A Scientific Review of the Health Benefits of Oats

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Summary: *EXISTING DOCUMENTATION—the cardiovascular benefit of oat consumption from its hypocholesterolemic effects. In 1997, the US FDA approved the use of a health claim for oats and coronary heart disease. The 3 grams/day of oat beta-glucan needed to lower blood total and low-density lipoprotein (LDL) cholesterol can be obtained by eating 1-1/2 cups of cooked Quaker oatmeal (3/4 cup of uncooked Quaker oatmeal) or 3 packets of Quaker instant oatmeal.*

EMERGING DOCUMENTATION—a number of observational and human studies indicate that oats can impact such heart disease risk factors as diabetes, obesity and hypertension, and may also exert direct vasoprotective effects. Efforts should be made to increase consumer awareness of oats and its multiple health benefits, and to encourage frequent consumption of oats.

OVERVIEW

CHD in the United States

Coronary heart disease (CHD) is the leading cause of mortality and morbidity in the United States, accounting for more than 450,000 deaths, or 20% of all deaths in 1998. In 2001, an estimated 1,100,000 Americans will have a new or recurrent heart attack, incurring health care and lost productivity costs that exceed $100 billion dollars.[1]

Diet Impacts 4 of 7 risk factors

Based on the most recent update from the National Cholesterol Education Program (NCEP), elevated levels of LDL cholesterol (≥160 mg/dL, depending on the number of other risk factors present) are a major cause of CHD[2]. Four of these seven factors, dyslipidemia, high blood pressure, diabetes, and obesity, are appropriate targets for dietary intervention.[3]

Results from a number of observational and clinical trials provide evidence that modifications in the diet can exert beneficial effects on common medical conditions. Guidelines from the NCEP and the American Heart Association (AHA) suggest a diet with adequate intake of minerals, vitamins, complex carbohydrates and fiber, and reductions in:[4,5]

- Fat (≤30%; one-third from saturated, monounsaturated, and polyunsaturated fatty acids)
- Cholesterol (≤300 mg/d)
- Sodium
- Refined sugars

Therapeutic lifestyle changes recommended by the NCEP indicate that dietary fat levels may range from 25-35%, provided that the intake of saturated fat is kept low (<7% of total calories).[2] An increased intake of viscous soluble fiber (10-25 g/d) and plant stanols/sterols (2g/d) is also recommended for the reduction of LDL cholesterol levels.[2]

Whole Grains Lower CHD Risk

U.S. dietary guidelines recommend eating several servings of whole grains and 25-30 g/d of dietary fiber.

- Based on a meta-analysis of 12 epidemiological studies, individuals who consumed 2.7-3.0 servings per day of whole grain fiber had a 26% reduced risk for CHD relative to non-consumers.[6]
- According to results from CARDIA (Coronary Artery Risk Development in Young Adults)—a 10-year prospective study in young adults—fiber intake was a better predictor of cardiovascular health than total or saturated fat consumption.[7]
- Data from two large separate studies involving 68,782 women[8] and 43,757 men[9] demonstrated that cereal fiber was strongly associated with a reduced risk for CHD.

There is also evidence that soluble fiber intake, in particular, is inversely related to CHD.[10,11] Oats, a whole grain food, is one of the richest dietary sources of the soluble fiber beta-glucan and has been associated with a reduced risk for CHD.[8,12]

Why oats differ from other grains

Oats provide one of the richest sources of the dietary soluble fiber beta-glucan, providing 5.0 g (oatmeal) to 7.2 g (oat bran) per 100 g serving.[13] Both are also valuable sources of total dietary fiber, which ranges from 9.9-14.9 g per 100 g serving.

Oats also contain more lipids (5-9%) than other cereal crops and are rich in unsaturated fats, including the essential fatty acid linoleic acid.[14] Oats contain unique antioxidants, called avenanthramides, as well as the vitamin E-like compounds, tocotrienols and tocopherols.[14]

The hypocholesterolemic effects of oats are well documented in over 50 clinical studies. However, oats also exert cardiovascular benefits that go beyond its cholesterol-reducing properties. Details follows on the

impact of oats on four key CHD risk factors:

- Blood cholesterol
- Diabetes
- Hypertension
- Obesity

BLOOD CHOLESTEROL AND OATS

Based on epidemiological, animal, genetic and physiologic evidence, elevated serum total cholesterol and low density lipoprotein (LDL)-cholesterol levels are associated with an increased risk for CHD.[15,16]

LDL-cholesterol, which contains the highest concentration of cholesterol, damages blood vessels because of its tendency to infiltrate and accumulate within arterial walls. LDL-cholesterol, and especially small, dense LDL-cholesterol, is also more susceptible to structural modifications including oxidation and glycosylation, which play major roles in the development of atherosclerosis.[15] High concentrations of serum high density lipoprotein (HDL)-cholesterol are protective against CHD, since HDL may scavenge and remove excess cholesterol in the arterial wall and also protect LDL against oxidation.[15]

Reducing cholesterol with oats

The hypocholesterolemic properties of oats were first demonstrated in 1963,[17] followed by at least 50 studies in humans evaluating the effects of oats on blood lipids (see Table I).

Oats were significantly hypocholesterolemic, lowering total and LDL-cholesterol by 2 to 23%. These results were obtained by providing 35-120 g of oats per day in the form of oat bran, oatmeal, or oat gum to both normocholesterolemic and hypercholesterolemic men and women aged 20-70 years, with the hypocholesterolemic efficacy being greater in subjects with higher baseline blood cholesterol levels.

Oats are consistently hypocholesterolemic, regardless of whether they are incorporated into an *ad libitum* diet or an energy- and fat-restricted diet. Oats do not reduce cholesterol by displacing fat and cholesterol intake,[18] and were shown to reduce blood cholesterol levels even when a baseline diet low in fat is consumed.[19] In most of the studies presented, oats reduced LDL-cholesterol concentrations without affecting HDL-cholesterol levels. In several studies, however, oats further improved lipid profiles by significantly increasing blood concentrations of HDL-cholesterol as well as apolipoprotein A-I, a major component of HDL.[20,21]

FDA recognition

The lipid lowering effects of oats were recognized by the US Food and Drug Administration in 1997 after an extensive review of 42 clinical trials. This first food-specific health claim states that ***"Soluble fiber from foods such as oat bran, rolled oats or oatmeal, and whole oat flour, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease"***. The recommended intake for a cholesterol-lowering effect is 3 g of oat beta-glucan per day.[22] Based on a meta-analysis of 20 human trials, three 28g-servings of oatmeal per day, providing a daily total of 3 g of beta-glucan, reduces total cholesterol by an average of 6 mg/dL.[18] Although these changes may seem small in comparison to those achieved with drug therapy, a 1% reduction in blood cholesterol can reduce CHD risk by 2-4%.[15,23]

Mode of action

A number of studies indicate that beta-glucan is the major active cholesterol-reducing component of oats. When beta-glucans are fed in a dose-dependent manner, significantly greater reductions in blood cholesterol are observed as beta-glucan content increases.[24] Furthermore, treatment of oats with enzymes that destroy beta-glucan results in a loss of cholesterol-lowering potential of oats.[25] Oats lowers blood cholesterol levels via the formation of a viscous gel by the oat soluble fiber. This binds bile acids and increases their excretion within the feces.[26,27] The production of more bile acids from cholesterol of endogenous origin or the circulation is thus stimulated, reducing circulating blood cholesterol.

There may be additional ways in which oats lower cholesterol beyond binding and removal of cholesterol-rich bile acids. Bacterial fermentation of the beta-glucans increases the release of short chain fatty acids, which may inhibit cholesterol biosynthesis.[13] Soluble fiber may also delay gastric emptying and reduce post-prandial insulin concentrations, which also inhibits cholesterol biosynthesis.[28] And there has been some indication that oat soluble fiber may reduce the intestinal absorption of cholesterol.[25]

DIABETES AND OATS

The primary metabolic abnormalities associated with non-insulin dependent diabetes mellitus include chronically elevated levels of blood glucose and insulin, both of which contribute to increased CHD risk through indirect and direct mechanisms. In addition to its association with other CHD risk factors such as obesity, hypertension, and dyslipidemia, elevated blood levels of glucose and insulin also:

- Enhance the glycosylation and subsequent oxidation of LDL, both of which increase LDL atherogenicity.[29,30,15]
- Interfere with nitric oxide-mediated arterial vasodilation.[31]
- Exacerbate dyslipidemia by increasing the hepatic secretion of coagulating factors as well as very low-density lipoproteins (VLDL), the precursor to the atherogenic LDL.[15]

To optimize glucose utilization and enhance insulin sensitivity, the American Diabetes Association recom-

mends a low-saturated fat, low-cholesterol diet rich in complex carbohydrates with 20-35 g/day of fiber.[32] The consumption of a high carbohydrate diet high in fiber may reduce insulin doses needed by diabetic patients.[33]

Evidence from a 10-year prospective study demonstrated that whole grain foods yielded a protective effect against diabetes in women. Analysis of individual whole grain foods showed that oats consumption alone also reduced the risk for diabetes onset.[34]

Oats improves postprandial glucose and insulin responses

Soluble fiber from oats, when incorporated into a low-glycemic diet, can improve postprandial glycemic and insulinemic responses in both non-insulin-dependent diabetes mellitus and healthy subjects.[35,36] More than 12 published studies report that oats, consumed as oat bran, oatmeal, or isolated beta-glucans, reduce both fasting and postprandial blood glucose and insulin levels.

Wursch and Pi-Suyner calculated that meals containing 8-10% (6-8.4g) beta-glucan reduce postprandial glycemic responses by as much as 50%.[37] These observed reductions in postprandial blood insulin and glucose concentrations have been reported for up to 8 hours postprandially.[38]

Oats may also improve fasting levels of blood glucose and insulin. Obese subjects who included oat soup into their daily meals for 23 weeks reduced their fasting blood glucose and insulin concentrations by 4% and 20%, respectively.[39]

Mode of action

Approximately 79-96% of the beneficial changes in postprandial glucose and insulin are attributable to the viscous soluble fiber in oats, beta-glucan.[40] When non-insulin dependent diabetic subjects were fed meals containing oat bran cereal with a beta-glucan content ranging from 4.0-8.4 g, an inverse relationship between the beta-glucan content and postprandial elevations in blood glucose and insulin was observed.[41] Conditions (chemical or enzymatic treatment) which eliminate the viscosity of beta-glucan reduce the capacity of beta-glucans to affect blood glucose and insulin levels.[36,40]

Although there is preliminary evidence suggesting that the soluble fiber in oats improves glycemic control, the mechanisms of action remain undefined. Results from animal and human studies show that the ingested gel-forming beta-glucans form a barrier to the digestion and absorption of nutrients, resulting in a decreased rate of glucose absorption and attenuated blood glucose and insulin responses.[40] The fermentation of soluble fiber and production of short chain fatty acids may also affect carbohydrate and lipid metabolism.[42] Soluble dietary fiber from oats may also affect levels of certain gut hormones that indirectly modify insulin secretion processes and improve insulin binding at the receptor site.

BLOOD PRESSURE AND OATS

High blood pressure (BP) is defined as having a systolic BP greater than 140 mm Hg or a diastolic BP greater than 90 mm Hg.[43] Due to the increasing internal pressure on the artery, hypertension contributes to endothelial injury and increases CHD risk by enhancing the infiltration of LDL particles.[15,29] Hypertension also accelerates the transformation of fatty streaks into fibrous plaques by enhancing smooth muscle proliferation.[15]

Oats may help maintain healthy blood pressure

The DASH (Dietary Approaches to Stop Hypertension) study demonstrated that a diet high in whole grains, fruit, vegetables and low fat dairy, and restricted in fat, lowers BP in hypertensive individuals.[44] Dietary consumption of oats is consistent with the DASH recommendations, and may confer a benefit due to its fiber content.

Accumulating evidence from epidemiological, clinical, and animal studies suggests that fiber sources, including oats, can significantly aid in reducing blood pressure and/or prevent the onset of hypertension. In two large epidemiological studies, individuals who consumed 6-10 g of fiber daily had lower systolic (-3 to 5 mm Hg) and diastolic (-2 to 3 mm Hg) blood pressure in comparison to their counterparts who ate 2-4 g of fiber per day.[45,46] Data from a large prospective study showed that fiber intakes of more than 24 g/d were associated with a 57% reduction in risk for the development of hypertension in comparison to those who consumed less than 12 g/d.[47]

Soluble fiber may be more effective

Results from animal, clinical, and epidemiological studies suggest that soluble fibers in particular are more effective in lowering blood pressure. Oat bran has been reported to attenuate increases in blood pressure induced in rats with high sucrose diets, while insoluble fiber sources such as cellulose or wheat bran did not.[48,49] An epidemiological study conducted in various regions of Southwest China demonstrated that individuals who reported eating more than 25 g of oats daily had lower systolic blood pressure (5.3 mm Hg) and lower diastolic blood pressure (1.8 mm Hg) than individuals who reported eating less than 25 g oats daily.[50] This association remained significant for the intake of soluble fiber only, and did not reach statistical significance for total dietary fiber.[50]

Oats vs. wheat

Keenan and associates have conducted a pilot clinical trial on 36 subjects in which the anti-hypertensive prop-

erties of oats were examined. Oats effectively reduced systolic and diastolic blood pressure, while wheat based cereals did not. A significant proportion of the patients in the oats group eliminated (50%) or reduced (20%) their need for hypertensive medications.[51]

Mode of action

To date, there are no published studies that examine the mechanisms behind the anti-hypertensive effects of oats. It has been postulated that the viscous soluble fiber in oats yields positive effects on blood pressure by improving glycemic and insulinemic profiles. Although both conditions are generally associated with one another, it remains unclear whether insulin resistance and hyperinsulinemia are causes and/or consequences of hypertension[52].

OBESITY AND OATS

Obesity is an independent risk factor for the development of coronary artery disease and also exacerbates other CHD risk factors such as dyslipidemia, high blood pressure, and elevated blood glucose. Observational studies show that patients who lose weight show an improvement in coronary risk profile.[53]

Maintaining healthy weight with oats

Epidemiological and clinical data suggest that fiber can aid in weight maintenance and/or the prevention of weight gain and subsequent obesity (>30% over ideal body weight). Studies have shown that:

- 5-30 g doses of soluble or insoluble fiber per day can effectively reduce food intake and/or hunger and produce weight losses that last for up to 52 weeks.[54]
- Individuals who ate less than 6 grams dietary fiber/1000 kcal weighed 8 lbs. more than those who consumed more than 11g dietary fiber/1000 kcal—concluded a 10-year prospective study conducted in young adults aged 18-30 years.[7]

In weight loss studies conducted with oats, there are consistent reports of increased satiety.

- In three studies with 182 overweight patients placed on different diets, more weight was lost when oat bran biscuits were incorporated into the daily diet.[55]
- Obese subjects who were placed on a calorie restricted diet that included an oat-based soup as the main meal once or twice daily lost significant amounts of weight after 23 weeks.[39]

In both of these studies, the subjects attributed the successful weight loss to the increased satiety obtained with oats.[55,39] Other papers have confirmed the satiating properties of oats. For example, oats ranked 3rd among 38 different foods based on its satiety rating.[56]

Mode of action

A number of mechanisms as to how fiber aids in weight loss have been proposed. Fiber may impart a textural quality that increases chewing time.[57] Viscous fibers have also been reported to prolong gastric emptying, small bowel transit time, and the digestion and absorption of carbohydrates and fat.[42,58] These actions, which effectively alter glycemic response, have been shown to intensify satiety and aid in the control of energy intake.[59] Meals enriched with beta-glucan elevate plasma levels of cholecystokinin (CCK), a hormone that mediates fat-induced satiety.[60] Fiber may also increase fecal energy excretion.[54]

Protein has also been found to be more satiating than isoenergetic amounts of carbohydrate or fat[61,62], and oats contains the highest protein content of all the common grains.[28]

OTHER HEART-HEALTH BENEFITS

Research on other heart healthy components of oats continues to emerge. Katz et al[62] reported that a single serving of oatmeal could oppose the disturbances in endothelial function observed after the consumption of a high fat meal. These same researchers have hypothesized even greater potential benefits of oat consumption in insulin resistance, and are testing this hypothesis in an on-going trial. It has been hypothesized that the beta-glucan, phytoestrogen, and fat-soluble antioxidant contents in oats play important roles in mediating endothelial responses to foods, which may be an important determinant in CHD risk.[63]

In addition to a high content of both soluble and insoluble fiber, oats contain lignans, a type of phytoestrogen.[64] Although at the present there are no reports on the specific physiological effects of oat lignans, others have demonstrated that lignans and other phytoestrogens may have vasoprotective effects and may reduce the risk for dyslipidemia, hypertension, diabetes, and obesity.[6]

Oats provide a unique blend of antioxidants which include wax alcohol and acid esters; avenanthramides; and oat saponins.[65] These oat extracts have been shown to inhibit the formation of reactive oxygen species *in vitro*, which oxidize and promote the atherogenicity of LDL-cholesterol.[66,65]

Compared to other cereal grains, oats contain a higher fatty acid content, comprised primarily of linoleic, oleic, and palmitic fatty acids. This lipid profile, which contains a higher proportion of polyunsaturated fatty acids (linoleic) and monounsaturated fatty acids (oleic) may also contribute to the hypocholesterolemic and hypotensive effects of oats.[67,68] Oats also possess an amino acid composition (low lysine to arginine ratio) which may also be cardioprotective. Earlier studies[69] have shown that proteins with lower lysine:arginine ratios were hypocholesterolemic in both humans and animals. Results from various *in vitro* and *in vivo* studies indicate that a low lysine:arginine ratio may exert beneficial effects on blood cholesterol concentrations by affecting rates of LDL-cholesterol synthesis and

catabolism.[70,71]

RECOMMENDATION

The cardiovascular benefits of oats consumption extend beyond its well- documented hypocholesterolemic effects. A number of observational and human studies indicate that oats may modify other CHD risk factors such as diabetes and hypertension, and may also exert direct vasoprotective effects.

The consumption of oats as a regular part of the diet should be encouraged. Both long-term and short-term consumer acceptability of oats has been reported.[38,72] For the purposes of reducing blood cholesterol levels, the consumption of the recommended 3 g of beta-glucan on a daily basis is neither unreasonable nor expensive.[73] This amount can be obtained by eating 1-1/2 cups of cooked Quaker Oatmeal (3/4 cup of uncooked Quaker Oatmeal) or 3 packets of Quaker Instant Oatmeal. Oats can also be consumed in forms other than cereal, including meatloaf, shakes, and pasta[74,75] and soup,[39] and thus can be incorporated into any meal.

Emerging research on the benefits of whole grains and antioxidants for heart disease suggests other heart-healthy benefits of oats. Efforts should be made to increase consumer awareness of oats and its multiple cardiovascular benefits, and to encourage habitual consumption of oats.

Acknowledgement:

We gratefully acknowledge the assistance of Dr. Eugenia Sohn and Dr. Cathy Kapica in the preparation of this manuscript.

TABLE I. Clinical Trials Examining Effects of Oat Consumption on Blood Lipids

Reference	*Oat Test Product*	**Daily Intake of Oat Products (g)**	*Number of Subjects*	**Change in total blood cholesterol from baseline (%)**
Hypercholesterolemic Subjects, Usual Diet				
De Groot, 1963[17]	OM-bread	140	21	-11.2;
Kirby et al., 1981[76]	OB-hot cereal, muffins, bread	94	8	-13.0*; LDL: -14.0*
Anderson et al., 1984a[77]	OB-hot cereal & muffins	98	20	-19.3*; LDL: -23.0*
Anderson et al., 1984b[78]	OB-hot cereal & muffins	100	10	-23.0*; LDL: -24.0*; HDL: +9.0
Anderson et al., 1990[79]	OB-RTE cereal	56	12	-5.4*; LDL: -8.5*
Demark-Wahnefried et al., 1990[80]	OB-RTE cereal	50	71	-10.1*
Kahn et al., 1990[81]	OB-muffins	80	16	-7.9*; LDL: -10.0*
Kestin et al., 1990[82]	OB-bread & muffins	95	24	-5.6*; LDL: -3.8*
Anderson et al., 1991[83]	OB-hot cereal & muffins	110	20	-12.8*; LDL: -12.1*
Leadbetter et al., 1991[84]	OB-hot cereal, muffins, bread	30	40	+1.9; LDL: -2.5
	OB-hot cereal, muffins, bread	60		+0.6; LDL: +1.7%
	OB-hot cereal, muffins, bread	90		-1.8; LDL: -4.0
Spiller et al., 1991[85]	Oat fiber in drink	77	13	-6.0*; LDL: -5.9*
Van Horn et al., 1991[86]	OM-instant	56	80	-6.2*; LDL: -9.2*
Bartram et al., 1992[87]	OB-muesli	60	13	-9.7*; LDL: -10.0*
Bridges et al., 1992[88]	OB-hot cereal & muffins	110	20	-12.8*; LDL: -12.1*
Kashtan et al., 1992[89]	OB-hot cereal	88	84	-10.6*; LDL: -12.5*
Saudia et al., 1992[90]	OB	84	20	-1.5
Torronen et al., 1992[91]	OB-bread	75	30	-0.8
Whyte et al., 1992[92]	OB-hot cereal + processed OB	123	23	-4.0*; LDL: -5.5*
Hegsted et al., 1993[93]	OB- baked goods	100	11	-7.0*; LDL: -14.0*
Poulter et al., 1993[94]	OB-RTE cereal	56	59	-2.2*; LDL: -4.6*
Braaten et al., 1994[95]	Oat gum in drink	7.2	21	-9.2*; LDL: -10.0*
Kelley et al., 1994[96]	OB-hot cereal & muffins	100	13	-8.2*; LDL: -9.9*
Pick et al., 1996[38]	OB fiber in bread	18	8	-13.0*; LDL: -23.0*; HDL: +8.0
Romero et al., 1998[75]	OB-cookies	100	30	-22.8*; LDL: -25.8*
Onning et al., 1999[97]	Oat milk	0.75	52	-6.0*; LDL: -10.3*
Lovegrove et al., 2000[98]	OB-supplement	20	62	-1.0; LDL: -2.3
O'Brien et al., 1985[99]	OB-hot cereal, recipes	50	45	-29.0
Van Horn et al., 1986[100]	OB	50	208	-7.8*; LDL: NS
	OM	50		-8.3*; LDL: NS
Beling et al., 1991[101]	OB-RTE cereal	56	351	-12.2*; LDL: -15.0*
Bremer et al., 1991[21]	OB-bread	45	12	-4.1; LDL:-5.4; HDL: +10.3*

HDL – high density cholesterol; OB – oat bran; OM – oatmeal; RTE – ready-to-eat; TC – total cholesterol *$p < 0.05$

TABLE I. Clinical Trials Examining Effects of Oat Consumption on Blood Lipids
(Continued)

Reference	*Oat Test Product*	**Daily Intake of Oat Products (g)**	*Number of Subjects*	**Change in total blood cholesterol from baseline (%)**
Hypercholesterolemic Subjects, Low Fat Diet				
Davidson et al., 1991[102]	OM-hot cereal, muffins, shake	28	156	-3.9; LDL: -5.8
	OM-hot cereal, muffins, shake	56		-2.7; LDL: -3.5
	OM-hot cereal, muffins, shake	84		-7.1*; LDL: -10.1*
	OB-hot cereal, muffins, shake	28		-2.7; LDL: -4.7
	OB-hot cereal, muffins, shake	56		-9.5*; LDL: -15.9*
	OB-hot cereal, muffins, shake	84		-6.9*; LDL: -11.5*
Keenan et al., 1991[103]	OB-RTE cereal	56	145	-2.2*; LDL: -3.9*
Lepre et al., 1992[104]	OB-muffins	60	37	-2.2; LDL: -3.1
Mackay and Ball, 1992[105]	OB-recipes	55	39	-0.0; HDL: +10*
Stewart et al., 1992[106]	OB-bread, recipes, RTE cereal	52	24	-0.9
Uusitupa et al., 1992[107]	OB + BG-hot cereal, drinks, dessert	50	36	-1.99; LDL: -3.3
Winblad et al., 1995[108]	OB-supplements	70	59	-6.2*; LDL: -9.5*
Behall et al., 1997[24]	Oat gum-recipes	2.1	23	-9.5*; LDL: -14.8*
		8.7		-14.6*; LDL: -20.8*
Gerhardt and Gallo, 1998[109]	OB-recipes	84	44	-14.0*; LDL: -17.1*
Normocholesterolemic Subjects, Low Fat Diet				
Van Horn et al., 1988[19]	OM-hot cereal & recipes	56	236	-9.3*; LDL: -14.9*
Zhang et al., 1992[110]	OB-bread	118	9	-9.0*; LDL: -12.0*
Rytter et al., 1996[39]	Oat soup	N/A	31	-8.9*; HDL:+15.3*
Gormley et al., 1978[111]	OM-hot cereal	43	68	-2.4
Judd and Truswell, 1981[26]	OM	125	10	-8.0
Gold et al., 1988[112]	OB-muffins	34	72	-5.3*; LDL: -8.7*
O'Kell and Duston, 1988[113]	Oats	40	52	-0.0
Swain et al., 1990[114]	OB-muffins & entrees	87	20	-7.5*; LDL: -9.1*
Welch, 1990[115]	OB	90	12	-6.5*
Poulter et al., 1993	OB-RTE cereal	56	59	-2.2*; LDL: -4.5*
Marlett et al., 1994[27]	Oat gum-recipes	6.9	9	-14.1*
Beer et al., 1995[116]	Oat gum-instant whip	9	14	-7.8; HDL:+6.8*
Romero et al., 1998[75]	OB-cookies	3	36	-14.0*; LDL: -26.4*

HDL – high density cholesterol; NA – information not available; OB – oat bran; OM – oatmeal; RTE – ready-to-eat; TC – total cholesterol *$p < 0.05$; NS – nonsignificant reduction, exact values not available.

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