

# The Effect of The Oil Consumption Pattern on Atherogenic Index of Plasma: Evidence From a Cohort Study in West of Iran

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## Research

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## Abstract

# Background

The amount and type of lipids consumed greatly impact serum lipid profile and risk of cardiovascular diseases (CVDs). A novel index named atherogenic index of plasma (AIP) is a better predictor of CVD risk factors than lipids alone. This study aimed to investigate the effect of edible oils on AIP.

## Methods

This cross-sectional study was conducted on the preliminary phase of Ravansar Non-Communicable Disease (RaNCD) cohort study. The amount of consumption of edible lipids was determined based on the validated Food Frequency Questionnaire (FFQ). AIP was calculated as  $\log_{10}(\text{TG}/\text{HDL-C})$ .

## Results

From 9996 participants, 4738 (47.4%), were male. The mean of AIP was  $0.98 \pm 0.6$  (range from  $-1.73$  to  $4.15$ ), which in females ( $0.97 \pm 0.6$ ) was lower than males ( $1.10 \pm 0.6$ ). After controlling for confounding and affecting variables, the AIP index decreased with increasing consumption of a local oil named Kermanshahi oil [ $\beta(\text{CI } 95\%): -0.006(-0.008, -0.003)$ ], butter [ $\beta(\text{CI } 95\%): -0.008(-0.011, -0.005)$ ] and not statistically significant decrease with Hydrogenated or partial hydrogenated oil [ $\beta(\text{CI } 95\%): -0.008(-0.001, 0.001)$ ] but the AIP index increased with un-hydrogenated oil [ $\beta(\text{CI } 95\%): 0.001(-0.001, 0.001)$ ]

## Conclusions

Kermanshahi oil and butter have a decreasing effect on AIP, the effect of margarine was neutral, and hydrogenated vegetable oil has a decreasing effect, whereas un-hydrogenated vegetable oil has an increasing effect on it. So, consumption of Kermanshahi oil may be associated with lower cardiovascular risk.

## Background

Prevention and control of non-communicable diseases are one of the priorities of the World Health Organization (WHO). Currently, 40 million deaths per year (approximately 70% of all deaths worldwide) are attributable to non-communicable diseases [1, 2]. The role of genetic factors, physical activity, smoking, and nutrition in preventing non-communicable diseases is well known [3]. In terms of nutrition, the consumption pattern of different oils is very important. The association between the type and amount of oil consumed has been observed with the occurrence of chronic diseases, especially cardiovascular diseases (CVDs) [3–5]. According to the nutritional guidelines, an adult's daily fat allowance is approximately 60 grams, with a maximum of 20 grams (equivalent to one-third), which can be saturated and the daily cholesterol intake should be less than 300 mg [3].

The functional role of edible oil on health depends on many factors such as fatty acid composition, percentage of saturated fatty acids, percentage of fatty acids with double bonds, arrangement of double bonds, length of fatty acids, and amount of cholesterol [3, 6]. One popular method for predicting chronic diseases (especially CVD and hypertension) is evaluating the lipid profile (TG, TC, HDL-C, and LDL-C). [7–9]. Atherogenic index of plasma (AIP) is calculated as  $\log(\text{TG}/\text{HDL-C})$ , and it has been designated as a predictor of atherosclerosis and surrogate of small low-density lipoprotein particle size [10, 11].

The pattern of oil consumption can be one of the effective factors in lipid profile levels. In Iran, vegetable oil is the main edible oil produced from mixing sunflower oil, soybean, canola, corn, etc. These oils are available as hydrogenated or un-hydrogenated (liquid). Un-hydrogenated oil is also available for both frying and cooking [12, 13]. In the west of Iran, ghee is commonly known as “Kermanshahi oil” or “Yellow oil” or “Kermanshahi roghan” which is produced from the melting of yogurt butter. Kermanshahi oil is a type of cold ghee technically used for cooking [14, 15]. Although it is made from animal fat and contains high amounts of saturated fatty acids (SFAs) and cholesterol, some studies reported it helped increase HDL-C and decrease LDL-C [16, 17]. Surveys showed there is no information about the effects of pattern of oils consumption on AIP. Therefore, this study aimed to investigate the effect of oil consumption patterns on AIP.

## Methods

### Study design and population

This is a cross-sectional study based on the Ravansar Non-Communicable Disease (RaNCD) cohort study in western Iran. The RaNCD cohort study is a part of Prospective Epidemiological Research Studies in Iran (PERSIAN cohort) conducted on various ethnicities of an Iranian population. Details of the methodology of RaNCD study have been published before [18, 19]. The number of participants in the baseline phase of the RaNCD was 10,000 adults that all participants in the initial phase of RaNCD entered this study. People with incomplete information were excluded from the study

### Data Collection And Measurements

Data collection and all measurements were conducted in the cohort site. Demographic information (gender, age, marital status, educational level, place of residence), socio-economic status (SES), lifestyle (smoking status, use alcohol), and physical activity were completed using digital questionnaires by trained experts from the Cohort Center.

Socio-economic status (SES) was calculated by Principal Component Analysis (PCA) and assessed the subjects' economic and social variables. According to SES, participants were categorized into five equal quintiles: the poorest, the poor, the middle class, the rich, and the richest [20]. The Bio-Impedance Analyzer BIA (Inbody 770, Inbody Co, Seoul, Korea) and BSM 370 (Biospace Co, Seoul, Korea) were used to measure the weight and height. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m<sup>2</sup>). The nonsmokers were individuals who reported they had not smoked at least 100 cigarettes during their lifetime. Former smokers were those who had quit with a history of smoking at least 100 cigarettes and current smoker is a person used at least 100 cigarettes and now he/she smokes [21]. The physical activity questionnaire was used to assess participant's physical activity. The questionnaire consisted of 22 questions base on the amount of an individual's daily activity [20].

Lipids profile (LDL-C, HDL-C, TG and total cholesterol) was measured at least after 8–12 hours of fasting using commercially available kits according to the manufacturer's protocol. The log TG / HDL-C formula was used to calculate AIP [9, 22], then AIP categorized into 5 equal quintile bases on the AIP score.

Consumption values and type of oil were measured based on Food Frequency Questionnaire (FFQ), which previously calculated its validity and reliability. In this study, according to the region's dietary pattern and the characteristics of oils, as in the previous study, the type of oil consumed in Iran was divided into six groups: 1) Kermanshahi oil 2-Butter 3-Margarine 4- Liquid oil (un-hydrogenated) 5- Hydrogenated oil 6- total oil that equals the sum of 1 to 5 [15].

### Statistical Analysis

In order to perform descriptive analysis, mean  $\pm$  standard deviations for continuous variables and frequency (percentage) for qualitative variables were calculated. Chi-square for trends was used to determine the linear relationship between the oils used with AIP. A fractional polynomial was used to determine the intensity of the association between the oils used with AIP.

To investigate the association between oil consumption and AIP, the linear model was fitted where the important variables in the model were adjusted. For this purpose, univariate and multiple linear regression analysis was performed on each of the studied oils and the significant variables were selected for inclusion in the model. Then using the backward method, the original model was fitted with significant variables. In less than 1% of the data, missing data were excluded and a significance level less than 0.05 was considered. Data analysis was performed using STATA 14.2 (Stata Corp, College Station, TX, USA).

## Results

A total of 9996 individuals, 4738(47.4%), were male and 5258(52.6%) were female. 5907 (59.1%) of participants were urban, and 4089 (40.1%) were rural. Only 2740 (27.6%) had normal BMI. The mean of AIP was  $0.98 \pm 0.6$  (range from - 1.73 to 4.15) that in females ( $0.97 \pm 0.6$ ) was lower than males ( $1.10 \pm 0.6$ ) ( $P < 0.001$ ) (Table 1).

Table 1  
Demographic characteristic of participants by AIP quantities

Variables		Total	Q1	Q2	Q3	Q4	Q5	P-value
		N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	
<b>Mean(min- max)</b>		<b>0.98(-1.73-4.15)</b>	<b>1.9(1.50-4.15)</b>	<b>0.1(-1.73-0.43)</b>	<b>0.62(0.43-0.8)</b>	<b>0.95(0.80-1.12)</b>	<b>1.3(1.12-1.51)</b>	
<b>Total N(%)</b>		<b>9996(100)</b>	<b>1999(20.0)</b>	<b>2000(20.0)</b>	<b>1999(20.0)</b>	<b>1999(20.0)</b>	<b>1999(20.0)</b>	
<b>Gender</b>	<b>Male</b>	4738(47.4)	1260(26.6)	706(14.1)	815(17.2)	928(19.6)	1029(21.7)	< 0.001
	<b>Female</b>	5258(52.6)	739(14.0)	1294(24.6)	1184(22.5)	1071(23.4)	970(18.5)	
<b>Age group</b>	<b>35-45</b>	4392(44.0)	836(19.0)	975(22.2)	917(20.9)	848(19.3)	816(18.6)	< 0.001
	<b>46-55</b>	3324(33.2)	710(21.4)	612(18.4)	621(18.7)	669(20.1)	712(21.4)	
	<b>56-65</b>	2280(22.8)	453(19.9)	413(18.1)	461(20.2)	482(21.1)	471(20.6)	
<b>place of Residence</b>	<b>Urban</b>	5907(59.1)	1271(21.5)	1001(16.9)	1142(19.3)	1209(20.4)	1284(21.7)	< 0.001
	<b>Rural</b>	4089(40.1)	728(17.8)	999(24.4)	857(20.9)	790(19.3)	715(17.5)	
<b>marital status</b>	<b>married</b>	9016(90.2)	1857(20.6)	1728(19.2)	1774(19.7)	1823(20.2)	1834(20.3)	< 0.001
	<b>single</b>	421(4.2)	54(12.8)	143(33.9)	102(24.2)	66(15.6)	56(13.3)	
	<b>divorced/widowed</b>	559(5.6)	88(15.7)	129(23.1)	123(22.0)	110(19.7)	109(19.5)	
<b>Level of education</b>	<b>illiterate (0 year)</b>	2482(24.8)	412(19.1)	527(21.2)	532(21.4)	537(19.1)	474(19.1)	< 0.001
	<b>1-5 years</b>	3821(38.2)	722(18.9)	793(20.8)	776(20.3)	737(19.3)	793(20.7)	
	<b>6-9 years</b>	1657(16.6)	382(23.0)	312(18.8)	309(18.6)	321(19.4)	333(20.1)	
	<b>10-12 years</b>	1259(12.6)	290(23.0)	246(19.5)	244(19.4)	226(17.9)	253(20.1)	
	<b>&gt;= 13 years</b>	777(7.7)	193(24.8)	122(15.7)	138(22.9)	178(17.8)	146(18.8)	
<b>smoking status</b>	<b>never smokers</b>	7975(80)	1483(18.6)	1715(21.5)	1659(20.8)	1600(20.0)	1518(19.0)	< 0.001
	<b>current smoker</b>	1169(11.8)	328(28.1)	156(13.3)	180(15.4)	235(20.1)	270(23.1)	
	<b>ex-smoker</b>	825(8.2)	182(22.0)	124(15.0)	157(19.0)	157(19.0)	206(25.0)	
<b>Use alcohol</b>	<b>No</b>	9366(93.7)	1824(19.5)	1912(20.4)	1890(20.2)	1876(20.0)	1864(19.9)	< 0.001
	<b>Yes</b>	630(6.3)	175(27.8)	88(14.0)	109(17.3)	123(19.5)	135(21.4)	
<b>Physical activity Daily METs</b>	<b>24-36.5</b>	2746(27.5)	695(25.3)	415(15.1)	477(17.4)	574(20.9)	585(21.3)	< 0.001
	<b>36.6-44.9</b>	5137(51.4)	928(18.0)	1105(21.5)	1081(21.0)	1013(19.7)	1010(19.7)	
	<b>≥ 45</b>	2108(21.1)	375(17.8)	478(22.7)	441(20.9)	410(19.4)	404(19.1)	
<b>BMI (kg/m<sup>2</sup>)</b>	<b>19-24.9</b>	2906(29.3)	306(10.5)	949(32.7)	694(23.9)	520(17.9)	437(15.0)	< 0.001
	<b>25-29.9</b>	4310(43.5)	1062(24.6)	703(16.3)	799(18.5)	830(19.3)	916(21.2)	
	<b>30-34.9</b>	2124(21.4)	504(23.7)	208(13.2)	383(18.0)	481(22.6)	476(22.4)	
	<b>≥ 35</b>	581(5.9)	112(19.3)	55(9.7)	112(19.3)	152(26.2)	150(25.8)	
<b>socioeconomic status</b>	<b>1st quintile ( the poorest )</b>	2009(20.1)	350(17.4)	439(21.8)	446(22.2)	389(19.4)	385(19.2)	< 0.001
	<b>2nd quintile</b>	1997(20.0)	385(19.3)	402(20.1)	389(19.4)	426(21.3)	395(19.8)	
	<b>3rd quintile</b>	2003(20.1)	405(20.2)	416(20.8)	381(19.0)	418(20.9)	383(19.1)	
	<b>4th quintile</b>	1998(20.1)	435(21.9)	351(17.7)	395(19.9)	385(19.4)	421(21.2)	

<b>5th quintile (the richest)</b>	1978( 19.7 )	435(21.9 )	351(17.7 )	395(19.9 )	385(19.4 )	421(21.2 )
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As Table 2 shows, the average consumption of different types of edible lipids in the different quantities of AIP index for Kermanshahi oil, butter, and Hydrogenated or partial hydrogenated oils varied, As the AIP index quantities increased, the amount of Kermanshah oil, Butter and Hydrogenated or partial hydrogenated oils decreased, But with increase in AIP index in un-hydrogenated oil men increased and no statistically significant change was observed for women (Table 2).

Table 2  
Relationship between the oils used with AIP quantities

Oil type		Total	Q1	Q2	Q3	Q4	Q5	Chi2 for tend
		Mean ± SD						
Kermanshahi oil	Male	2.65 ± 5.74	3.24 ± 7.43	2.93 ± 5.87	2.58 ± 5.44	2.57 ± 5.36	2.27 ± 5.03	< 0.001
	Female	2.24 ± 4.77	2.46 ± 5.05	2.40 ± 4.89	2.17 ± 4.38	2.17 ± 4.74	1.79 ± 4.64	< 0.001
Butter	Male	2.68 ± 4.90	2.96 ± 4.63	3.16 ± 6.02	2.61 ± 5.11	2.71 ± 4.88	2.24 ± 3.98	< 0.001
	Female	1.92 ± 3.60	2.24 ± 4.16	1.98 ± 3.72	1.91 ± 3.52	1.74 ± 2.94	1.58 ± 3.15	< 0.001
Margarine	Male	0.90 ± 2.68	0.79 ± 2.18	0.87 ± 2.54	1.06 ± 3.38	0.87 ± 2.43	0.88 ± 2.63	0.02
	Female	0.54 ± 2.28	0.48 ± 1.74	0.67 ± 3.4	0.49 ± 1.91	0.47 ± 1.68	0.57 ± 2.03	0.3
Un- hydrogenated oil	Male	16.38 ± 19.67	15.00 ± 19.78	14.47 ± 17.44	17.15 ± 20.32	17.29 ± 19.37	16.91 ± 20.60	< 0.001
	Female	15.09 ± 19.04	13.94 ± 17.99	15.73 ± 19.60	15.17 ± 18.83	14.95 ± 18.90	16.11 ± 20.29	0.1
Hydrogenated or partial hydrogenated oil	Male	19.87 ± 20.88	18.42 ± 21.84	18.65 ± 20.97	17.38 ± 19.52	17.91 ± 20.39	18.65 ± 21.61	0.06
	Female	18.30 ± 20.08	18.70 ± 19.70	19.10 ± 20.91	18.79 ± 20.65	17.47 ± 20.05	16.70 ± 18.43	0.001
Total oil	Male	40.98 ± 24.11	41.87 ± 25.38	40.09 ± 23.90	40.80 ± 24.09	41.35 ± 23.16	40.96 ± 24.30	0.8
	Female	38.09 ± 22.95	37.80 ± 22.01	39.90 ± 23.70	38.53 ± 23.30	36.79 ± 23.60	36.75 ± 21.80	0.002

**Table 3-** The effect of Kermanshahi oil, Butter, Margarine, and un/ hydrogenated oil on AIP using crude and adjusted linear regression (increase 1 gram per day )

Variable	Crude $\beta$ (CI 95% )	Model1 $\beta$ (CI 95% )	Model 2 $\beta$ (CI 95% )
Kermanshahi oil	-0.005(-0.008, -0.003)	-0.006(-0.008, -0.003)	-0.006(-0.008, -0.003)
Butter	-0.007(-0.01, -0.004)	-0.009 (-0.012, -0.006)	-0.008(-0.011, -0.005)
Margarine	0.006(0.001,0.011)	0.001(-0.004,0.005)	0.001(-0.003, 0.006)
Un- hydrogenated oil	0.001(0.001,0.001)	0.001(0.001,0.001)	0.001(-0.001, 0.001)
Hydrogenated or partial hydrogenated	-0.008(-0.001,-0.002)	-0.001(-0.001,-0.001)	-0.008(-0.001, 0.001)

**Model1:** Adjusted for baseline age, gender, smoking status, place, education level, socio economic status

**Model2:** Additionally adjusted for BMI, physical activity, caloric intake

Regardless of the type of oil consumed, there is no correlation between the amount of oil consumed and the AIP index. However, in the oil subgroups, the AIP index decreased with increasing Kermanshahi oil (Figure A1), butter (Fig. 1B) and Hydrogenated or partial hydrogenated oil (Fig. 1D). However, the AIP index increased with un-hydrogenated oil (Fig. 1E).

After controlling for confounding and affecting variables, the AIP index decreased with increasing Kermanshahi oil [ $\beta$ (CI 95% ): -0.006(-0.008, -0.003)], butter [ $\beta$ (CI 95% ): -0.008(-0.011, -0.005)] and not statistically significant decrease with Hydrogenated or partial hydrogenated oil [ $\beta$ (CI 95% ): -0.008(-0.001, 0.001)] but the AIP index increased with un-hydrogenated oil [ $\beta$ (CI 95% ): 0.001(-0.001, 0.001)].

## Discussion

In this cross-sectional study on the adult population of RaNCd cohort, we detected a positive effect of Kermanshah ghee on AIP index. There are enough studies about the influence of edible lipids on lipid profile fraction but data are rare about edible lipids and AIP. None of the discussed studies reported AIP, but we calculate it based on their HDL-C and TG data. According to this article, milk-based lipids such as Kermanshah oil and butter acts better than vegetable one's.

## Kermanshah oil

Despite high SFAs and cholesterol content, we observed consumption of Kermanshah oil has reduced the amount of AIP in male and female, Therefore, its impacts on AIP is favorable and has a protective role in the incidence of CVDs. In accordance with our findings, the results of a study by Rawashdeh et al in Jordan showed that a diet based exclusively on ghee resulted in a decrease in TG, an increase in TC, an increase in TC / HDL-C ratio and an increase in LDL-C / HDL-C but a diet based exclusively on olive oil results in an increase in TG, a decrease in TC, a decrease in TC / HDL-C ratio, and a decrease in LDL-C / HDL-C ratio. This is calculable that AIP has increased during the intervention in the olive oil group compared to starting point slightly, whereas ghee consumption decreased AIP in Jordanians[23].

The results of a cross-sectional study during 2009–2011 period by Vyas et al has reported an inverse relationship between the amount of ghee and the history of CHD in the urban North Indian adults; they have concluded that people with the highest consumption of ghee per month and the lowest consumption of vegetable oil (mustard) have a better history of CHD[17].

Also the result of another clinical trial study in India by Shankar et al has shown that both mustard oil and ghee (10% of energy intake) have decreasing effects on AIP decreased for eight weeks [24].

Similar to our findings, the results of a randomized clinical trial on 206 Iranian adults are implied that ghee consumption has decreased the amount of AIP slightly[15].

## Butter

We observed that butter consumption had reduced the amount of AIP in two genders, and the relationship between butter and AIP was favorable similar to Kermanshahi oil consumption.

In agreement with us, Asadi et al. concluded that yogurt butter has a positive effect by increasing HDL-C in the animal model[25].

A meta-analysis study that analyzed 9 studies in 15 countries concluded that butter has a neutral or weak effect association with overall mortality, cardiovascular disease, and diabetes[26].

The Nurses' Health Cohort Study findings reported that dairy fat consumption is associated with an increased risk of IHD[27].

The result of a prospective cohort study in the United States on 2907 people over the age of 65 has shown that there was no significant relationship between pentadecanoic, heptadecanoic, and trans- palmitoleic phospholipids (as biomarkers of dairy fat intake) with total mortality and incidence of CVDs[28].

In another meta-analysis study of 13 studies, it was observable that a higher intake of dairy fat was not associated with an increased risk of cardiovascular disease[29].

## **Margarine**

We observed that in both males and females with increasing margarine intake, AIP did not change, and its effect was almost neutral. In contrast with our finding, the results of a randomized clinical trial on 206 Iranian adults are shown that margarine consumption has decreased the amount of AIP slightly. According to Iranian standards, 5 types of margarine are produced with different amounts of Trans fatty acids[12]; perhaps the difference of results is related to the type of consumed margarine in the two studies.

## **Hydrogenated or partial hydrogenated oil**

In the present study, both males and females had a negative and slightly inverse relationship between hydrogenated vegetable oil and AIP, although no significant relationship was found after controlling for confounding variables. In general, the hydrogenated vegetable oil not only did not increase AIP but also slightly reduced it. This finding is somewhat different from previous studies because most of them implied the adverse effect of hydrogenated vegetable oil on the lipid profile[15, 30]. Nour et al. in Egypt have done a study that represented based on HDL-C and TG data, AIP was the lowest in the ghee group and the highest in the hydrogenated vegetable oil group[31].

The results of Nour et al study in Egypt on hydrogenated vegetable oil are somewhat different from the results of our study that is due to the fact that Egyptian hydrogenated vegetable oil is made from palm oil while Iranian hydrogenated vegetable oil is made from a mixture of soybean oil, canola, corn, etc[6, 12, 15]. As we know, palm oil is the source of atherogenic fatty acids naturally.

In contrast with our findings, the aforementioned randomized clinical trial results on 206 Iranian adults were shown that hydrogenated vegetable oil consumption had increased the amount of AIP slightly[15]. This difference may be reasonable because their study carried out at 2009 while we collected data in 2013; the Trans fatty acids reduction program was implemented in Iran in 2013 so that the amount of trans fatty acids in hydrogenated vegetable oils should be less than 2 percent. Asgary et al. reported that the amount of trans fatty acids in hydrogenated vegetable oils was about 30% at 2009[12, 13].

There have been many studies on the adverse effects of vanaspati, which is a type of hydrogenated vegetable oil in India, but it should be remarkable that vanaspati is made up of 20 different oils and the amount of trans fatty acid is also high; therefore, the vanaspati available in India differs from Iranian hydrogenated vegetable oil[5, 32]. Although various studies have reported adverse effects on hydrogenated vegetable oil[33, 34], the effect of hydrogenated vegetable oils depends on the amount of trans fatty acids and is not a risk factor if trans fatty acids be controlled [33, 35].

## **Un-hydrogenated (liquid) oil**

Unexpectedly, the relationship between liquid oil consumption and AIP in both genders was direct and it can be said that liquid oil consumption had an atherogenic effect; however, after controlling for confounding variables, it was significant. In a clinical trial study conducted in Iran during 2009, liquid oil consumption had no effect on AIP[15], but in the current study, its effect was unfavorable, and it is maybe that increasing the amount of liquid oil consumption lead to increasing the chance of CVDs. In our opinion, the first reason of this contradiction is related to type of study so that their study was a clinical trial and they used a specific liquid oil, whereas in our study only liquidity was considered as un-hydrogenation. Maybe the second reason is improper usage of these oils in our study. Both Frying oils and cooking oils are liquid but their properties are different. If cooking oil is used instead of frying oil, its fatty acids will be oxidized and peroxidized, which have harmful effects on serum lipid profile[3].

## **Total oil**

We conclude that Kermanshahi oil and butter have decreasing effects on AIP, the effect of margarine was neutral, hydrogenated vegetable oil has trace decreasing effect whereas un-hydrogenated vegetable oil has increasing effect on it.

Summarily, we can say that Kermanshahi oil and butter have covered the effect of un-hydrogenated (liquid) oil so that total oil consumption in men had no effect on AIP but in women slightly reduced AIP. We observed that although Kermanshahi oil and butter are rich in cholesterol and saturated fatty acids but have a favorable effect on AIP. Maybe that's why Ayurveda medicine has considered ghee (clarified butter) to be the healthiest source of edible fat for thousands of years.

## Study strengths and weaknesses

This study will be one of the first studies in Iran to investigate the relationship between different types of edible oils and AIP because other studies have been done based on lipid profile fractions. Overall, this study has several strengths, most notably the high sample size, the study of all types of oils (especially kermanshahi oil), and trained nutritionists' data. The FFQ questionnaire was confirmed and validated formerly. Also this study had some weaknesses such as the amount of oils per day is so low that therefore the effect of the amount of oils per day on AIP is neglectable, quality of oils in the same group of oil are different. Furthermore, given the questionnaire-based nature of the current study, the finding may have been affected by information bias. Moreover, resembling other cross-sectional studies, it is hard to declaration a cause-and-effect relationship.

## Conclusions

we concluded that milk-based oils' effect on the AIP is more beneficial than vegetable-based oils. Kermanshahi oil and butter have a decreasing effect on AIP. The effect of margarine was neutral. Hydrogenated vegetable oil has a decreasing neglectable effect, whereas un-hydrogenated vegetable oil has an increasing effect. The present study indicates that Milk-based oil consumption in a low amount is not only harmless but also is beneficial regarding AIP as a strong index of atherogenicity. Maybe that is why Ayurveda medicine has considered ghee (clarified butter) to be the healthiest source of edible fat for thousands of years. It seems that Iranian hydrogenated vegetable oils are safe because of the trans fatty acid reduction program's success. We recommended that the Iranian ministry of health reeducate people about the proper usage of frying oils and cooking oils via public media.

## Declarations

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### Authors' contributions

BS analyzed the data and wrote the manuscript; MM analyzed the data; MD, BH,RS and BS contributed to discussion; YP ,BH, and FN designed the study, edited the manuscript, and contributed to discussion. All authors read and approved the final manuscript. **Funding** This study was supported by the Kermanshah University of Medical Sciences, Kermanshah, Iran, and registered (No: 92472) at the Research and Technology Deputy

### Ethics approval and consent to participate

The research was approved by the ethics committee of Kermanshah University of Medical Sciences (KUMS.REC.1394.318). All participants gave written informed consent to participate in the study

### Competing interests

The authors declare that they have no competing interest

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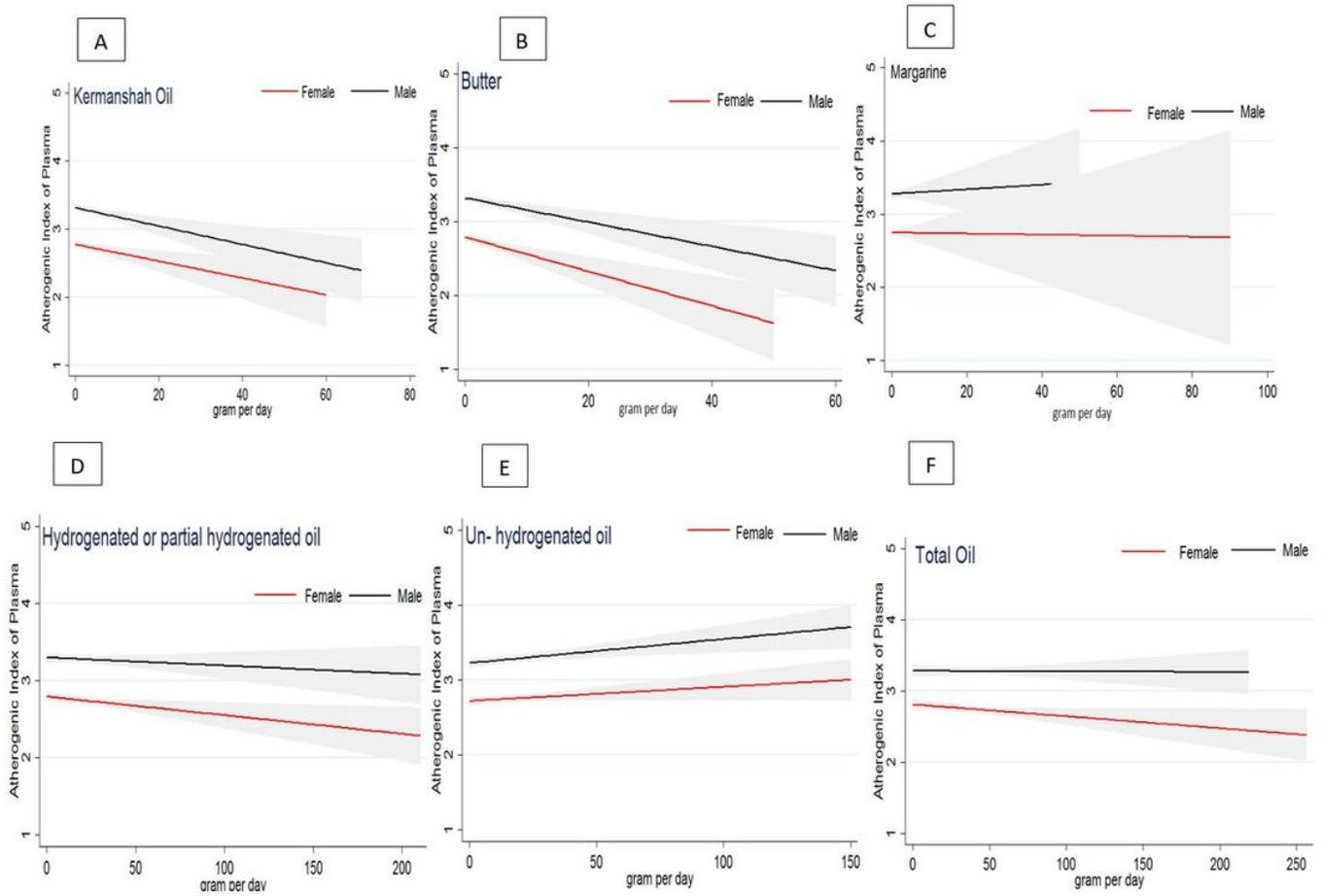
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## Figures



**Figure 1**

The association between AIP index and A: Kermanshahi oil, B: Butter, C: Margarine, D: Un- hydrogenated oil E: Hydrogenated or partial hydrogenated oil and F Total