The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
20(3): S.I (3), 776-778, 2025 www.thebioscan.com

Mini review of Phytosterols: Benefits, Mechanisms and Biomedical Applications

E. Santhiya and R. Mahesh

Department of Botany, S. T. Hindu College, Nagercoil– 629002, Kanyakumari District, Tamil Nadu. (Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627 012).

DOI: 10.63001/tbs.2025.v20.i03.S.I(3).pp776-778

KEYWORDS
Phytosterols, Benefits, Biomedical Applications

Received on:
06-07-2025

Accepted on:

05-08-2025

Published on:

09-09-2025

ABSTRACT

Phytosterols, or plant sterols, are natural compounds with a chemical structure similar to cholesterol, enabling them to lower LDL cholesterol by inhibiting its absorption. This systematically examines the science of phytosterols, beginning with an exploration of their chemical structure, side-chain variations, and the specific types, including beta-sitosterol, campesterol, and stigmasterol. The analysis extends to a review of their primary sources, from natural plant-based foods to commercially fortified products and supplements. The document synthesizes current research on the health benefits, particularly the proven reduction of LDL cholesterol by 5-15% with a daily intake of 2 grams. It also addresses potential side effects, such as reduced absorption of fat-soluble vitamins, and concludes by validating phytosterols as a crucial component of a heart-healthy diet.

INTRODUCTION

Phytosterols are integral components of plant cell membranes and contribute to the structure and function of plants. In the human diet, they offer notable health benefits, particularly in managing cholesterol levels and reducing the risk of cardiovascular disease. This chapter delves into the science behind phytosterols, exploring their chemical properties, sources, and the ways in which they positively impact human health(**Moreau *et al.*,,2018**).Phytosterols, also known as plant sterols, are naturally occurring compounds found in a variety of plant-based foods. They share a similar structure with cholesterol and have been shown to have a significant impact on human health, particularly in the context of cardiovascular disease prevention(**Genser *et al.*,, 2012**).In the pursuit of optimal health and well-being, dietary choices play a crucial role. Among the many nutrients and compounds that have garnered attention for their health benefits, phytosterols stand out as a particularly promising group.

Chemical Structure and Types of Phytosterols: Phytosterols, or plant sterols, are a diverse group of naturally occurring compounds found in plant cell membranes. Their chemical structure is similar to that of cholesterol, which is key to their biological activity and health benefits. The chemical structure of phytosterols and explores the overview of the main types and their characteristics.

Chemical Structure: The basic chemical structure of phytosterols consists of a steroid nucleus with a four-ring core structure, which is similar to cholesterol. This core structure is composed of three six-membered rings and one five-membered ring. Phytosterols differ from cholesterol in the following ways:

Side Chain: The primary difference between phytosterols and cholesterol lies in the side chain attached to the steroid nucleus. While cholesterol has a saturated side chain, phytosterols possess different variations in the side chain, which affects their biological activity.

Double Bond: Many phytosterols contain an additional double bond in the ring structure compared to cholesterol, influencing their interactions with cellular membranes.

The similarity in structure between phytosterols and cholesterol allows phytosterols to compete with cholesterol for absorption in the digestive tract, which is crucial for their cholesterol-lowering effects (**Li *et al.*,,2022**).

Types of Phytosterols: There are several types of phytosterols, each with distinct properties and potential health benefits. The most studied and prevalent phytosterols include: **Beta-Sitosterol** the most abundant and well-researched phytosterol. It has a chemical structure similar to cholesterol but with a double bond in the side chain. Beta-sitosterol is known for its cholesterol-lowering effects and is commonly found in vegetable oils, nuts, and seeds. Its benefits extend beyond cholesterol management, including potential anti-inflammatory and immune-modulating effects.

Campesterol is another common phytosterol, characterized by its similar steroid nucleus but with a slightly different side chain structure. It is found in vegetable oils, whole grains, and vegetables. Campesterol has been shown to contribute to lowering LDL cholesterol levels and may also have anti-inflammatory properties.

Stigmasterol is found in a variety of plant sources, including legumes, nuts, and seeds. It differs from beta-sitosterol in its side chain configuration, which affects its interaction with cholesterol absorption. Stigmasterol is believed to have potential cardiovascular benefits and may also influence cholesterol metabolism (**Ogbe *et al.*,, 2015**).

Other Phytosterols: In addition to the primary phytosterols listed above, there are other less common sterols, such as:**Sitostanol**: A hydrogenated form of beta-sitosterol, which may have enhanced cholesterol-lowering effects.

Brassicasterol: Found mainly in cruciferous vegetables, it has been less studied but may contribute to overall phytosterol intake.Each type of phytosterol contributes to the overall

effectiveness of phytosterols in lowering cholesterol levels and promoting health. The diversity in structure and function among these phytosterols allows for a range of beneficial effects when incorporated into the diet (**Ogbe *et al*.,, 2015; Li *et al*.,, 2022**).

Structural Variations and their Implications: The variations in the chemical structure of phytosterols influence their absorption, metabolism, and effectiveness in lowering cholesterol. For example, the presence of a double bond or different side chain structures can affect how well a phytosterol competes with cholesterol for absorption in the intestines. Understanding these structural differences is crucial for optimizing the use of phytosterols in dietary strategies aimed at improving cardiovascular health (**Moreau *et al*.,, 2018**).Phytosterols are a group of plant-derived compounds with a chemical structure similar to cholesterol. The main types-beta-sitosterol, campesterol, stigmasterol, and others-each play a role in cholesterol management and offer various health benefits. Their structural similarities and differences impact their effectiveness and application in health promotion (**Moreau *et al*.,2018**).

Sources of Phytosterols: Phytosterols are naturally occurring compounds found in a wide array of plant-based foods. They are integral components of plant cell membranes and contribute to the nutritional profile of various foods. Understanding the sources of phytosterols can help individuals make dietary choices that enhance their health, particularly in managing cholesterol levels. This section explores the primary sources of phytosterols, including both natural foods and fortified products (**Racette *et al*., 2015**).

Natural Sources of Phytosterols: Phytosterols are present in a variety of plant-based foods, though their concentration can vary. Key sources include:Vegetable oils are among the richest sources of phytosterols. Common oils high in phytosterols include:

Corn Oil: One of the highest sources of phytosterols, especially beta-sitosterol.

Soybean Oil: Contains a significant amount of beta-sitosterol and campesterol.

Canola Oil: Offers a good balance of different phytosterols, including beta-sitosterol and campestral (**Bortolomeazzi *et al*., 2003; Seki *et al*., 2003**).

Nuts and seeds are also excellent sources of phytosterols. The types and concentrations of phytosterols vary among different varieties:

Almonds: Rich in beta-sitosterol and campesterol.

Walnuts: Contain significant amounts of beta-sitosterol.

Sunflower Seeds: High in phytosterols, particularly beta-sitosterol.

Whole grains are a valuable source of phytosterols and contribute to overall dietary intake. Examples include:

Oats: Provide a moderate amount of phytosterols, including beta-sitosterol.

Wheat Germ: High in beta-sitosterol and campesterol.

Barley: Contains a variety of phytosterols, including beta-sitosterol (**Phillips *et al*.,2005; Islam *et al*.,2017**).

Legumes such as beans and lentils offer a good amount of phytosterols:**Lentils**: Contain phytosterols, though in smaller amounts compared to nuts and seeds.

Chickpeas: Provide a source of phytosterols, contributing to a balanced diet(**Ryan *et al*.,2007**).

Fruits and Vegetables: Although fruits and vegetables contain lower concentrations of phytosterols compared to oils and nuts, they still contribute to overall intake. Examples include:

Avocados: Contain phytosterols and are also a rich source of healthy fats.

Spinach: Provides a modest amount of phytosterols, including beta-sitosterol.

Fortified Foods

In addition to natural sources, phytosterols are often added to processed foods to enhance their cholesterol-lowering benefits. Commonly fortified foods include:**Margarines and Spreads:** Phytosterol-enriched margarines and spreads are specifically formulated to provide a concentrated source of phytosterols. These products typically contain added plant sterols to help reduce LDL cholesterol levels effectively.

Dairy Products: Certain dairy products, such as milk and yogurt, are fortified with phytosterols. These fortified dairy products offer an additional way to increase phytosterol intake, especially for individuals who may not consume sufficient amounts through natural food sources.

Breakfast Cereals: Some breakfast cereals are fortified with phytosterols to help consumers achieve their recommended daily intake. These fortified cereals provide a convenient way to include phytosterols in the diet (**Phillips *et al*.,2005; Islam *et al*.,2017**).

Phytosterol supplements are available for those who wish to increase their intake beyond what can be achieved through diet alone. These supplements come in various forms, including capsules and tablets, and are often used in conjunction with dietary strategies to manage cholesterol levels.

Phytosterols are found in a wide range of plant-based foods, with the highest concentrations in vegetable oils, nuts, seeds, and whole grains. Fortified foods and supplements provide additional avenues for increasing phytosterol intake. Incorporating these sources into the diet can help leverage the cholesterol-lowering benefits of phytosterols and contribute to overall health (**Dumolt and Rideout 2017;Ghaedi *et al*.,2020**).

Health Benefits

Cholesterol Reduction: The primary health benefit of phytosterols is their ability to reduce low-density lipoprotein (LDL) cholesterol levels. By competing with cholesterol for absorption in the intestines, phytosterols can lower blood cholesterol levels numerous clinical studies have demonstrated that daily intake of phytosterols can reduce LDL cholesterol in blood levels by approximately 5-15%.

Cardiovascular Health: Long-term consumption of phytosterols has been associated with a reduced risk of cardiovascular disease. They contribute to improved endothelial function and reduced arterial inflammation (**Zawistowski 2010**).

Emerging research suggests potential benefits in areas such as:**Cancer prevention:** Some studies indicate that phytosterols may help reduce the risk of certain types of cancer.

Immune function: Phytosterols might influence immune responses, though more research is needed in this area ((**Ramprasath and Awad, 2015**).

Phytosterols lower cholesterol levels through several mechanisms:**Competitive Inhibition:**Phytosterols compete with dietary cholesterol for absorption in the small intestine, reducing the amount of cholesterol that enters the bloodstream.

Increased Excretion: They may enhance the excretion of cholesterol by promoting its conversion into bile acids (**Zawistowski 2010; Dumoltand Rideout2017**).

Recommended Intake and Guidelines: Health organizations recommend a daily intake of approximately 2 grams of phytosterols to achieve significant cholesterol-lowering effects. This can typically be achieved through a combination of phytosterol-enriched foods and dietary supplements (**Phillips *et al*.,2005; Islam *et al*.,2017**).

Practical Achievability: Achieving the recommended intake through diet alone can be challenging, especially if one's diet lacks a high concentration of phytosterol-rich foods. For those not consuming enough phytosterol-rich foods, fortified products and supplements can help meet daily requirements.

Potential Side Effects and Considerations: While phytosterols are generally safe, excessive intake can lead to potential side effects such as:

Reduced absorption of fat-soluble vitamins: High doses may interfere with the absorption of vitamins A, D, E, and K.

Digestive issues: Some individuals may experience gastrointestinal discomfort (**Ghaedi *et al*.,2020**).

CONCLUSION

Phytosterols are a valuable component of a heart-healthy diet. Their ability to lower LDL cholesterol levels and potentially reduce the risk of cardiovascular disease makes them an important focus for both researchers and healthcare professionals. Incorporating phytosterol-rich foods into the diet

can be a practical strategy for improving overall health and managing cholesterol levels.

REFERENCES

- Bortolomeazzi, R., Cordaro, F., Pizzale, L. and Conte, L.S., 2003. Presence of phytosterol oxides in crude vegetable oils and their fate during refining. Journal of agricultural and food chemistry, 51(8), pp.2394-2401.
- Dumolt, J.H. and Rideout, T.C., 2017. The lipid-lowering effects and associated mechanisms of dietary phytosterol supplementation. Current pharmaceutical design, 23(34), pp.5077-5085.
- Genser, B., Silbernagel, G., De Backer, G., Bruckert, E., Carmena, R., Chapman, M.J., Deanfield, J., Descamps, O.S., Rietzschel, E.R., Dias, K.C. and März, W., 2012. Plant sterols and cardiovascular disease: a systematic review and meta-analysis. European heart journal, 33(4), pp.444-451.
- Ghaedi, E., Foshati, S., Ziaei, R., Beigrezaei, S., Kord-Varkaneh, H., Ghavami, A. and Miraghajani, M., 2020. Effects of phytosterols supplementation on blood pressure: A systematic review and meta-analysis. Clinical Nutrition, 39(9), pp.2702-2710.
- Islam, M.A., Jeong, B.G., Jung, J., Shin, E.C., Choi, S.G. and Chun, J., 2017. Phytosterol determination and method validation for selected nuts and seeds. Food Analytical Methods, 10, pp.3225-3234.
- Li, X., Xin, Y., Mo, Y., Marozik, P., He, T. and Guo, H., 2022. The bioavailability and biological activities of phytosterols as modulators of cholesterol metabolism. Molecules, 27(2), p.523.
- Moreau, R.A., Nystrom, L., Whitaker, B.D., Winkler-Moser, J.K., Baer, D.J., Gebauer, S.K. and Hicks, K.B., 2018. Phytosterols and their derivatives: Structural diversity, distribution, metabolism, analysis, and health-promoting uses. Progress in Lipid Research, 70, pp. 35-61.
- Ogbe, R.J., Ochalefu, D.O., Mafulul, S.G. and Olaniru, O.B., 2015. A review on dietary phytosterols: Their occurrence, metabolism and health benefits. Asian J. Plant Sci. Res, 5(4), pp.10-21.
- Phillips, K.M., Ruggio, D.M. and Ashraf-Khorassani, M., 2005. Phytosterol composition of nuts and seeds commonly consumed in the United States. Journal of agricultural and food chemistry, 53(24), pp.9436-9445.
- Racette, S.B., Lin, X., Ma, L. and Ostlund, Jr, R.E., 2015. Natural dietary phytosterols. Journal of AOAC International, 98(3), pp.679-684.
- Ramprasath, V.R. and Awad, A.B., 2015. Role of phytosterols in cancer prevention and treatment. Journal of AOAC International, 98(3), pp.735-738.
- Ryan, E., Galvin, K., O'Connor, T.P., Maguire, A.R. and O'Brien, N.M., 2007. Phytosterol, squalene, tocopherol content and fatty acid profile of selected seeds, grains, and legumes. Plant Foods for Human Nutrition, 62, pp.85-91.
- Seki, S., Hidaka, I., Kojima, K., Yoshino, H., Aoyama, T., Okazaki, M. and Kondo, K., 2003. Effects of phytosterol ester-enriched vegetable oil on plasma lipoproteins in healthy men. Asia Pacific Journal of Clinical Nutrition, 12(3).
- Zawistowski, J., 2010. Tangible health benefits of phytosterol functional foods. Functional food product development, pp.362-387.