

Effect of Oat Consumption on Lipid Profiles in Hypercholesterolemic Adults

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Background: Hypercholesterolemia is a strong risk factor in cardiovascular disease. Oat (*Avena sativa* L.) beta-glucan, the soluble fiber in oat, has been known to reduce blood cholesterol levels considerably. However, the effect of oat soluble fiber in the Thai population is unknown.

Objective: To determine the effect of oat consumption on serum lipid profiles in Thai hypercholesterolemic adults.

Material and Method: The present study was a randomized, crossover design. Twenty-four hypercholesterolemic adults, male and female aged 30-60 years, were randomly assigned into two groups of twelve each. Group 1 consumed 70 g (3g beta-glucan) of oatmeal daily through the first 4-week intervention, and then switched to 70 g rice porridge (control product) daily for the next 4-week intervention. Group 2 consumed rice porridge first and then oatmeal. Before and after each intervention period, lipid profiles including total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C), and low density lipoprotein cholesterol (LDL-C) of all subjects were measured.

Results: Following daily oat consumption, total cholesterol and LDL-cholesterol levels were significantly lower than baseline levels and lower than the levels observed with rice consumption. Oat consumption reduced total cholesterol by 5% and LDL-cholesterol by 10% from baseline levels. In addition, mean and percent changes were significantly different from the levels after consuming rice porridge ($p < 0.05$).

Conclusion: Oatmeal reduced serum total cholesterol and LDL-cholesterol levels in hypercholesterolemic Thai adults. Hence, oat consumption is a reasonable recommendation for Thai individuals with hyperlipidemia.

Keywords: Lipid profiles, Hypercholesterolemia, Oatmeal

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Cardiovascular disease is the leading cause of mortality and morbidity in Thailand⁽¹⁾. Many factors increase the risk of cardiovascular disease: poor eating behavior, smoking, lack of exercise, hypertension, hyperlipidemia, inflammation, and oxidative stress⁽²⁾. In Thailand, a rapid increase in the prevalence of overweight and obesity, hyperglycemia, and hypercholesterolemia have contributed to the increase in cardiovascular disease in recent years⁽³⁾.

Many countries face high financial costs for medical treatment as a direct result of the increase in the incidence of cardiovascular disease⁽⁴⁾. Hence,

governments in many countries are concerned about the high incidence of cardiovascular disease and undertake research into methods for prevention.

Elevation of total or LDL-cholesterol levels without triglyceride elevation is termed "hypercholesterolemia" and is associated with endothelial cell dysfunction, elevated oxidant stress, and the creation of a strong pro-inflammatory condition^(5,6).

Oats are rich in beta-glucan (37-43%), a soluble dietary fiber, which is the active component of oats responsible for lowering serum cholesterol levels. The consumption of around 3 g/day of beta-glucan may reduce the risk of heart disease, including conditions such as atherosclerosis^(7,8). Some studies have investigated the effect of consuming two portions of whole-grain ready to eat oat cereal daily (3 g/day oat

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beta-glucan) on lipid profiles and waist circumference in overweight and obese adults. LDL-cholesterol levels and waist circumference were significantly reduced in the whole-grain oat cereal group compared to control group. Larger reductions in total cholesterol, LDL-cholesterol, and waist circumference were evident as early as week 4 in the whole-grain oat cereal group⁽⁹⁻¹¹⁾. Other studies have confirmed that consuming approximately 3 g of beta-glucan from oats daily can aid in lowering cholesterol in those with elevated cholesterol levels⁽¹²⁻¹⁴⁾. Based on the totality of published evidence, in 1997 the US Food and Drug Administration (FDA) approved the first food-specific health claim that foods containing whole oat sources of soluble fiber (oats, oat bran, and oat flour) reduce risk of coronary heart disease (CHD)⁽¹⁵⁾.

The challenge, however, is that although many studies have confirmed oat consumption may help lower cholesterol levels, few studies have focused specifically on oat consumption or on comparing oats with rice, which is the main staple food in many Asian countries. No studies have assessed the impact of oat consumption in the Thai population. As oats and oat products are now widely available in Thailand, and cardiovascular disease is a leading health concern, the researchers of this study decided to assess the impact of consuming oatmeal on lipid profiles in hypercholesterolemic adults in Thailand.

Material and Method

Subject selection

Men and women aged between 30 and 60 years with a body mass index (BMI) of 23.0-30.0 kg/m², total cholesterol levels >220 mg/dL, and LDL-cholesterol 130-190 mg/dL were recruited⁽¹⁶⁾. Participants agreed to maintain constant body weight throughout the present study. Exclusion criteria included pregnant or lactating women; history of cardiovascular, hepatic, renal and diabetic diseases; baseline triglycerides >300 mg/dL; relevant food allergies or inability to eat oat meal; use of food supplements or drugs to reduce blood pressure, blood sugar and cholesterol; and being on a weight loss diet or having significant weight loss in the three months prior to the study period. Fifty men and women were screened for participation in the study and 24 were enrolled. The study protocol was approved by the Ethics Committee for Human Research, Faculty of Public Health, Mahidol University (MUPH 2012-026). All subjects signed an informed consent form (ICF) before participation. The research coordinator and

principal investigator witnessed the signing and signed the ICF as witnesses.

Study design

The present study was designed as a randomized, crossover study, with 4-week dietary intervention periods. All subjects were asked to consume their usual diet and avoid consuming oat cereal and vitamin or mineral supplements through a 1-week wash out period before the intervention and throughout the study. The 24 hypercholesterolemic subjects were randomly assigned into two groups with 12 members each.

During the first intervention period, the treatment (oat) group ate 70 g of oatmeal for breakfast and the control (rice) group ate 70 g of rice porridge daily for four weeks. Participants were asked to consume two regular meals in addition to an oat or rice based meal for breakfast daily. They were asked to maintain their routine lifestyle including dietary intake, physical activity, and exercise.

After the first intervention period, subjects were switched to the other intervention for an additional four weeks. Subjects who consumed oatmeal during the first intervention period consumed rice porridge during the second intervention period, while those who consumed rice porridge during the first intervention period consumed oatmeal during the second intervention.

Study product

The experimental meal was instant oatmeal, made with 100% whole grain oatmeal. The control meal was made with instant white rice flakes. Seventy grams of instant oatmeal or instant white rice flakes were mixed with 160 ml of hot water before consumption.

Anthropometric assessment

Weight measurements were taken every Monday and body fat percentage, visceral fat, and waist circumference were recorded before and after each intervention period.

Body weight, body fat, and visceral fat were determined with a body fat analyzer scale Model HBF-356 (Omron) that uses Bioelectrical Impedance (BI)⁽¹⁷⁾. The subject's weight was measured in kilograms and recorded to the nearest 0.1 kilogram. Subjects wore light indoor clothing and removed their shoes during this weighing.

Body mass index (BMI) was calculated by dividing an individual's body weight (in kgs) by the

square of their height (in meters). Height was measured in centimeters, to the nearest 0.1 cm, with the help of a stadiometer. Waist circumference was measured at the umbilicus with a non-stretch anthropometric tape. Subjects' waist circumference was taken three times consecutively, and mean was recorded to the nearest 0.1 cm.

Biochemical analysis

Blood samples were collected before and after each intervention period from all subjects. Samples were obtained after the subjects had fasted for 12 hours overnight. Blood samples of 3-5 ml were collected in lithium-heparin tubes to assess lipid profiles including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C)⁽¹⁸⁾.

Dietary & physical activity assessment

In order to assess food consumption, energy, and macronutrient intake data, all subjects were asked to maintain a three-day dietary record, comprising two weekdays and one weekend day prior to and at the end of each intervention period. Subjects recorded the type and amount of food and beverages they consumed. The subjects estimated food portion sizes by using standard household measures. Food intake records were analyzed by the INMUCAL-Nutrients computer program. Participants also recorded their physical activity levels during the intervention periods.

Statistical analysis

Demographic data of the subjects was described in terms of percentage, mean, and standard deviation.

Anthropometric assessment and biochemical analysis results of subjects in each group were

compared before and after the intervention periods by paired sample t-test, analysis of variance (ANOVA) in case of normally distributed data, and Wilcoxon-signed rank test to determine if the variables were not normally distributed. Three-way analysis ANOVA with repeated measures was used to detect statistically significant differences for all variables and compare among subjects during each intervention period. Statistical significance was defined as \pm standard errors or 95% CI.

Results

Twenty-four hypercholesterolemic adults (2 men, 22 women) ranging in age from 30 to 60 years with a mean age of 51.04 ± 6.87 years participated in the present study.

Half of the subjects were married and had an average income of between 10,000-20,000 baht per month and 45.8% of the subjects had graduated from high school. About 50% of the subjects never exercised and 54.2% were engaged in non-sedentary work. Also, 62.5% had no family history of disease and 87.4% had never consumed alcohol. None of the subjects smoked. Anthropometric measurements of subjects at baseline and during the treatment and control intervention periods are shown in Table 1. No significant differences in body weight, body mass index, body fat percentage, visceral fat, and waist circumference were observed within subjects at baseline, or during the treatment and control periods.

The average energy and macronutrient intake at baseline, and treatment and control intervention periods were calculated from the dietary records shown in Table 2. There was no statistically significant difference in energy, grams of carbohydrate, protein, and fat between each period. On average, dietary composition of macronutrients in each period ranged

Table 1. Anthropometric measurements (Mean \pm SD) of subjects at baseline, and treatment and control intervention periods (n = 24)

Parameter	Period			p-value
	Baseline	Treatment	Control	
Body weight, kg	64.69 \pm 14.42	64.65 \pm 13.96	64.87 \pm 14.28	0.443
Body mass index, kg/m ²	26.78 \pm 5.81	26.77 \pm 5.64	26.86 \pm 5.79	0.381
Body fat percentage	35.13 \pm 5.34	34.85 \pm 5.28	35.19 \pm 5.05	0.891
Visceral fat	10.17 \pm 6.59	10.13 \pm 6.39	10.25 \pm 6.50	0.583
Waist circumference, cm	86.88 \pm 10.82	86.75 \pm 10.77	86.79 \pm 10.74	0.171

Significant at 95%CI

from 61-65% carbohydrate, 13-14% protein, and 21-25% fat. However, a statistically significant difference (p-value = 0.035 and 0.026, respectively) was observed in the percentage of carbohydrate and fat between the periods. During the control intervention period, the percentage of carbohydrate significantly increased and the percentage of fat significantly decreased.

Lipid profiles of subjects at baseline, and during the treatment and control intervention periods are shown in Table 3. Repeated measurements were explored to compare between subjects during each period. During the treatment intervention period, total and LDL-cholesterol decreased significantly after oat consumption, but no significant decrease was observed with rice porridge consumption. Oat consumption reduced total and LDL-cholesterol by 5 to 10% from baseline levels, respectively (Table 4). Mean and percent changes were significantly different from levels after the control intervention period at p<0.05. No significant differences were observed in triglyceride

and HDL-cholesterol levels in either period.

Discussion

The main finding of the present study was that consumption of 70 grams per day of oatmeal containing three grams of beta-glucan for four consecutive weeks reduced significantly both total cholesterol and LDL-cholesterols by 5.45% (p<0.01) and 10.40% (p<0.01), respectively; mean and percent changes were significantly different from levels following the control intervention period (p<0.05). The present study also determined that oat consumption did not affect HDL-cholesterol and triglyceride levels. These results are similar to the results observed in meta-analyses conducted by Brown et al in 1999 and 2007⁽¹⁹⁾.

In 1999, Brown et al produced a meta-analysis of the cholesterol-reducing effects of several soluble fibers, including that from oats, and found a significant impact on total and LDL-cholesterol and no effect on HDL-cholesterol or triglyceride concentrations⁽¹²⁾. In

Table 2. Energy and macronutrient intake of subjects at baseline, and treatment and control intervention periods (n = 24)

Energy and nutrients	Period			p-value
	Baseline	Treatment	Control	
Energy				
Kilocalories	1,663.72±320.82	1,699.63±297.58	1,687.98±356.19	0.624
Carbohydrate				
Gram	254.11±40.86	266.74±53.79	269.57±45.71	0.113
Percent	61.64±6.44 ^a	62.79±6.75 ^a	64.74±5.72 ^b	0.035
Protein				
Gram	56.17±14.15	58.11±13.32	58.74±21.35	0.417
Percent	13.55±2.19	13.66±2.04	13.60±2.16	0.912
Fat				
Gram	47.07±18.87	44.76±12.71	42.08±16.02	0.114
Percent	24.81±6.10 ^a	23.56±5.10 ^a	21.66±4.15 ^b	0.026

Different superscripts denote significant difference between groups at 95% CI

Table 3. Lipid profiles (Mean ± SD) of subjects at baseline, and treatment and control intervention periods (n = 24)

Lipid profiles	Period			p-value
	Baseline	Treatment	Control	
Total cholesterol, mg/dL	243.29±24.48 ^a	229.08±23.00 ^b	245.92±29.51 ^a	0.598
Triglyceride, mg/dL	134.08±57.94	159.83±27.95	210.25±67.77	0.227
HDL-cholesterol, mg/dL	58.88±11.26	57.88±12.18	58.58±12.76	0.862
LDL-cholesterol, mg/dL	175.21±24.81 ^a	156.04±23.00 ^b	169.38±31.80 ^a	0.334

Different superscripts denote significant difference between groups at 95% CI

Table 4. Mean and percent changes in lipid profiles of subjects between treatment and control intervention periods (Mean \pm SD) from initial values (n = 24)

Lipid profiles	Period		p-value
	Treatment	Control	
Total cholesterol, mg/dL			
Mean change	-14.21 \pm 23.68	2.63 \pm 23.62	0.004
Percent change	-5.45 \pm 8.82	1.28 \pm 9.29	0.003
Triglyceride, mg/dL			
Mean change	25.75 \pm 98.97	76.17 \pm 296.69	0.574 ⁺
Percent change	16.99 \pm 50.62	39.73 \pm 109.11	0.503 ⁺
HDL-cholesterol, mg/dL			
Mean change	-1.00 \pm 7.82	-2.92 \pm 8.07	0.705
Percent change	-1.21 \pm 13.17	-0.34 \pm 13.41	0.773
LDL-cholesterol, mg/dL			
Mean change	-19.17 \pm 21.74	-5.83 \pm 28.30	0.016 ⁺
Percent change	-10.40 \pm 11.01	-2.89 \pm 15.37	0.008

Significant at 95% CI (paired samples t-test)

⁺ Wilcoxon signed ranks test

2007, data from eight oat studies were pooled in a meta-analysis and a significant effect of oat consumption on lowering total cholesterol ($p = 0.0005$) and LDL-cholesterol concentrations ($p = 0.0008$) was observed. The LDL-cholesterol value equated to a mean percentage reduction (95% confidence interval) from baseline of -4.9% (-7.6% to -2.4%). HDL-cholesterol and triglyceride concentrations were measured in an additional six studies and the weighted treatment differences in the meta-analysis were not significant ($p = 0.95$ for HDL-cholesterol, $p = 0.83$ for triglyceride)⁽²⁰⁻²³⁾.

Anthropometric assessment including body weight, body mass index, body fat percentage, visceral fat, and waist circumference of subjects were not significantly different throughout the intervention periods. Subjects were asked to control their regular meals and physical activity to maintain current weight status. Likewise, the energy and nutrient intake were not statistically, significantly different, with the exception of percentage of carbohydrate, which significantly increased during the control period because subjects did not to reduce their standard rice intake.

A 5% reduction in LDL-cholesterol is significant, as it could reduce CHD risk from 5% to 15%; every 1% reduction in LDL-cholesterol is associated with a decreased risk for CHD of 1% to 3%⁽²⁴⁻²⁸⁾. These results are important for the population

of Thailand, as the study demonstrated a cholesterol lowering impact in the Thai population. Cardiovascular disease (CVD) is the leading cause of mortality and morbidity in Thailand⁽¹⁾, and a rapid increase in the prevalence of hypercholesterolemia has been observed in Thailand in recent years⁽³⁾.

In addition, white rice is the most popular staple food in Thailand and the present study highlighted that white rice porridge did not significantly lower total and LDL-cholesterol levels. This indicates that educating the general population about the advantages of consuming oat porridge versus rice porridge should be considered in the hypercholesterolemic adult, especially with the prevalence of CVD increasing in the population.

The mechanism by which oats reduce cholesterol is unknown, but ample evidence points to role of the viscous soluble fiber beta-glucan in oats binding with and increasing bile acid excretion. This increases bile acid synthesis and hence reduces circulating concentrations of cholesterol⁽²⁹⁻³²⁾. It is also important to note that other components in oats can contribute to the cholesterol-lowering effect. Liu et al found that avenanthramide extract reduced plasma levels of total cholesterol, LDL-cholesterol, and triglycerides in humans⁽³³⁾.

A minimum dose of 3 g of oat beta-glucan daily is recommended for a beneficial reduction in blood cholesterol levels and, subsequently, a decrease in the

risk of coronary heart disease (CHD)⁽¹⁵⁾. This level of beta-glucan can be found in approximately 70 g of oats, which is the level that was used in the present study.

Potential conflicts of interest

None.

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ผลของการบริโภคข้าวโอ๊ตต่อระดับไขมันในเลือดในผู้ที่มีภาวะคอเลสเตอรอลในเลือดสูง

พิมลพรรณ ทองอุ่น, พัชรานี ภวัตกุล, เอกราช บำรุงพีชน, ปราณนา สติชัยวิภาวี, Yashna Harjani, Anne Kurilich

ภูมิหลัง: ภาวะคอเลสเตอรอลสูงเป็นปัจจัยเสี่ยงที่สำคัญของการเกิดโรคหัวใจและหลอดเลือด ซึ่งมีรายงานพบว่าเบต้ากลูแคนในข้าวโอ๊ตสามารถลดระดับคอเลสเตอรอลในเลือดได้ แต่ยังไม่มีการศึกษาผลของการกินข้าวโอ๊ตในคนไทย

วัตถุประสงค์: เพื่อศึกษาผลของการบริโภคข้าวโอ๊ตต่อระดับไขมันในเลือดของคนไทยที่มีภาวะคอเลสเตอรอลในเลือดสูง

วัสดุและวิธีการ: การศึกษานี้มีรูปแบบการศึกษาแบบไขว้กัน โดยคัดเลือกผู้ที่มีภาวะคอเลสเตอรอลสูง 24 ราย เพศชายและเพศหญิงที่มีอายุระหว่าง 30-60 ปี และมีการแบ่งกลุ่มเป็น 2 กลุ่ม กลุ่มละ 12 ราย โดยการสุ่มแบบง่าย กลุ่มที่ 1 บริโภคข้าวโอ๊ต 70 กรัม (เบต้ากลูแคน 3 กรัม) ทุกวัน 4 สัปดาห์ก่อน หลังจากนั้นสลับมาบริโภคโจ๊กข้าว 70 กรัม ทุกวันเป็นเวลา 4 สัปดาห์ กลุ่มที่ 2 บริโภคโจ๊กข้าวก่อน หลังจากนั้นบริโภคข้าวโอ๊ต ก่อนและหลังการศึกษาแต่ละช่วงผู้เข้าร่วมงานศึกษาจะถูกวัดระดับไขมันในเลือดรวมถึงระดับคอเลสเตอรอลรวม ไตรกลีเซอไรด์ ไลโปโปรตีนชนิดความหนาแน่นสูงและไลโปโปรตีนชนิดความหนาแน่นต่ำ

ผลการศึกษา: หลังจากการบริโภคข้าวโอ๊ตพบว่า ระดับคอเลสเตอรอลรวมและไลโปโปรตีนชนิดความหนาแน่นต่ำลดลงอย่างมีนัยสำคัญเมื่อเปรียบเทียบกับก่อนเข้าการศึกษาและช่วงที่บริโภคโจ๊กข้าว การบริโภคข้าวโอ๊ตช่วยลดระดับคอเลสเตอรอลรวมและไลโปโปรตีนชนิดความหนาแน่นต่ำร้อยละ 5 และ ร้อยละ 10 ตามลำดับจากก่อนการศึกษา ซึ่งค่าเฉลี่ยและร้อยละการเปลี่ยนแปลงมีความแตกต่างกันอย่างมีนัยสำคัญเมื่อเปรียบเทียบกับช่วงที่บริโภคโจ๊กข้าว ($p < 0.05$)

สรุป: ข้าวโอ๊ตช่วยลดระดับคอเลสเตอรอลรวมและไลโปโปรตีนชนิดความหนาแน่นต่ำในผู้ที่มีภาวะคอเลสเตอรอลสูง ซึ่งประโยชน์นี้อาจจะนำมาใช้แนะนำในการบริโภคเพื่อลดระดับไขมันในเลือดในผู้ป่วยที่มีภาวะคอเลสเตอรอลสูง
