

Phytosterols and Stanols

Complementing a healthy diet



Natural plant sterols can effectively lower blood cholesterol¹, enhance the immune system and decrease the risk of certain cancers² – proven by 50 years of research.

Plant sterols or phytosterols and esters are natural, fat-like compounds structurally similar to cholesterol. Plant sterols can be commonly found in vegetables, fruits, legumes, unrefined vegetable oils (i.e. safflower, sunflower, corn, soy, olive, canola) and tall oil – a by-product of the coniferous wood pulp industry.

Over 40 plant sterols have been identified with β -sitosterol, stigmasterol and campesterol being the most abundant. These sterols are usually present as free sterols or fatty acid esters. Plant stanols are saturated sterols (no double bonds in the chemical structure) and are less abundant in nature than sterols. Stanols are more resistant to oxidation, but are as effective as sterols in reducing cholesterol absorption.

Health Benefits

Plant sterols differ from cholesterol in the presence of a methyl or ethyl group in the side chain. This difference enables plant sterols and stanols to be absorbed minimally or not at all by the intestines. Most of the ingested plant sterols pass through the gut and are excreted.³

Cholesterol, the predominant sterol in animals is produced by the human body and obtained through diet. The human body requires cholesterol, as it is a precursor for steroid hormones like testosterone and estrogen⁴ and bile acids, and serves as a stabilizer for cell membranes.

Phytosterols compete with cholesterol absorption and uptake in the small intestine⁵ thereby reducing the supply of cholesterol in the blood stream. Since high blood total cholesterol and low-density lipoprotein (LDL) cholesterol levels are the main risk factors for coronary heart disease⁶ (CHD) and other diseases related to atherosclerosis, reducing cholesterol levels reduces the risk of CHD. Phytosterols have no effect on the levels of triacylglycerol or HDL cholesterol.⁵

Food containing sterols and stanols complement a healthy diet low in saturated fat and cholesterol and high in fruits, vegetables and whole grains. Studies show daily intake of 2-3 g sterols⁷ and stanols lowers

LDL levels by 10% and likely lowers CHD risk by 12-20% in the first 5 years and by 20% over a lifetime.⁸ By combining phytosterols with other functional ingredients like soy protein and viscous fibres in a low saturated fat diet, cholesterol levels can be reduced up to 35%.⁹ Studies also demonstrate plant sterols provide safe additional cholesterol lowering effect with statins.⁷ In some, cases the addition of phytosterols to statin therapy lowered LDL cholesterol equivalent to doubling the dose of statin.¹⁰

Daily intake of 2-3 g sterols and stanols can lower coronary heart disease risk by 20% over a lifetime.

Based upon results of clinical studies, plant sterols appear to be safe^{8,11,12} and non-toxic.^{13,14} No effect has been found on the reproductive system.^{15,16} The U.S. Food and Drug Administration (FDA) granted Generally Recognized As Safe (GRAS) status for plant sterols/stanols, and the European Union Scientific Committee on Foods has concluded phytosterol esters margarines and dairy products are safe for human consumption.¹⁷

The FDA has approved a health claim that foods containing plant sterols/stanols esters may reduce the risk of coronary heart disease¹⁸ by reducing blood cholesterol levels as part of a diet low in saturated fat and cholesterol.

Canadian Research Expertise



- Lipoprotein nutrition, metabolism and coronary heart disease (**M. Moghadasian**)

Richardson Centre for Functional Foods and Nutraceuticals
Canada Research Chair in Nutrition and Functional Foods
Winnipeg, MB

- Dietary factors controlling cholesterol and plant sterol metabolism in humans and in animal models; human dietary fatty acid absorption and oxidation; human energy metabolism (**P. Jones**)

University of British Columbia
Vancouver, BC

- Research studies in dyslipidemias, atherosclerosis, phytosterols in medicine, genetic determinants of response to inflammation and atherosclerosis, and HDL metabolism as well as clinical trial of new lipid lowering medications (**J. Frolich**)

Canadian Centre for Agricultural Research in Health and Medicine (CCARM)
St. Boniface General Hospital
Winnipeg, MB

- Investigating health benefits of functional ingredients on cardiovascular disease and its determinants (**G. Pierce**)

Université Laval
Institute of Nutraceuticals and Functional Foods (INAF)
Quebec, QC

- Nutrition, functional foods and cardiovascular health (**B. Lamarche**)

University of Toronto
Toronto, ON

- Nutrition and metabolism of lipid-lowering ingredients in functional foods (**D. Jenkins, C. Kendall**)

Applications

Phytosterols play a major role in pharmaceuticals for production of therapeutic steroids, in nutrition as anti-cholesterol additives and in cosmetics. The use of foods with high phytosterol content could be an alternative to supplements.

Phytosterols from vegetable oils (i.e. canola, soybean, sunflower, corn) are a by-product in the isolation of tocopherols (vitamin E). They are recovered from deodorizer distillate during oil refining and are purified by crystallization.¹⁹



Tall oil phytosterols are extracted from coniferous woods. Sterols are recovered by solvent extraction, distillation and recrystallization. Tall oil contains significant levels of β -sitosterol, campesterol and naturally occurring saturated (stanol) compounds sitostanol and campestanol. They are also in a free non-esterified form.¹⁷

Esterification of plant sterols and stanols with long chain fatty acids increases solubility in fats and oils facilitating incorporation into foods. This gives sterols and stanols the desired physical characteristics. Free sterols and stanols are poorly soluble in fat or water phases making it difficult to incorporate the free forms into foods. However, microcrystalline, lecithin-solublized forms and sterols dissolved in diacylglycerol appear to work in low-fat foods.²⁰ Research studies have shown the food matrix and emulsification processes affect the efficacy of free sterols and stanols and stress the importance of evaluating new food forms for efficacy if they differ greatly from previously tested forms.²¹

Recent work shows that phytosterols are bioactive in natural food matrices. Proven efficacy of esterified plant sterols in a variety of low fat foods²²⁻²⁵ has prompted multinational food companies to include phytosterols in food formulations.

The hot new trend is to combine phytosterols with other health promoting ingredients to target specific medical conditions:

- Sterols with soy protein and soluble fibre for heart health
- Cocoa flavonols and soy sterol esters for a healthy heart
- Saw palmetto extract, nettles, lycopene, green tea and phytosterols for prostate health



- Plant sterols with calcium, magnesium and potassium (patented Multibene platform) for bone health, blood pressure reduction and reduced serum cholesterol levels
- Plant sterols and vitamin mixtures for improved well being
- Add plant sterol complexes to blends of soy and canola oils or to mixtures of flax oil, pumpkin seed oil, lignans, and phospholipids

Comparison of sterol composition

		Relative content (% w/w of total sterols)			
Sterol	Sitosterol	Wood-derived	72	Vegetable oil-derived	45
	Campesterol		8.2		26.8
	Sigmasterol		0.3		19.3
	Brassicasterol		0		1.6
	Sitostanol		15.3		2.1
	Campestanol		1.6		0.8
	Other minor sterols		2.6		4.4

Phytosterols—Applications and Opportunities

Current Uses	Potential Uses	Novel Forms
Margarines, fat spreads, soft spreadable cheeses, mayonnaise, salad dressings, low fat dairy products, milks, yogurts and cheeses, snack and energy bars, fry oils, breakfast cereals, blended juice/milk smoothie beverages	Baked pastry products, egg noodles and pasta, custard, ice cream, frozen desserts, muesli, bars and soups, meat products, rice beverages, cereal grains and flours, food flavourings and coffees	Encapsulation with egg proteins to increase bioavailability in foods Water soluble powders for inclusion in beverages (orange juice) and non-fat foods

Canadian Suppliers

- **Cognis Canada Ltd.**
Mississauga, ON | www.cognis.com
- **Forbes Medi-Tech Ltd.**
Vancouver, BC | www.forbesmedi.com

The Canadian Advantage in the Global Marketplace

Quality
is in our **nature**

Natural Resources • Canada's abundant natural resources are proven building blocks for a high tech industry that produces an array of high quality agri-food products.

World-Class Standards • Canada's regulatory and food inspection systems are internationally recognized, resulting in world-class standards and products that are safe, nutritious and high quality.

Innovative Research • Canada has developed a strong network of research facilities across the country where scientific innovators are focused on developing leading-edge products and new technologies.

Collaborative Teamwork • Collaboration among governments, health institutions, universities and industry has helped this vibrant sector prosper by encouraging innovation and manufacturing of diverse agri-food products with proven health benefits.

To learn more about Canada's functional food and natural health products industry, visit: www.agr.gc.ca

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