



[IFIC.org](http://www.ific.org) > [Publications](#) > [Fact Sheets](#) > Functional Foods Fact Sheet: Plant Stanols and Sterols

Functional Foods Fact Sheet: Plant Stanols and Sterols

July 2007

Background

Plant sterols and stanols are *phytosterols*—essential components of plant membranes—that resemble the chemical structure of animal cholesterol and carry out similar cellular functions in plants.¹⁻² *Sterols* are present naturally in small quantities in many fruits, vegetables, nuts, seeds, cereals, legumes, vegetable oils, and other plant sources.³⁻⁴ *Stanols* occur in even smaller quantities in many of the same sources.⁴ Cholesterol can be obtained from non-dietary sources through processes in the human body such as liver synthesis and intestinal absorption. Plant sterols and stanols differ from cholesterol in that they can only be obtained through dietary sources.⁵ Including plant sterols/stanols in the diet may lower blood cholesterol levels: a health effect that has been studied for more than 50 years.^{1,5}

Cholesterol, Phytosterols, and Coronary Heart Disease (CHD)

Many public health campaigns have focused on reducing the risk of coronary heart disease (CHD) among Americans by educating them on the role cholesterol plays in the development of CHD. As a result, the word "cholesterol" may quickly be associated with CHD and other heart problems. However, cholesterol—a fat-like substance (lipid)—also has essential functions in the body. It provides structure for cell membranes and is a precursor of bile acids (liver secretions that aid fat absorption) and hormones.⁶

The intestine absorbs cholesterol from dietary and biliary (liver) sources. In a diet containing 300 to 400 mg/day of cholesterol, approximately 200 mg is absorbed and transported to the liver. About 1,000 mg/day of cholesterol is secreted into the bile, 60 percent of which is reabsorbed and the rest is excreted.⁵ Cholesterol is absorbed in the intestine through "mixed micelles:" tiny spherical particles that are needed for cholesterol transport and absorption through the intestinal wall.^{5, 7-8}

The amount of cholesterol absorbed and type that circulates in the body has implications for cardiovascular health. Cholesterol travels in the blood through

"lipoproteins," distinct particles containing both lipids and protein.⁶ These include high-density lipoprotein (HDL) cholesterol and low-density lipoprotein (LDL) cholesterol—sometimes referred to as "good" and "bad" cholesterol, respectively.⁹ Excess cholesterol in the blood—particularly LDL cholesterol—may increase the risk of developing CHD.⁶ High levels of LDL cholesterol may contribute to fatty buildup on artery walls, forming plaque deposits that narrow the arteries. Plaque restricts blood flow and can raise blood pressure. When unstable plaques rupture, they tend to form clots, which may lead to a heart attack or stroke.^{6, 10}

Plant phytosterols may help lower LDL cholesterol levels by blocking its absorption. If enough sterols/stanols are consumed in the diet, they will compete with cholesterol in the digestive tract in the formation of "mixed micelles." This ultimately results in a reduction of the amount of cholesterol that is absorbed in the body and returned to the liver.^{5,7-8} Despite the ability of plant sterols/stanols to block cholesterol absorption, the human intestine poorly absorbs them.⁵ In addition to the "mixed micelle" mechanism, special proteins lining the small intestine called "ATP cassette transporters" also play a role in lowering cholesterol by pumping absorbed plant sterols back into the gut.¹¹

Plant Sterols and Stanols in Food

Plant sterols/stanols may be consumed every day, but the amounts are often not great enough to have significant cholesterol-lowering effects.⁵ The challenge of incorporating larger amounts of plant phytosterols into the diet has been overcome in many countries by fortifying foods with sterols and stanols. This is an important development because CHD is a leading cause of morbidity and mortality worldwide.¹

To make plant sterols and stanols easier to incorporate in foods with relatively higher fat content (e.g., spreads and salad dressings), innovative food processing techniques extract these plant components from vegetable oils then modify their chemical structure to form esters.¹² New food products, with the added benefit of sterol/stanol esters, may provide a more healthful alternative to high-saturated fat, high-cholesterol products such as butter.⁹ Plant sterol/stanol esters have also been incorporated in low-fat foods including bread and cereals, low-fat milk, and low-fat yogurt.^{1,13-14} Fruit juice, such as orange juice containing free or "unesterified" plant sterols, are also available in the US.^{1,15-16} There is minimal difference among the various food sources in terms of their efficacy.¹⁷ Free sterols/stanols can have the same effects on blood cholesterol as esterified forms.¹

Food products and dietary supplements (in softgel form) that contain esterified or free forms of sterols/stanols may qualify for a health claim for reduced CHD risk when consumed as part of a low-fat, low-cholesterol diet.¹⁸⁻¹⁹ The following is an example of a US Food and Drug Administration (FDA)-approved health claim for

plant sterol/stanol esters and reduced risk of heart disease: "Diets low in saturated fat and cholesterol that include at least 1.3 grams of plant sterol esters or 3.4 grams of plant stanol esters, consumed in two meals with other foods, may reduce the risk of heart disease." The FDA allows products to carry the health claim provided that the product also meets the requirements for low saturated fat (one gram or less per serving) and low cholesterol (20 milligrams or less per serving), and contain no more than 13 grams of total fat per serving and per 50 grams.^{4, 20} Although the sample health claim recommends consuming phytosterols with two meals, more recent research suggests that the frequency may not matter: similar LDL cholesterol-lowering effects were achieved when 2.5 grams of plant stanol esters were consumed only at lunch as compared with the same amount divided over three meals.⁷

In its 2006 Diet and Lifestyle Recommendations, the American Heart Association (AHA) stated that individuals should consume plant sterols/stanols daily from a wide variety of foods and beverages—just as they would use cholesterol-lowering medication—in order to maintain LDL cholesterol reductions from these products. The AHA also notes that maximum effects are achieved at sterol/stanol intakes of approximately two grams per day.²¹ This is consistent with the evidence statement made by the National Cholesterol Education Program's Adult Treatment Panel III (ATP III) which says, "daily intakes of two to three grams per day of plant sterol/stanol esters will reduce LDL cholesterol by six to 15 percent."⁶

Phytosterols in Blood Cholesterol Management

People with high blood cholesterol levels (*hypercholesterolemia*) are typically advised by health professionals to consume a diet high in fiber and low in saturated fat and cholesterol. When medically safe, exercise is often encouraged as an adjunct to weight reduction and for its other cardiovascular benefits. Although these measures can reduce blood cholesterol, sometimes they do not go far enough. Other interventions may be needed, including cholesterol-lowering medicines (e.g. statins) and/or the addition of plant sterols/stanols to the diet.

LDL cholesterol still receives the most attention because a wide variety of observational and experimental evidence gathered over several decades suggests that high blood levels of LDL is a strong risk factor for CHD.⁶ For this reason, the following discussion focuses on sterols/stanols and their role in lowering LDL cholesterol levels. While there is growing evidence that HDL cholesterol plays an important role in atherogenesis (plaque formation), it receives consideration after LDL in the overall management of persons at risk for CHD.⁶

Several food products fortified with plant sterols/stanols have demonstrated LDL cholesterol-lowering effects. In a meta-analysis of randomized controlled intervention trials that involved persons with a family history of hypercholesterolemia, consuming spreads fortified with 1.8 to 2.8 grams of sterols/stanols per day over a period of four weeks to three months significantly lowered total cholesterol by seven to 11 percent.²² A randomized, double-blind

clinical trial conducted with mildly hypercholesterolemic individuals demonstrated that consuming sterol-fortified orange juice lowered LDL cholesterol levels by about 12.4 percent over a two-month period.¹⁶ Persons with moderate hypercholesterolemia had lowered their LDL cholesterol levels by five to six percent after consuming sterol-/stanol-fortified yogurt for three weeks.¹⁴ At intakes of 2 to 2.5 grams sterols/stanols per day, other studies have shown a 10 to 14 percent reduction in LDL cholesterol without side effects.^{7,17,23} No additional LDL cholesterol-lowering benefit has been observed at intakes greater than 2.5 grams per day.¹

Patients on statin drug therapy may achieve further reductions in their blood cholesterol levels when consuming a plant sterol-/stanol-rich diet. A 10 to 15 percent reduction in LDL cholesterol levels has been seen in some studies for patients who combined statins with a higher intake of plant sterols.²⁴ Studies show nine to 10 percent reductions in LDL cholesterol levels among patients who were given stanol tablets and stanol ester margarine, respectively.²⁵⁻²⁶ Adding sterols/stanols to the diet appears to be somewhat more effective than doubling the statin dose, which usually produces an additional lowering of LDL cholesterol levels by only five to seven percent.¹ A review suggested that long-term use of sterol-/stanol-containing products resulted in a 20 percent reduction in the incidence of CHD.²⁷

Beyond CHD: Other Potential Health Benefits of Phytosterols

The cholesterol-lowering effects of plant sterols/stanols are not limited to those with hypercholesterolemia or CHD. Healthy persons, people with type II diabetes, and postmenopausal women have also benefited from consuming plant sterols/stanols.²⁸⁻²⁹ Anti-cancer health effects have also been suggested in several studies, namely, the reduced risk of stomach, colon, breast, and prostate cancers.²⁻³ However, the Netherlands Cohort Study on Diet and Cancer, comprised of 120,852 participants, found no association between high plant sterol intakes and lower risk of colorectal cancer.³⁰ More research is needed to help explain how phytosterols influence cell growth and tumor development. In addition, the interaction between plant sterols/stanol and other beneficial food components that have demonstrated protective effects against cancer—such as phytoestrogens, vitamin E, and antioxidants—should be explored.²

The Bottom Line

Foods and beverages supplemented with plant sterols/stanols may reduce cholesterol and are a promising addition to interventions aimed at lowering heart disease risk. Maximum effects are observed at plant sterol/stanol intakes of approximately two to three grams per day. The level of LDL cholesterol reduction ranges between six to 15 percent. A growing body of scientific evidence also suggests other positive health outcomes that include the reduced risk of certain types of cancer.

Examples of Plant Sterols and Stanols

Class/Components	Source*	Potential Benefit
<i>Plant Stanols/Sterols</i>		
Free Stanols/Sterols*	corn, soy, wheat, wood oils, fortified foods and beverages	may reduce risk of CHD
Stanol/Sterol Esters*	fortified table spreads and salad dressings, stanol ester dietary supplements	may reduce risk of CHD

Chart adapted from *International Food Information Council Foundation: Media Guide on Food Safety and Nutrition: 2007-2009.*

*Examples are not an all-inclusive list

References:

- ¹ Katan MB, Grundy SM, Jones P, Law M, Miettinen T, Paoletti R; Stresa Workshop Participants. Efficacy and safety of plant stanols and sterols in the management of blood cholesterol levels. *Mayo Clin Proc.* 2003;78(8):965-78.
- ² Awad AB, Fink CS. Phytosterols as anticancer dietary components: Evidence and mechanism of action. *J Nutr.* 2000;130(9):2127-30.
- ³ Piironen V, Toivo J, Puupponen-Pimia R, Lampi AM. Plant sterols in vegetables, fruits, and berries. *J Sci Food Agric.* 2003;83:330-337.
- ⁴ FDA Authorizes New Coronary Heart Disease Health Claim for Plant Sterol and Plant Stanol Esters. *FDA Talk Paper.* Available at: <http://www.cfsan.fda.gov/~lrd/tpsterol.html>. Accessed October 4, 2006.
- ⁵ Cater NB, Grundy SM. Lowering serum cholesterol with plant sterols and stanols: Historical perspectives. *J Postgrad Med.* 1998;6-14.
- ⁶ National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Final Report. NIH Publication No. 02-5215. September 2002.
- ⁷ Plat J, Mensink RP. Plant stanol and sterol esters in the control of blood cholesterol levels: mechanism and safety aspects. *Am J Cardiol.* 2005;96(1A):15D-22D.

- ⁸ Charest A, Desroches S, Vanstone CA, Jones PJH, Lamarche B. Unesterified plant sterols and stanols do not affect LDL electrophoretic characteristics in hypercholesterolemic subjects. *J Nutr.* 2004;134:592-595.
- ⁹ Lewis C. Health claims that could lower heart disease risk. *FDA Consumer Magazine.* 2000. Available at: http://www.fda.gov/fdac/features/2000/600_claims.html. Accessed October 4, 2006.
- ¹⁰ De Caterina R, Zampolli A, Del Turco S, Madonna R, Massaro M. Nutritional mechanisms that influence cardiovascular disease. *Am J Clin Nutr.* 2006;83 (suppl):421S-426S.
- ¹¹ von Bergmann K, Sudhop T, Lutjohann D. Cholesterol and plant sterol absorption: Recent insights. *Am J Cardiol.* 2005 Jul 4;96(1A):10D-14D. Review.
- ¹² Schweitzer C, Moran K, Timmermann F. Phytosterols: Esterified phytosterols are safe and approved by FDA for a cholesterol-lowering claim in some foods. *Nutra Wrld.* 2002; 40-3.
- ¹³ Pouteau EB, Monnard IE, Piguet-Welsch C, Groux MJA, Sagalowicz L, Berger A. Non-esterified plant sterols solubilized in low fat milks inhibit cholesterol absorption : A stable isotope double-blind crossover study. *Eur J Nutr.* 2003;42 (3):154-64.
- ¹⁴ Noakes M, Clifton PM, Doornbos AM, Trautwein EA. Plant sterol ester-enriched milk and yoghurt effectively reduce serum cholesterol in modestly hypercholesterolemic subjects. *Eur J Nutr.* 2005;44(4):214-22.
- ¹⁵ Devaraj S, Autret BC, Jialal I. Reduced-calorie orange juice beverage with plant sterols lowers C-reactive protein concentrations and improves the lipid profile in human volunteers. *Am J Clin Nutr.* 2006 Oct; 84(4):756-61.
- ¹⁶ Devaraj S, Jialal I, Vega-Lopez S. Plant sterol-fortified orange juice effectively lowers cholesterol levels in mildly hypercholesterolemic healthy individuals. *Arterioscler Thromb Vasc Biol.* 2004 Mar;24(3):e25-8.
- ¹⁷ Bhattacharya S. Therapy and clinical trials: Plant sterols and stanols in management of hypercholesterolemia: where are we now? *Curr Opin Lipidol.* 2006;17(1):98-100.

- ¹⁸ US Federal Register 2000;65:54687-54739
- ¹⁹ FDA Letter Regarding Enforcement Discretion With Respect to Expanded Use of an Interim Final Rule About Sterol/Stanol Esters and Reduced Risk of Coronary Heart Disease. Available at: <http://www.cfsan.fda.gov/~dms/ds-ltr30.html>. Accessed October 4, 2006.
- ²⁰ A Food Labeling Guide—Appendix A: Definition of Nutrient Content Claims. Available at: <http://www.cfsan.fda.gov/~dms/flg-6a.html>. Accessed March 22, 2007.
- ²¹ Lichtenstein AH, Appel LJ, Brands M, Carnethon M, Daniels S, Franch HA, Franklin B, Kris-Etherton P, Harris WS, Howard B, Karanja N, Lefevre M, Rudel L, Sacks F, Van Horn L, Winston M, Wylie-Rosett J. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. *Circulation*. 2006;114:000-000.
- ²² Moriusi KG, Oosthuizen W, Opperman AM. Phytosterols/stanols lower cholesterol concentrations in familial hypercholesterolemic subjects: A systematic review with meta-analysis. *J Am Coll Nutr*. 2006;25(1):41-8.
- ²³ Nauman E, Plat J, Mensink RP. Changes in serum concentrations of noncholesterol sterols and lipoproteins in healthy subjects do not depend on the ratio of plant sterols to stanols in the diet. *J Nutr*. 2003;133(9):2741-7.
- ²⁴ Neil HAW, Meijer GW, Roe LS. Randomised controlled trial of use by hypercholesterolaemic patients of a vegetable oil sterol-enriched fat spread. *Atherosclerosis*. 2001;156(2):329-37.
- ²⁵ Goldberg AC, Ostlund RE Jr, Bateman JH, Schimmoeller L, McPherson TB, Spilburg CA. Effect of plant stanol tablets on low-density lipoprotein cholesterol lowering in patients on statin drugs. *Am J Cardiol*. 2006;1:97(3):376-9.
- ²⁶ Blair SN, Capuzzi DM, Gottlieb SO, Nguyen T, Morgan JM, Cater NB. Incremental reduction of serum total cholesterol and low-density lipoprotein cholesterol with the addition of plant stanol ester-containing spread to statin therapy. *Am J Cardiol*. 2000;86:46-52.
- ²⁷ Miettinen TA, Gylling H. Plant stanol and sterol esters in prevention of cardiovascular diseases: A review. *Int J Clin Pharmacol Ther*. 2006;44(6):247-50.

²⁸ Lau VWY, Journoud M, Jones PJH. Plant sterols are efficacious in lowering plasma LDL and non-HDL cholesterol in hypercholesterolemic type 2 diabetic and nondiabetic persons. *Am J Clin Nutr.* 2005;81(6):1351-8.

²⁹ Cater NB, Garcia-Garcia AB, Vega GL, Grundy SM. Responsiveness of plasma lipids and lipoproteins to plant stanol esters. *Am J Cardiol.* 2005;4:96(1A):23D-28D.

³⁰ Normen AL, Brants HAM, Voorrips LE, Andersson HA, van den Brandt PA, Goldbohm RA. Plant sterol intakes and colorectal cancer risk in the Netherlands Cohort Study on Diet and Cancer. *Am J Clin Nutr.* 2001;74(1):141-8.

Source: <http://ific.org> © 2009 International Food Information Council Foundation