differences between VAO and EVO groups at baseline and at the end of the study. The diet-period interaction of all these parameters was not significant for both groups.

Serum Lipid Values

Table 4 shows the variations in serum lipid values between baseline and 3 weeks after VAO and EVO diets for all subjects. In both dietary groups, the serum TC concentrations decreased, but not significantly, 3 weeks after VAO and EVO diets as compared with baseline values. However, the serum TG concentration decreased significantly (17.5%, $p = 0.039$) 3 weeks after the VAO diet. Serum HDL cholesterol and apo A-I concentrations increased significantly after VAO (8.4%, $p = 0.012$, and 5.2%, $p = 0.027$, respectively) and EVO diets (17.3%, $p = 0.001$, and 5.9%, $p = 0.036$, respectively) as compared with baseline values. Serum LDL cholesterol and apo B concentrations decreased significantly only after the EVO diet (13.8%, $p = 0.037$, and 7.8%, $p = 0.039$, respectively).

The serum lipid parameters, except for HDL cholesterol, did not change significantly between the groups, neither at baseline nor after 3 weeks of VAO or EVO diets.

Table 3. Body weight, BMI, SBP, and DBP in the study participants at baseline and after 3 weeks of VAO and EVO diets (mean \pm SD)

| | VAO group | | | | EVO group | | | | p (comparisons between both groups) | |
|------------------------|-----------------|-----------------|------|-------|-----------------|----------------|------|-------|-------------------------------------|---------------|
| | baseline | after 3 weeks | % | p | baseline | after 3 weeks | % | p | baseline | after 3 weeks |
| Body weight, kg | 66.6 \pm 6.7 | 66.7 \pm 6.5 | +0.1 | 0.188 | 67.1 \pm 7.9 | 67.3 \pm 8.1 | +0.4 | 0.700 | 0.291 | 0.338 |
| BMI, kg/m ² | 21.6 \pm 1.9 | 21.7 \pm 1.9 | +0.3 | 0.494 | 22.3 \pm 2.4 | 22.5 \pm 2.5 | +0.8 | 0.288 | 0.364 | 0.226 |
| DBP, mm Hg | 69.4 \pm 6.6 | 67.2 \pm 6.6 | -3.2 | 0.538 | 69.2 \pm 6.6 | 67 \pm 5.3 | -3.3 | 0.700 | 0.863 | 0.449 |
| SBP, mm Hg | 118.1 \pm 9.2 | 118.8 \pm 5.5 | +0.6 | 0.455 | 118.7 \pm 6.9 | 119 \pm 6.1 | +0.3 | 0.754 | 0.969 | 0.704 |

The p values were significantly different from baseline.

Table 4. Serum lipid levels in the study participants at baseline and after 3 weeks of VAO and EVO diets (mean \pm SD)

| | VAO group | | | | EVO group | | | | p (comparison between both groups) | |
|------------------------|------------------|------------------|-------|-------|------------------|------------------|-------|-------|------------------------------------|---------------|
| | baseline | after 3 weeks | % | p | baseline | after 3 weeks | % | p | baseline | after 3 weeks |
| TC, mg/dl | 162.6 \pm 37.1 | 153.2 \pm 36 | -5.8 | 0.270 | 151.2 \pm 39.4 | 143.3 \pm 31.4 | -5.2 | 0.299 | 0.181 | 0.251 |
| TG, mg/dl | 76.9 \pm 34.2 | 63.5 \pm 21.7 | -17.5 | 0.039 | 75.7 \pm 33.4 | 68 \pm 29.1 | -10.2 | 0.185 | 0.894 | 0.610 |
| HDL cholesterol, mg/dl | 45.4 \pm 6.5 | 49.6 \pm 7.1 | +8.4 | 0.012 | 41 \pm 8 | 49.2 \pm 10.5 | +17.4 | 0.001 | 0.024 | 0.652 |
| LDL cholesterol, mg/dl | 101.7 \pm 35.4 | 91.1 \pm 31.7 | -10.5 | 0.131 | 93.9 \pm 37.9 | 81 \pm 21.7 | -13.8 | 0.037 | 0.209 | 0.175 |
| Apo A-I, mg/dl | 136.6 \pm 18.9 | 144.1 \pm 16.3 | +5.2 | 0.027 | 128.9 \pm 21 | 137 \pm 20 | +5.9 | 0.036 | 0.264 | 0.146 |
| Apo B, mg/dl | 78.1 \pm 22.3 | 74.4 \pm 23.1 | -4.7 | 0.430 | 75.8 \pm 22.7 | 69.9 \pm 21.4 | -7.8 | 0.039 | 0.818 | 0.539 |

The p values were significantly different from baseline.

Discussion

Carried out under strict experimental conditions, in this randomized study 25 g of VAO/day was provided within an isocaloric diet during 3 weeks, after a 2-week stabilization period with the same quantity of butter using EVO as control. Apparently no nutritional intervention study in human was carried out in this field before. Therefore, the cardioprotective effect of argan oil was studied towards its effect on anthropometric parameters and serum lipid and apo levels.

In this study, the body weight of the participants in both groups did not change. This result is probably due to the stability of daily habits and total energy intake. In fact, the dietary periods were comparable for total energy, carbohydrates, protein, and total lipids and only differed for saturated and mono- and polyunsaturated lipid composition. These results are similar to the findings of Ber-

rada et al. [14] and Benajiba et al. [15] after administration of argan oil to rats and similar to those obtained by Lasserre et al. [16] using olive oil in humans. Likewise, SBP and DBP of our study participants did not change significantly during the study period. However, it has been suggested [14, 17] that ingestion of 5 ml/kg/day of argan oil in hypertensive rats during 2 months causes a normalization of their blood pressures. Also in hypertensive patients, Ferrara et al. [18] noticed a favorable effect on blood pressure after 6 months under a dietary intervention based on the use of EVO. This discrepancy could be due to the oil quantity used, the duration of study, and the difference between human and rat metabolism.

Many trials have been carried out comparing the different effects of food lipids on cholesterolemia. Most of these studies showed that the change from saturated fatty acids to unsaturated fatty acids in food intake leads to a TC and LDL cholesterol reduction and a decreased CVD

mortality risk as well [2, 4–6]. A second mechanism of action is assigned to the content in sterols of vegetable oils [19]. Indeed, because of the similarity in structure of cholesterol and sterols, there is a claim for a human plasma cholesterol reduction common to both of them [20]. These findings are consistent with our results which showed a LDL cholesterol-lowering effect after EVO consumption and provided its convenience of use in patients with hypercholesterolemia. More recently, Drissi et al. [21], in subjects consuming VAO, found decreased plasma LDL cholesterol and Lp(a) levels.

Argan oil, after 3 weeks of consumption, achieved not only a significant increase in HDL cholesterol, but also a significant reduction of TG. This reduction might be due to the change from saturated fatty acids to polyunsaturated fatty acids [22]. It is exciting that hypertriglyceridemia has been recently admitted to be a major and independent cardiovascular risk factor [23, 24]. For this reason, the VAO TG-lowering effect might be useful in the case of isolated or combined hypertriglyceridemia. Berrougui et al. [25] have recently observed in hyperlipidemic rats treated with VAO a significant plasma TG reduction. The significant increase of serum HDL cholesterol after VAO and EVO diets could be related to their fatty acid composition. It is well known that increasing the serum HDL cholesterol level reduces the risk of developing atherosclerosis and the incidence of CVD [26]. Numerous interventional studies aimed at increasing the HDL cholesterol level by modifications of the fat intake, but a comparison between saturated or unsaturated fatty acid rich diets gave inconsistent results. Many authors [27, 28] have reported a reduced HDL cholesterol level after a diet rich in polyunsaturated fatty acids. Other studies [16, 29] reported no effect of different diets on the HDL cholesterol values. In our study, we found a signifi-

cant increase in the HDL cholesterol concentrations in both groups which might be due to the increase of unsaturated fatty acids in the food. Regarding the apo, the apo A-I serum concentration significantly increased in both VAO and EVO groups. In addition, apo B significantly decreased only in the EVO group. These modifications of apo A-I and B are in accordance with the HDL and LDL cholesterol values. These are a very exciting results in the sense that apo A-I is considered a CVD prevention marker, whereas apo B is considered a CVD risk marker [30, 31]. Indeed, several studies [32, 33] pointed out that AGMI provided with olive oil plays an important role in balancing apo A-I liver expression in apo-E-deficient male rats and mice, inducing an increase in the serum concentration of this apo. However, other authors [34] have shown that an olive-oil-rich diet reduces the apo B plasma concentration by 10% in patients with hypercholesterolemia at the end of a 6-week intervention period.

In conclusion, the interesting results of this study confirm the lipid-lowering effect of olive oil and show for the first time evidence of TG-lowering effects of argan oil in humans.

Acknowledgments

We thank all volunteers for their cooperation and participation. We are indebted to the Director of IFCS of Meknès and all his staff for technical, administrative, and logistic support and Dr. Rachid Derouiche from the Centre de Santé Riyadh (Meknès) for his help in realizing the medical consultations. We also thank Prof. Abderrahman Belhouari (Casablanca) for his valuable help in our statistical analysis and the Institute AICHA Santé et Nutrition (Meknès) for financial support.

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