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Argan oil reduces, in rats, the high fat diet-induced metabolic effects of obesity

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Abstract *Background and Aim:* Obesity is a multi-factorial disorder which is of worldwide concern. In addition to calorie control, some specific dietary components might help resolving some of the complication of obesity, by providing antioxidant and anti-inflammatory activities. We investigated the effect of argan oil supplementation on plasma lipid profile and oxidant-antioxidant status of rats with high-fat diet (HFD)-induced obesity compared with rats fed a normal diet (ND).
Methods and Results: We used an animal model of high fat diet-induced obesity to study the metabolic effects of argan oil and we measured several markers lipid and redox statuses. Consumption of a high-fat diet led to an increase in serum total cholesterol (TC), LDL-cholesterol (LDL-C), and triacylglycerols (TAG) concentrations; however, argan oil blunted the increases of TC, LDL-C and TG, glucose, and insulin. Plasma total antioxidant capacity, erythrocyte catalase and superoxide dismutase activities were lower, whereas plasma hydroperoxide, thiobarbituric acid-reacting substances, and susceptibility of LDL to copper-induced oxidation were higher in obese rats compared with normal rats. Administration of argan oil ameliorated all these indices of redox status.
Conclusions: Proper diet and lifestyle should be foremost implemented to reduce the lipoprotein metabolism and oxidant/antioxidant status alterations brought about by obesity. In addition, argan oil reduces the metabolic effects of obesity and its use might be promoted within the context of a balanced diet.

Introduction

Obesity is a multi-factorial disorder whose major cause is a surplus energy intake over expenditure. This condition is characterized by excessive body fat content (assessed as body mass index) and glucose and lipid/lipoprotein abnormalities. The latter include elevated cholesterol [namely low-density lipoprotein (LDL) cholesterol]; triacylglycerols; and apolipoprotein B, and lower high density lipoprotein (HDL) cholesterol concentrations. In addition to adipose tissue hypertrophy, obesity is associated with important co-morbidity, in part due to the secretion of noxious mediators from adipocytes. In addition to dyslpipidemia, oxidative stress has been suggested as a contributor to obesity and associated metabolic syndrome (MetS). Indeed an impairment of some antioxidant enzymes', i.e. superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR), and glutathione peroxidase

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(GPx), activities is one of obesity's characteristics [1]. Also, low-weight, non-enzymatic antioxidants appear to be negatively affects by obesity [2].

In addition to calorie control, some specific dietary components might help resolving some of the complication of obesity, by providing antioxidant and anti-inflammatory activities [3]. One vegetable oil potentially helpful in modulating obesity's co-factors is argan oil, which is obtained from the fruit of *Argania spinosa* (Sapotaceae), an endemic tree which mostly grows in Maghreb, namely South-Western Morocco and Algeria (in the Tindouf countryside). The average fatty acid content of argan oil consists of 45% monounsaturated fatty acids (MUFA), 35% polyunsaturated fatty acids (PUFA), and 20% saturated fatty acids (SFA) [4]. Moreover, virgin argan oil contains minor, bioactive components such as phenolic compounds, phytosterols, and tocopherols [4]. The profile of its phytochemical composition suggests a potential role in the nutritional prevention of cardiovascular diseases [4]. Indeed, recent experimental studies reported hypolipidemic, hypocholesterolemic, and antihypertensive effects of argan oil in the rat [5]. Similar studies have demonstrated that the phenolic portion of argan oil inhibits human low-density lipoprotein oxidation and increases cholesterol efflux from human T-helper precursor-1 macrophages [6]. Furthermore, the phenolic, tocopherol, and saponin constituents of argan oil have been shown to provide powerful antioxidant effects [7]. Other properties that have been attributed to argan oil include antidiabetic [8,9] and antithrombotic activity [10]. Indeed, we performed a human trial of argan oil (from Algeria) and we showed that argan oil is able to positively modulate some surrogate markers of cardiovascular disease (CVD) [4]. However, the in vivo effects of argan oil have never been investigated in a high-fat diet-induced obesity model. Therefore, we sought to comprehensively determine the effects of argan oil supplementation on plasma glucose, insulin, leptin, lipid profile, and oxidant-antioxidant status of rats fed an obesity-inducing high-fat diet as compared with rats fed a normal diet.

Methods

Animals and experimental diets

This investigation conforms to the Guide for the Care and Use of Laboratory Animals, published by the US National Research Council (Eight Edition, 2010) and was approved by the local ethics committee. This manuscript conforms to the ARRIVE Guidelines for Reporting Animal Research. Adult male Wistar rats (180–200 g) were obtained from the Pasteur Institute of Algiers (Algeria) and were housed individually in plastic cages. Rats were kept under controlled conditions of light (12-h:12-h; light:dark cycle) and temperature (25°C ± 1 °C) at 60% ± 5% humidity, with free access to feed and water. A total of 20 were randomly distributed into four groups. The composition of the experimental diets is given in Table 1. The normal diet (ND) group was fed with ND for 12 weeks; the ND-AO group was fed for eight weeks a normal diet, then for four other weeks a normal diet in which 30 g of corn oil were replaced by argan oil; the high-fat diet (HFD) group was fed for 12 weeks high-fat diet; the HFD-AO group was fed for eight weeks a high-fat diet, then for four other weeks high-fat diet in which 50 g of corn oil were replaced by argan oil. ND contained 50 g of fat per kilogram (50 g of corn oil), HFD contained 200 g of fat per kilogram (170 g of sheep fat + 30 g of corn oil to provide essential fatty acids and 1% cholesterol by weight). The HFD was formulated to provide 40% of the total energy from fat, by replacing carbohydrate energy with sheep fat, corn oil, and cholesterol and had a same amount of vitamins and minerals per kilojoule as the ND. Argan fruits were harvested in the Tindouf area of South-Western Algeria. The argan oil used in the present work was produced from freshly picked and roasted seeds of a single harvest, using traditional hand-methods; its chemical composition is provided in Table 2.

Table 1 Composition (g/kg) of the experimental diets fed to rats.

Ingredient	ND	ND-AO	HFD	HFD-AO
Casein	200	200	200	200
Methionine	3	3	3	3
Corn starch	150	150	111	111
Sucrose	500	500	370	370
Cellulose	50	50	50	50
Corn oil	50	/	30	/
Argan oil	/	50	/	30
Fat sheep	/	/	170	170
Mineral mixture	35	35	42	42
Vitamin mixture	10	10	12	12
Cholesterol	/	/	10	10
Fat, %Kj	11.5	11.5	40	40

ND, normal diet; ND-AO, normal diet with argan oil; HFD, high-fat diet; HFD-AO, high-fat diet with argan oil. The fatty acid composition of corn oil was: 12.1% palmitic acid, 2.2% stearic acid, 30.7% oleic acid, 1% linolenic acid, and 54% linoleic acid.

Food intake was recorded daily and body weights were measured every three days.

At the end of the feeding period, rats were anesthetized with an intraperitoneal injection of sodium pentobarbital (60 mg/kg of body weight). The abdominal cavity was

Table 2 Composition of the argan oil adopted in this study [4].

Fatty acid	%
C16:0	12.89
C18:0	4.83
C16:1n-9	0.4
C18:1n-9	45.01
C18:2n-6	35.39
C18:3n-3	0.2
Total SFA	17.72
Total MUFA + PUFA	81
MUFA/PUFA	1.27
α-Tocopherol (mg/kg)	56.34
Phenolic compounds (mg/kg)	52.36

SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid.