The Effects of Peanut Oil on Lipid Profile of Normolipidemic Adults: A Three-country Collaborative Study.

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ABSTRACT

Peanut oil has been associated with reduced levels of plasma cholesterol and triacylglycerol, possibly due to its high monounsaturated (MUFA) lipid profile. This study evaluated the effects of peanut oil intake on blood lipid levels of healthy, normolipidemic, young adults (18-50 y/o). One hundred twenty nine subjects were recruited in Brazil (32), Ghana (64), and in the United States (33). Men (64) and women (65) were assigned to 1 of 4 experimental groups: control (32), peanut (32), safflower (33), and olive oil (32). Participants received a daily milk shake containing 30% of their basal energy requirement as 1 of the test oils for 8 weeks, except the control group, which did not receive the shake. The levels of total cholesterol, HDL-cholesterol, LDL-cholesterol, and triacylglycerol were assayed at baseline and on weeks 4 and 8. Waist/hip ratio, blood pressure, and heart rate were also evaluated. The concentration of LDL-cholesterol was significantly reduced in the safflower group ($p<0.05$). Systolic and diastolic blood pressures were consistently lower in the olive oil group and for the Ghanaian participants in the peanut oil group ($p<0.05$). In conclusion, safflower oil elicited a stronger LDL-lowering property than peanut and olive oil, while olive oil, and to a lesser extent peanut oil, were more effective at reducing blood pressure. The weak and intermediate effects of the peanut oil on cholesterol and blood pressure relative to the other oils suggest a contribution of its MUFA composition as well as other constituents in whole peanuts.

INTRODUCTION

The role of lipids in the etiology and management of obesity and coronary heart disease (CHD) has been of concern for decades. [1,2] Until recently, low-fat, and often, very low-fat, high-carbohydrate diets, were widely recommended to address these problems. However, there is strong support that moderate-fat diets can be effective as well,[3,4] or better.[5] In addition, moderate-fat diets that incorporate tree nuts and peanuts may generally promote healthy dietary practices.[6]

Although classified with tree nuts, peanuts are legumes and grow underground. They are similar to tree nuts in form and fat content. Approximately 60% of the energy in nuts and peanuts is derived from fat, and greater than 75% of this fat is unsaturated.[7] Much of the health benefit attributed to nuts stems from the lipid-lowering effects[8] of their

high unsaturated fatty acid profile as well as actions of other constituents like fiber, vitamin E, and phytochemicals. [9]

Replacing dietary carbohydrate with monounsaturated fat raises HDL cholesterol without affecting the LDL fraction.[10-14] In addition, monounsaturated fat is resistant to oxidation. The fiber in nuts can aid cholesterol excretion,[7] and their micronutrients and phytochemicals can reduce lipid oxidation,[15] relax vascular tone,[16] and decrease platelet aggregation[17] among other effects. Beef, dairy products, and partially hydrogenated vegetables oils are also significant sources of monounsaturated fat in the diet, but their consumption is often associated with intake of saturated and *trans* fats,[18] which adversely impact lipid profiles. Aside from nuts, the major non-animal sources of monounsaturated fat include olive and canola oils and avocados. Olive oil contains 80% MUFAs. In contrast, safflower oil has a high PUFA content (~78%). Peanut oil is intermediate, with 35% PUFAs and 50% of MUFAs. Each of these plant oils has about same quantity of SFA.[11]

The objective of this study was to evaluate the effects of the peanut oil on blood lipid of healthy, normolipidemic, young adults. Values were contrasted with responses to safflower and olive oils, which vary in fatty acid profile.

METHODS

Oil Source and Fatty Acid Profile

Peanut oil (Hollywood Enriched Gold Peanut Oil, The Hain Celestial Group Inc, Melville, NY), safflower oil (Hollywood Enriched Expeller Pressed Safflower Oil, The Hain Celextial Group Inc, Uniondale, NY), and olive oil (Pilippo Berio Extra Light Tasting Olive Oil, Salov North America Corp, Hackensack, NJ) were purchased in the United States. The fatty acid profiles of the oils were determined by gas chromatography (GC-17A Shimadzu/Class), with the following operating conditions: fused silica capillary column (100 m x 0.25 mm) SP-2560; carrier gas, hydrogen with flow rate of 20 $cm.sec^{-1}$; initial oven temperature, 140ºC for 5 minutes, that increased to 240ºC, at 4ºC.min^{-1}, where it was held at 240ºC for 30 min; and injection split ratio of 1/50 at 250ºC; vaporization and detector temperatures of 250ºC and 260ºC, respectively. The injection volume was 1 µL of sample. The retention times of methyl ester standards (SIGMA Chemical Co®, São Paulo, Brazil) were used to identify peaks.

Subjects

One hundred and twenty nine healthy adults (18 to 50 y/o) were recruited for the study in Brazil (n=32), Ghana (n=64), and in the United States (n=33) They were comprised of 64 men and 65 women, distributed in 4 groups: Control (15 male and 17 female), Peanut oil (15 male and 17 female), Olive oil (17 male and 15 female), and Safflower oil (17 male and 16 female). Treatments were randomized across participants within each country.

Their body mass index (BMI) ranged from 18 to 25 $kg.m^{-2}$, and their body weight was stable (less than 3 kg variation in the prior 6 months). Exclusionary criteria included regular use of medication, except oral contraceptives, smoking, vigorous regular exercise, hypertension, blood cholesterol > 220 mg/dL, diabetes, glucose intolerance, and daily intake of fat lower than 27% of daily energy intake. The volunteers signed informed consent forms approved by the Ethics Committees in each country.

Test Meal

The volunteers reported in fasting state to the laboratory daily for 8 weeks to receive the test load (milkshake). It consisted of a milk shake made with skimmed milk, sugar, flour mix, and fruit. The flour mix contained wheat

Table 1 - Baseline Characteristics of Participants

Age (years)	25.05 ± 5.58
Height (m)	1.68 ± 0.09
Weight (kg)	62.67 ± 10.93
BMI (kg/m^2)	22.09 ± 2.58
Body fat (kg)	13.47 ± 6.9
Lean body mass (kg)	48.90 ± 0.87
Waist circumference (cm)	95.77 ± 8.62
Waist to hip ratio	0.79 ± 0.01
BMR (kcal)	1551.40 ± 219.96

Values are mean ± sd. n= 129.

flour, sugar, and powdered milk. Flavors of the milkshakes varied throughout the study according to participant preferences. The milk shake contained peanut, safflower, or olive oil according to the test group. This oil was the only source of lipid in the shake, and provided 30% of each participant's resting energy needs as measured by indirect calorimetry. In all cases, the total energy provided by the test meal with the oil varied only from 690 to 760 kcal.

Biochemical, Clinical, and Anthropometric Analyses

Screening blood cholesterol levels were analyzed by finger-stick bleeding using Accu-Check™ InstantPlus™. After recruitment, a 10 mL blood sample was collected by venous puncture. Total cholesterol, LDL-cholesterol, HDL-cholesterol, triacylglycerol, glucose, creatinine, urea, and uric acid were assayed with a Cobas Mira blood sample analyzer (Roche Diagnostic). Analyses were conducted on samples collected at baseline and weeks 4 and 8.

Anthropometric measurements were taken at weeks 0, 4, and 8. Body height was measured with participants in a standing position. Participants were weighed in gowns or light indoor clothing after voiding. Standing height was measured to the nearest 0.5 cm. Bioelectrical impedance was used to determine total body fat and percentage of lean body mass and fat mass (Tanita Corporation of America Inc. Arlington Heights, IL; BIA model 310).

The waist/hip ratio was evaluated by measuring the waist and hip circumferences with an inelastic tape at the respective minimum and maximum curvatures. Blood pressure and heart rate were also measured with an Automatic Blood Pressure Monitor with IntelliSense? Model HEM-711AC at baseline and weeks 4 and 8.

Resting energy expenditure (REE) and diet-induced thermogenesis (DIT) were measured by indirect calorimetry using a Deltatrac metabolic monitor (Deltatrac II, Datex, Helsink, Finland), an open-circuit ventilated canopy measurement system, at baseline and week 8. Participants reported to the laboratory after a 12-h fast. They were instructed to refrain from exercise the day before, and to minimize activity during the morning of the measurement. DIT was measured during two 15-min periods each hour for 5 hr after ingestion of a preferred-flavor shake. The shakes used for DIT were consumed within 30 min and contained the oil tested (30% of REE). DIT was calculated as an average of the energy increment above basal value for 5 hr after shake ingestion and expressed in kilocalories per minute.

Dietary Assessment

Dietary intake was assessed by diet

Table 2 – Lipid Profile of the Volunteers According to the Dietary Group at Baseline and Weeks 4 and 8 (Mean ± SD).

Blood Lipid	Week	Peanut oil	Safflower oil	Olive oil	Control
			mg/dL		
HDL	Baseline	59 ± 14.2	57 ± 15.7	59 ± 9.4	56 ± 12.1
	Week 4	61 ± 18.5	58 ± 14.5	62 ± 16.8	56 ± 11
	Week 8	62 ± 20.3	58 ± 14.7	62 ± 16.0	58 ± 10.4
LDL	Baseline	92 ± 22.8	100 ± 32.6[a]	84 ± 21.6	93 ± 26.6
	Week 4	84 ± 21.8	81 ± 29.8[b]	83 ± 20.5	90 ± 25.0
	Week 8	89 ± 28.6	85 ± 28.0[b]	90 ± 30.6	93 ± 27.0
Total Chol	Baseline	164 ± 30.0	164 ± 48.3	156 ± 36.3	162 ± 30.0
	Week 4	157 ± 33.8	148 ± 37.7	159 ± 30.3	157 ± 38.7
	Week 8	164 ± 44.2	153 ± 39.3	164 ± 42.0	165 ± 32.4
TG	Baseline	64 ± 36.8	60 ± 52.9	67 ± 45.6	58 ± 21.9
	Week 4	61 ± 25.3	58 ± 26.4	67 ± 45.1	61 ± 25.0
	Week 8	66 ± 32.1	64 ± 29.6	73 ± 49.4	63 ± 30.3

HDL: High-density lipoprotein; LDL: Low-density lipoprotein; Total Chol: Total cholesterol; TG: Triacylglycerol.
Mean values of each parameter followed by different letter in a column differs statistically ($P<0.05$),

records completed by participants at weeks 0, 4, and 8. Participants were trained to record every food item consumed, along with portion sizes. For food mixtures, participants listed each ingredient separately. A diet record model was provided to serve as a guide. Records were completed on three non-consecutive days (2 weekdays and 1 weekend day). The diet records were analyzed by country-specific databases.

Physical Activity Assessment

Participants maintained 24-hr physical activity logs at baseline and weeks 2, 4, 6, and 8 to determine that they maintained their normal activities during the study as they were advised. Physical activity data were analyzed with Nutri Quest 2.1 (McGraw-Hill, Columbus, OH, USA).

Statistical Analysis

Repeated measures analysis of variance (RMANOVA) was performed using SPSS, version 10.0, to evaluate the effects of the oils (Control, Peanut, Safflower and Olive oil) on HDL, LDL, TC, TG, blood pressure, WHR. When appropriate, post-hoc testing was conducted with a paired t-test. Significance was defined as a $p<0.05$, 2-tailed.

RESULTS

The average age of participants was 25±5.8 years (mean ± standard deviation); body mass index (BMI) was 22±2.5 $kg.m^{-2;}$ and body fat was 13.4±6.9% (Table 1).

LDL-cholesterol concentrations were significantly reduced in the safflower group at weeks 4 and 8 compared to baseline. Consumption of safflower oil lowered total cholesterol in 6,7% and LDL in 15% compared to other oils (Table 2). There were no significant interactions between treatment oil and either country or sex.

The US patients had higher basal levels of total cholesterol and HDL-cholesterol than the volunteers of the other 2 countries, and their values remained higher throughout the experimental period. The triacylglycerol levels were lower in the Ghanaian volunteers compared to the Brazilian and US samples. The Americans had higher levels of LDL-cholesterol than the volunteers of the other countries at week 8. A significant difference of lipid profile was also observed between genders. The concentrations of total cholesterol and HDL-cholesterol were significantly higher in women than in men throughout the experimental period in all countries.

Table 3 – Nutrient Intakes Across Treatment Groups

		Peanut	Safflower	Olive	Control
Energy	Baseline	2056.54 ± 111.75[a]	1892.47 ± 104.54[a]	2192.82 ± 106.21[a]	1845.23 ± 109.81
	Week 4	2320.52 ± 121.13[b]	2046.99 ± 113.30[b]	2379.74 ± 115.12[b]	2109.88 ± 119.81
	Week 8	2287.77 ± 129.16[b]	2299.96 ± 120.82[b]	2528.11 ± 122.75[b]	1931.46 ± 126.91
Fat	Baseline	31.28 ± 1.42[a]	33.14 ± 1.32[a]	32.14 ± 1.35[a]	30.95 ± 1.39
	Week 4	43.62 ± 1.73[b]	45.45 ± 1.61[b]	44.75 ± 1.64[b]	31.99 ± 1.70
	Week 8	43.14 ± 1.49[b]	44.38 ± 1.40[b]	45.66 ± 1.42[b]	34.02 ± 1.47
MUFA	Baseline	20.84 ± 2.08[a]	22.13 ± 1.95[a]	23.29 ± 1.98[a]	19.99 ± 2.04
	Week 4	46.12 ± 2.84[b]	29.12 ± 2.66[b]	54.26 ± 2.69[b]	24.78 ± 2.79
	Week 8	44.40 ± 2.73[b]	37.24 ± 2.55[b]	58.75 ± 2.59[b]	21.81 ± 2.68
PUFA	Baseline	11.19 ± 1.31[a]	11.38 ± 1.22[a]	12.79 ± 1.24[a]	10.43 ± 1.28
	Week 4	28.17 ± 2.31[b]	42.27 ± 2.16[b]	21.26 ± 2.19[b]	14.35 ± 2.27
	Week 8	27.83 ± 3.09[b]	44.06 ± 2.07[b]	23.94 ± 2.94[b]	13.12 ± 3.03
SFA	Baseline	20.95 ± 1.85	21.72 ± 1.79	23.21 ± 1.85	19.69 ± 1.92
	Week 4	27.62 ± 2.16	24.20 ± 2.09	25.99 ± 2.16	24.69 ± 2.24
	Week 8	27.73 ± 2.35	25.37 ± 2.28	28.93 ± 2.35	22.59 ± 2.44

Energy: Kcal/d; Fat: % energy; MUFA: Monounsaturated fatty acids (g); PUFA: Polyunsaturated fatty acids (g); SFA: Saturated fatty acids (g).
Mean values of each parameter followed by different letter in a column differs statistically ($P<0.05$),

LDL-cholesterol concentration was significantly higher for females at week 8.

Overall, the systolic and diastolic blood pressures of the volunteers consuming olive oil were significantly lower than those associated with the other oils (Table 5). Systolic blood pressure was lower in men consuming all oils, compared with the control group at week 8. This was true for females only with the olive oil consumption. The within-country comparisons showed that systolic blood pressure was significantly reduced in the Ghanaian volunteers consuming olive oil and peanut oil. No significant differences were observed among groups for waist/hip ratio or heart rate throughout the experimental period.

The average energy intake increased with the addition of the oil loads in the 3 active intervention groups. No difference in energy intake was observed in the control groups over time. The mean energy intake increased 12% in the peanut and olive oil and 15% in safflower oil groups. The percentage of energy obtained from fat also increased significantly at weeks 4 and 8 within the intervention groups.

Body weight increased significantly at week 4 in the olive oil group, but not in peanut or safflower oil groups. However, at week 8, there was a significant increase in weight relative to baseline in all 3 oil intervention groups, albeit less than theoretically predicted. Observed weight gain was 0.67, 0.64 and 0.95 kg for peanut, safflower and olive oil respectively, compared with a possible predicted weight gain of 3.4 kg.

DISCUSSION

This study contrasts the effects of 3 oils varying in fatty acid profiles on plasma triacylglycerol, total cholesterol, HDL-cholesterol, and LDL-cholesterol. Prior work with whole nuts documented reductions in each of these lipid frac-

Table 4 – Body Weight of the Volunteers According to the Dietary Group at Baseline and Weeks 4 and 8 (Mean ± SD).

	Peanut	Safflower	Olive	Control
Baseline	62.43 ± 1.99	63.05 ± 1.95	63.64 ± 2.05	66.30 ± 2.01
Week 4	62.67 ± 1.94	63.39 ± 1.90	64.17 ± 1.99	66.17 ± 1.96
Week 8	63.10 ± 1.94	63.69 ± 1.93	64.59 ± 2.03	66.07 ± 1.99

Mean values of each parameter followed by different letter in a column differs statistically ($P<0.05$),

tions associated with chronic consumption[8] and it has been assumed to stem from the fat profile. For almonds, it has been demonstrated that the nut and the oil have similar effects on lipid profile and LDL oxidation.[19]

Despite literature report on the effect of nuts and peanuts[1,20] on lipid profile improvement, the current study revealed no significant changes on the triacylglycerol, total cholesterol and HDL-cholesterol levels after peanut and other oils intake. There are several plausible explanations for the lack of effects. The first is that the fatty acids are not the only responsible factors for the lipid-lowering effect of the nuts. Besides its high MUFA content, nuts are also rich in copper, magnesium, phytochemicals, plant protein, dietary fiber, and arginine (a precursor of nitric oxide). These constituents may favorably affect lipid profiles and are largely present in the non-lipid fraction of nuts.[8,19] However, it seems unlikely the oil component is not involved, at least in part, as other studies have demonstrated lipid lowering effects of unsaturated fats either when they displace saturated fats[1,10,13,20-24] or change the unsaturated to saturated ratio by simply increasing the former without changing the latter.[25] Indeed, there are studies showing comparable effects of nuts and nut oils.[19,26] Failure to ingest the experimental oils would also lead to a null effect, but this is not the explanation because the shakes were ingested in the laboratory under supervision. A third option holds that this study's participants were resistant to the effects. Normal lipidemic individuals have lower responses to dietary lipid interventions than those who are hyperlipidemic.[1,13] The volunteers of this study were young adults with baseline plasma cholesterol levels below 220 mg/dL (median of 166 mg/dL). Cholesterol and triacylglycerol reductions have been reported in such a population with whole nuts,[25] but the intervention was larger and longer. Thus, while it was more ecologically relevant than many former studies, the protocol may not have maximized conditions to demonstrate an effect.

Most studies that consistently demonstrated an association between nut consumption and coronary heart disease morbidity and mortality in different population groups are epidemiologic prospective studies.[5,6,14,23] One of these studies compared people consuming nuts once a week with those whose consumption is 1-4 times/wk, and showed a 25% reduction on the risk of dying from CHD in the last group. The consumers eating nuts more than 5 times/wk experienced a ~50% reduction in risk.[27] Even, after adjustments for several confounding parameters such as age, sex, smoking, alcohol, BMI (Body Mass Index), physical activity, and blood pressure, nut consumption was inversely associated with CHD risk.[14,17,23]

Several clinical studies also demonstrated improvement of lipid profile after nut ingestions.[25,28] However, the experimental designs of these studies were variable. Subject characteristics

Table 5 - Systolic and Diastolic Blood Pressure, Waist/Hip Ratio and Heart Rate of the Volunteers – Difference between Week 8 and Baseline

		Peanut Oil	Safflower Oil	Olive Oil	Control
Systolic	Overall	-4.63	-2.21	-6.32[a*]	-0.48
Blood	Men	-6.2	-4.41	-5.59	-0.27*
Pressure	Women	-3.23	0.13	-6.73[a*]	1.18
	Brazil	-2.13	-4.25	0.63	2.5
	Ghana	-9.44*	-6.81	-11.94*	-1
	US	2.5	7.78	-1.25	-0.13
Blood	Overall	1.22	0.91	-2.68*	1.74
Pressure	Men	2.87	0.59	-1.35	0.27
Diastolic	Women	-0.24	1.25	-4	3.12
	Brazil	7.63	-0.13	-1	6.25
	Ghana	-2.63	-4.31	-4.69	0.27
	US	2.5	11.11	0	1.08
Waist/	Overall	0.009	0.003	-0.005	-0.008
Hip	Men	-0.003	0.002	0.006	-0.005
Ratio	Women	0.02	0.004	-0.02	-0.01
	Brazil	0.02	0.02	-0.004	0.02
	Ghana	-0.008	-0.006	-0.01	-0.01
	US	0.03	0.006	0.009	-0.02
Heart	Overall	-1.53	-1.18	-1.28	-2.38
Rate	Men	-4.4	-1.47	0.06	-3.07
	Women	1	-0.88	-2.8	-1.76
	Brazil	6.75	7.5	-0.5	5.25
	Ghana	-1.44	-3.44	-2.81	-4.88
	US	-10	-4.89	1	-4.39

a: difference between week 8 and baseline significantly different
* significant difference between treatments (peanut, safflower, olive oil and control)

were different, as the degree of dietary control, the type and amount of fat, amount of nuts consumed, studies duration, control diets, and sample sizes. Most of nut intervention diets were low in SFA, *trans* fatty acids, and dietary cholesterol and high in unsaturated fatty acids and dietary fiber.[23,25,28]

In the current study, the volunteers receiving high MUFA oils (peanut and olive) experienced no significant change in their levels of HDL, LDL and triacylglycerol. These results differ from others in the literature,[1,10,13,20,21,23,24] where the intake of MUFA or carbohydrate replaced SFA intake. In our study, participants showed limited dietary compensation so the oil loads added lipid to the diet. Total intake of lipids increased from 30 to 43% of energy and SFA intake increased 2%. Intake of carbohydrate was reduced. This resulted in a total fat intake that was above the recommended upper level of 35%.[29] Nevertheless, blood lipids did not increase. This supports the view that the nature of the dietary lipids ingested, rather than the total amount, is the primary determinant of plasma lipid concentrations.[1,10,21,30-33]

A 10% reduction in LDL cholesterol has been reported following replacement of foods high in SFA by nuts or cereal, and this was estimated to reduce lipid-related CVD risk by. 20%.[34] There was a significant 15% reduction of LDL-cholesterol in the safflower oil group. Others[35] have reported that linoleic acid, the major fatty acid of safflower oil, is more effective at reducing LDL-cholesterol levels in moderate hypercholesterolemic subjects than oleic acid (a

monounsaturated fat). However there is also evidence[30] of only slight differences among individuals consuming diets richer in stearic, oleic, or linoleic acid.

The healthy effects of safflower oil on LDL-cholesterol cannot be visualized in isolation.[36] High intakes of PUFA are associated with increased susceptibility to LDL-cholesterol peroxidation,[13] which may initiate atherosclerosis. MUFA-rich diets may reduce insulin requirements, exert hypotensive effects, promotes higher LDL oxidation resistance, lower monocyte adhesion and, chymiotaxis. MUFA also reduces protrhrombotic factors such as coagulation and fibrinolysis in relation to PUFA.[37] These factors contribute to the reduced risk of cardiovascular diseases of MUFA.

In the present study, the female participants had higher levels of HDL, LDL, and total cholesterol than the males. The High HDL levels in our young females is consistent with prior observations.[34,38] It was anticipated that LDL-cholesterol would be lower in this group, but this lipid fraction is less dependent on gender and age.[39] The trend for higher triacylglycerol concentrations in males has been reported previously.[40-42]

Blood pressure was significantly reduced in the olive oil group compared to the other groups. Peanut oil also reduced blood pressure in the Ghanaian group, which suggests an effect of MUFA since these oils are rich sources of oleic acid. These data support observations that high MUFA diets lower blood pressure in normotensive[43] and Type-2 diabetic[24] individuals. However, it is not clear the oleic acid component is entirely responsible since accompanying polyphenol compounds may also contribute.[44-46] The mechanism may entail an increased concentration of nitric oxide, which promotes arterial dilatation, and consequently reduces blood pressure.[45] MUFA are also related to a lower platelet aggregation[47] and increases of both fibrinolysis and clotting time, which protects against thrombogenesis.[48]

Besides having evidence that a nut-enriched diets does not induce weight gain, the oils used in this study elicited a weaker compensatory dietary response. So, body weight increased significantly, but less than theoretically predicted.

CONCLUSION

The daily ingestion of unsaturated oils led to a significant increase in fat consumption, but did not adversely effect lipid profiles. Safflower oil loads were effective in reducing LDL-cholesterol levels, while olive oil, and to a lesser extent, peanut oil loads elicited significant reductions of blood pressure. The intermediate effects of the peanut oil in both of these outcomes are consistent with its intermediate fatty acid profile. Overall, the inclusion of safflower oil, containing high P/S ratio and olive and peanut oils, rich sources of MUFA in the diet, exert protective effects against the risk of CHD.

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