# The Effect of Edible Lipids on Atherogenic Index of Plasma: Results From RaNCD Cohort Study

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**Research**

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# Abstract

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

**Methods**: This cross-sectional study conducted on preliminary phase of Ravansar Non-Communicable Disease (RaNCD) cohort study. The amount of consumption of edible lipids was determined based on validated Food Frequency Questionnaire (FFQ). Lipid profiles including triglyceride (TG), and lipoprotein cholesterol (HDL-C) were measured, and AIP was calculated as log10 (TG/HDL-C).

**Results**: A total of 9996 individuals, 4738(47.4%) were male. The mean of AIP was 0.98±0.6 (range from -1.73 to 4.15) that in females (0.97 ± 0.6) was lower than males (1.10 ± 0.6). After controlling for confounding and affecting variables, the AIP index decreased with increasing consumption of a local oil named Kermanshahi oil [β(CI 95% ): -0.006(-0.008, -0.003)], butter[β(CI 95% ): -0.008(-0.011, -0.005)] and not statistically significant decrease with Hydrogenated or partial hydrogenated oil [β(CI 95% ): -0.008(-0.001, 0.001)] but the AIP index increased with un-hydrogenated oil [β(CI 95% ): 0.001(-0.001, 0.001)]

**Conclusion**: Kermanshahi oil and butter have decreasing effect 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. So, consumption of Kermanshahi oil may be associated with lower cardiovascular risk.


# Introduction

Cardiovascular diseases (CVDs) are the first cause of death in the world and impose enormous burden[1, 2]. The role of genetic factors, physical activity, smoking and, nutrition in the prevention of CVDs is well known[3]. The amount and type of oil consumed has a significant influence impact on cardiovascular health[1, 3, 4]. According to the nutritional guidelines, an adult's daily fat content is approximately 60 grams, with a maximum of 20 grams (equivalent to one-third) of which can be saturated and the daily cholesterol intake should be less than 300 mg[3] .

The functional role of edible lipids on the body 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, amount of cholesterol, etc.[3, 5]. Nowadays, better indicators have been defined for lipid profiles based on TG, TC, HDL-C and LDL-C parameters which are more reliable to predict CVDs[6–8].The atherogenic index of plasma (AIP) is an accurate, robust and useful indicator for predicting likelihood of CVDs, stroke, subclinical atherosclerosis, fatty liver and dyslipidemia. AIP is being directly linked to CVDs, so the higher amount of the AIP predicts the greater the chance of these diseases. Therefore, any factor that has a decreasing effect on AIP has a protective role for CVDs[7, 9–12].

In Iran, vegetable oil is the main edible lipids produced from the blend of 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[13, 14]. In the west of Iran, ghee is commonly known as “Kermanshahi oil” or “Yellow oil” or “Kermanshahi roghan” which is produced from melting of yogurt butter. Kermanshahi oil is type of cold ghee technically which used for cooking[15, 16]. Although it is made from animal fat and contains high amounts of saturated fatty acids (SFAs) and cholesterol, some studies reported it was useful for increasing HDL-C and decreasing LDL-C[17, 18]. To our knowledge, data on the effects of Kermanshahi oil on AIP is scarce. Furthermore, there is paucity of scientific research regarding the effect of consumption of edible oil on AIP. The aim of this study was to investigate the effect of edible oil including Kermanshahi oil on AIP.

# Methods

### Study design and population

This is a cross-sectional study based on baseline data of 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. The PERSIAN cohort consists of 21 cohorts in different regions of Iran, covering a wide

range of ethnic groups of different ethnicities, with the aim of pursuing a 15-year follow-up of all participants. See the article's protocol and preliminary results of cohort for further details [19, 20].

### Data collection and Measurements

Data collection and all measurements were conducted in the cohort site. For the purpose of this research, we extracted the following variables from the questionnaires: gender, age, marital status, educational level, place of residential, socio-economic status, smoking status, use alcohol, physical activity, anthropometric index and dietary pattern and the characteristics of oils.

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 person used at least 100 cigarettes and now he/she smokes [21].

Socio-economic status (SES) was calculated by Principal Component Analysis (PCA) and assessed the subjects' economic and social variables. According to SES, participants was categorized into five equal quintiles: the poorest, the poor, the middle class, the rich, and the richest[22]

The physical activity questionnaire was used to assess Participants physical activity. The questionnaire consisted of 22 questions base the amount of an individual's daily activity. then metabolic equivalent of task (MET), as an indicator for level and measure of physical activity, were extracted and entered the model. MET is the amount of oxygen consumed at rest (about 3.5 ml 02/kg/min) and equals to resting metabolic rate. MET for each activity was extracted using compendium of physical activities[22].

Lipids profile was measured at least after 8 hours of fasting using commercially available kits according to the manufacturer's protocol. 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 ($m^2$).

Consumption values of each 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 sum of 1 to 5 [16]. The log TG / HDL-C formula was used to calculate AIP[8, 11, 23, 24]. Then AIP categorized into 5 equal quintile bases on atherogenic score.

### Statistical Analysis

In order to perform descriptive analysis, mean ± standard deviations for continue variables and frequency (percentage) for qualitative variables were calculated. Chi-square for trend were 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 effect of the important variables in the model was 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 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 were considered. Data analysis was performed using STATA 14.2 (Stata Corp, College Station, TX, USA).

## Results

Out of 10,065 participants in the RaNCD cohort, there was no measuring FFQ for 69 individuals. A total of 9996 individuals, 4738(47.4%) were male and 5258(52.6%) were female. From total, 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 ± 0.6 (range from − 1.73 to 4.15) that in females (0.97 ± 0.6) was lower than males (1.10 ± 0.6) (p.value < 0.001). All demographic data are shown in Table 1.

Table 1
Demographic characteristic of participants by AIP quantities

| Total Mean ± SD | | Total Mean ± SD | Q1 (better) Mean ± SD | Q2 Mean ± SD | Q3 Mean ± SD | Q4 Mean ± SD | Q5 (worse) Mean ± SD | P value |
|---|---|---|---|---|---|---|---|---|
| **Mean(min- max)** | | **1.9(1.50–4.15)** | **0.98(-1.73 -4.15)** | **0.1(-1.73 -0.43)** | **0.62(0.43–0.8)** | **0.95(0.80–1.12)** | **1.3(1.12–1.51)** | |
| **Total** | | **1999(20.0)** | **9996(100)** | **2000(20.0)** | **1999(20.0)** | **1999(20.0)** | **1999(20.0)** | |
| Gender | Male | 1260(26.6) | 4738(47.4) | 706(14.1) | 815(17.2) | 928(19.6) | 1029(21.7) | < 0.001 |
| | Female | 739(14.0) | 5258(52.6) | 1294(24.6) | 1184(22.5) | 1071(23.4) | 970(18. 5) | |
| Age group | 35–45 | 836(19.0) | 4392(44.0) | 975(22.2) | 917(20.9) | 848(19.3) | 816(18.6) | < 0.001 |
| | 46–55 | 710(21.4) | 3324(33.2) | 612(18.4) | 621(18.7) | 669(20.1) | 712(21.4) | |
| | 56–65 | 453(19.9) | 2280(22.8) | 413(18.1) | 461(20.2) | 482(21.1) | 471(20.6) | |
| place of Residence | Urban | 1271(21.5) | 5907(59.1) | 1001(16.9) | 1142(19.3) | 1209(20.4) | 1284(21.7) | < 0.001 |
| | Rural | 728(17.8) | 4089(40.1) | 999(24.4) | 857(20.9) | 790(19.3) | 715(17.5) | |
| marital status | married | 1857(20.6) | 9016(90.2) | 1728(19.2) | 1774(19.7) | 1823(20.2) | 1834(20.3) | < 0.001 |
| | single | 54(12.8) | 421(4.2) | 143(33.9) | 102(24.2) | 66(15.6) | 56(13.3) | |
| | divorced/widowed | 88(15.7) | 559(5.6) | 129(23.1) | 123(22.0) | 110(19.7) | 109(19.5) | |
| Level of education | illiterate (0 year) | 412(19.1) | 2482(24.8) | 527(21.2) | 532(21.4) | 537(19.1) | 474(19.1) | < 0.001 |
| | 1–5 years | 722(18.9) | 3821(38.2) | 793(20.8) | 776(20.3) | 737(19.3) | 793(20.7) | |
| | 6–9 years | 382(23.0) | 1657(16.6) | 312(18.8) | 309(18.6) | 321(19.4) | 333(20.1) | |
| | 10–12 years | 290(23.0) | 1259(12.6) | 246(19.5) | 244(19.4) | 226(17.9) | 253(20.1) | |
| | >= 13 years | 193(24.8) | 777(7.7) | 122(15.7) | 138(22.9) | 178(17.8) | 146(18.8) | |
| smoking status | never smoked | 1483(18.6) | 7975(80) | 1715(21.5) | 1659(20.8) | 1600(20.0) | 1518(19.0) | < 0.001 |
| | smoker | 328(28.1) | 1169(11.8) | 156(13.3) | 180(15.4) | 235(20.1) | 270(23.1) | |
| | Ex-smoker | 182(22.0) | 825(8.2) | 124(15.0) | 157(19.0) | 157(19.0) | 206(25.0) | |
| Use alcohol | No | 1824(19.5) | 9366(93.7) | 1912(20.4) | 1890(20.2) | 1876(20.0) | 1864(19.9) | < 0.001 |
| | Yes | 175(27.8) | 630(6.3) | 88(14.0) | 109(17.3) | 123(19.5) | 135(21.4) | |
| Physical activity Daily METs | 24-36.5 | 695(25.3) | 2746(27.5) | 415(15.1) | 477(17.4) | 574(20.9) | 585(21.3) | < 0.001 |
| | 36.6–44.9 | 928(18.0) | 5137(51.4) | 1105(21.5) | 1081(21.0) | 1013(19.7) | 1010(19.7) | |
| | ≥ 45 | 375(17.8) | 2108(21.1) | 478(22.7) | 441(20.9) | 410(19.4) | 404(19.1) | |
| BMI ($kg/m^2$) | 19-24.9 | 306(10.5) | 2906(29.3) | 949(32.7) | 694(23.9) | 520(17.9) | 437(15.0) | < 0.001 |
| | 25 -29.9 | 1062(24.6) | 4310(43.5) | 703(16.3) | 799(18.5) | 830(19.3) | 916(21.2) | |
| | 30-34.9 | 504(23.7) | 2124(21.4) | 208(13.2) | 383(18.0) | 481(22.6) | 476(22.4) | |
| | ≥ 35 | 112(19.3) | 581(5.9) | 55(9.7) | 112(19.3) | 152(26.2) | 150(25.8) | |
| Socio-economic status | 1st quintile ( the poorest) | 350(17.4 ) | 2009(20.1 ) | 439(21.8 ) | 446(22.2) | 389(19.4) | 385(19.2) | < 0.001 |
| | 2nd quintile | 385(19.3 ) | 1997(20.0 ) | 402(20.1) | 389(19.4) | 426(21.3) | 395(19.8) | |

| Total<br>Mean ± SD | | Total<br>Mean ± SD | Q1<br>(better)<br>Mean ± SD | Q2<br>Mean ± SD | Q3<br>Mean ± SD | Q4<br>Mean ± SD | Q5<br>(worse)<br>Mean ± SD | P value |
|---|---|---|---|---|---|---|---|---|
| | 3rd quintile | 405(20.2 ) | 2003(20.1 ) | 416(20.8) | 381(19.0) | 418(20.9) | 383(19.1) | |
| | 4th quintile | 435(21.9 ) | 1998(20.1 ) | 351(17.7 ) | 395(19.9) | 385(19.4) | 421(21.2) | |
| | 5th quintile (the richest) | 435(21.9 ) | 1978( 19.7 ) | 351(17.7 ) | 395(19.9) | 385(19.4) | 421(21.2) | |

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<br>Mean ± SD | Q1<br>Mean ± SD | Q2<br>Mean ± SD | Q3<br>Mean ± SD | Q4<br>Mean ± SD | Q5<br>Mean ± SD | Chi2 for tend |
|---|---|---|---|---|---|---|---|---|
| **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 |

Figure 1 shows the dose-response association between the AIP index and the types of oils. Regardless of the type of oil consumed, there is no correlation between the amount of oil consumed and the AIP index. But 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). But 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 [β(CI 95% ): -0.006(-0.008, -0.003)], butter[β(CI 95% ): -0.008(-0.011, -0.005)] and not statistically significant decrease with Hydrogenated or partial hydrogenated oil [β(CI 95% ): -0.008(-0.001, 0.001)] but the AIP index increased with un-hydrogenated oil [β(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 discuses study did not reported AIP but we calculate it based on their HDL-C and TG data. According 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 intervention in the olive oil group compared to starting point slightly, whereas ghee consumption decreased AIP in Jordanians [25]. 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 has concluded People with the highest consumption of ghee per month and the lowest consumption of vegetable oil (mustard) have a better history of CHD[18].

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 week [26]. Similar to our findindg, the results of a randomized clinical trial on 206 iranian adults are implied that ghee consumption has decreased the amount of AIP slightly[16] .

### Butter

We observed that butter consumption has reduced the amount of AIP in two gender 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 positive effect by increasing HDL-C in animal model[27]. A meta-analysis study that analyzed 9 studies in 15 countries concluded that butter has neutral or weak effect association with overall mortality, cardiovascular disease, and diabetes[28]. The findings of the Nurses' Health Cohort Study reported that dairy fat consumption is associated with an increased risk of IHD[29].

The result of a prospective cohort study in the United States on 2907 people over the age of 65 has been shown that there were no significant relationship between pentadecanoic, heptadecanoic and trans- palmitoleic phospholipids (as biomarkers of dairy fat intake) with total mortality and incidence of CVDs [30]. In another meta-analysis study of 13 studies, it was observable that higher intake of dairy fat was not associated with an increased risk of cardiovascular disease[31] .

### 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[13], 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 male and female 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 is somewhat different from previous studies because

most of them implied adverse effect of hydrogenated vegetable oil on the lipid profile[16, 32]. 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[33].

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[5, 13, 16]. As we know, palm oil is source of atherogenic fatty acids naturally.

In contrast with our findindg, the results of aforementioned randomized clinical trial on 206 iranian adults were shown that hydrogenated vegetable oil consumption has increased the amount of AIP slightly[16]. This difference maybe reasonable because their study carried out at 2009 while we collected data at 2013, Trans fatty acids reduction's program was implemented in Iran especially at 2013 so that the amount of trans fatty acids in hydrogenated vegetable oils should be less than 2 percent. Asgary el al reported that the amount of trans fatty acids in hydrogenated vegetable oils was about 30% at 2009[13, 14].

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[4, 34]. Although various studies have reported negative effects on hydrogenated vegetable oil[35, 36], 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 [35, 37].

### 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[16], 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 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 peroxided, which have harmful effects on serum lipid profile[3].

### Total oil

We conclude that Kermanshahi oil and butter have decreasing effect 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 although Kermanshahi oil and butter are rich in cholesterol and saturated fatty acids but have 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 the collection of data have done by trained nutritionists. The FFQ questionnaire was confirmed and validated formerly .Also this study had some weaknesses such as amount of oils per day is so low therefor effect of amount of oils per day on AIP is neglect able , quality of oils in the same type of oil are different. Furthermore, given the questionnaire-based nature of 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.

## Conclusion

We conclude that Kermanshahi oil and butter have decreasing effect 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. We observed although Kermanshahi oil and butter are rich in cholesterol and saturated fatty acids but have 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. Also we found 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.

# Declarations


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Ravansar Non-Communicable Disease (RaNCD) cohort study is a part of Prospective
Epidemiological Research Studies in IrAN (PERSIAN) national cohort. We would like to thank professor Reza Menkzadeh Deputy of Research and Technology at the Ministry of Health and Medical Education of Iran and Director of the PERSIAN cohort and also Dr. Hossein Poustchi Executive Director of PERSIAN cohort for all their support during design and running of RaNCD cohort study. The research was registered (grant: 92472) at the Research and Technology Deputy.


### Ethics approval and consent to participate

RaNCD cohort study was registered to Kermanshah University of Medical Sciences. The ethical committee review all procedures and questionnaire and approved the research (KUMS.REC.1394.318). All the participants that met the inclusion criteria were provided oral and written informed consent.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.


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There was no funding for this study.


### Authors' contributions

Conceptualization: Pasdar Y, Sahargahi B, Najafi N

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# Tables

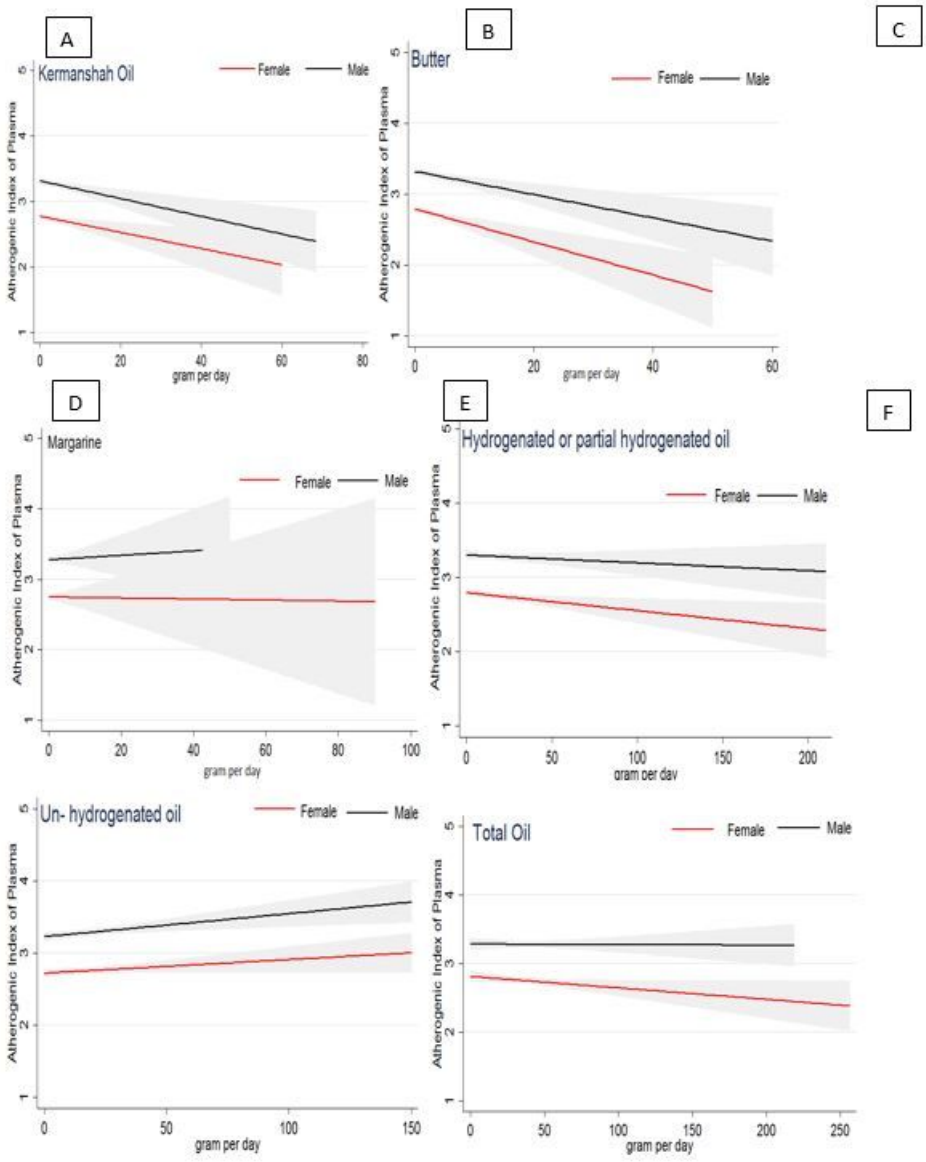
**Table 3- The effect of Kermanshahi oil, Butter, Margarine, and un/ hydrogenated oil on AIP using crude and adjusted linear regression (increase 1 gram per day )**

| Variable | Crude<br>β(CI 95% ) | Model1<br>β(CI 95% ) | Model 2<br>β(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

# 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