



A Review On Phytosterol (Ps) Enriched Mayonnaise

Baishaki Ghosh¹, Ishita Bhowmik², Sagniki Dey³ Rupali Dhara Mitra^{4*}

^{1,2,3} M.Sc. Student, Department of Food and Nutrition, Swami Vivekananda University, Barrackpore, W. B., India.

^{4*} Assistant Professor, Department of Food and Nutrition, School of Allied Health Sciences, Swami Vivekananda University, Barrackpore, W.B. India.

***Corresponding Author:** Rupali Dhara Mitra

*Assistant Professor, Department of Food and Nutrition, School of Allied Health Sciences, Swami Vivekananda University, Barrackpore, W.B. India. E-Mail: rupalidm@svu.ac.in.

Article History	Abstract
Received: 30/09/2023 Revised: 15/10/2023 Accepted: 30/10/2023	This study focuses on the nutritional significance of phytosterol (PS) enriched mayonnaise in our everyday diets. We have explored various methods for creating PS-enriched mayonnaise and evaluated their sensory characteristics. Phytosterols are natural compounds present in plant-based foods. Sources of phytosterols include unrefined plant lecithin, nuts, legumes, wheat germ, seeds, whole grains, plant-based fruits, and vegetables. Phytosterols share a similar structural composition with cholesterol, but they are not absorbed in substantial amounts by the body. Phytosterols play a vital role in human health, particularly in lowering cholesterol levels. It is recommended that a daily intake of approximately 2 grams of phytosterols (sterols and stanols) can lead to a reduction of approximately 10% in LDL cholesterol levels. This article delves into the preparation of phytosterol-enriched mayonnaise and highlights its nutritional benefits in our daily lives.
CC License CC-BY-NC-SA 4.0	Keywords: Phytosterol, mayonnaise, cholesterol, sensory analysis

Introduction:

The discussion of food emulsions holds great significance in the food industry, with a prominent example being mayonnaise. Mayonnaise serves as a valuable dressing material, enhancing the taste and flavor of various dishes, and it has gained increasing popularity among people nowadays. However, with a growing emphasis on health consciousness, individuals must monitor their cholesterol levels closely. (Matsuoka *et al.*, 2020)

Mayonnaise is an emulsion of oil in water, commonly added to foods to improve their flavor and overall appeal. It has become one of the most widely used sauces or condiments globally in recent times, primarily utilized as a dressing material. Mayonnaise and similar dressings have a long history in human culinary practices, with commercial production dating back to the 1900s and gaining significant popularity in America between 1917 and 1927 (Harrison & Cunningham, 1985). Notably, research has shown a 21% increase in sales in Japan from 1987 to 1990 (Jung *et al.*, 2008).

Mayonnaise primarily consists of egg yolk, vegetable oil, and acetic acid. Both traditional mayonnaise and mayo-type products contain omega-3 and omega-6 fatty acids derived from the oils used in their preparation. Although egg yolk, being a main ingredient, raises concerns regarding its cholesterol content, it remains a crucial component due to its exceptional emulsifying properties. Egg yolk's ability to form a stable emulsion

is highly valued, and it contributes to achieving the desired texture in mayonnaise and similar products. Additionally, egg yolk emulsions have the unique characteristic of flocculating to provide the correct texture, further emphasizing its importance in these formulations. [Jung *et al.*, 2008]

Mayonnaise, due to its egg yolk content, is often avoided by individuals with hypercholesterolemia due to concerns about cholesterol intake. However, it's important to note that mayonnaise can also have a positive impact on cholesterol levels. Research has demonstrated that consuming 2400 mg of plant sterols per day for four consecutive weeks does not lead to changes in serum vitamin A or vitamin E levels. (Matsuoka *et al.*, 2004)

Mayonnaise serves as a valuable source of healthy monounsaturated and polyunsaturated fats, which have the potential to lower cholesterol levels and reduce the risk of cardiovascular diseases. Additionally, mayonnaise contains omega-3 fatty acids, which can help to reduce inflammation in the body, potentially preventing chronic diseases such as cancer and heart diseases.

With this in mind, our plan is to develop low-energy mayonnaise-type dressing materials enriched with functional ingredients like phytosterols to actively lower serum cholesterol levels. Other functional ingredients known for their cholesterol-reducing properties include dietary fiber, chitosan, catechin, soybean proteins, egg white proteins, and phytosterol. Here, we selected phytosterol as functional ingredients as they are effective at lowering the level of cholesterol. Phytosterol is more effective at lower doses other than any other functional ingredients, as well as plant sterol absorption is considerably lower than other cholesterol (Engel *et al.*, 2005) as the phytosterol has high hydrophobicity, phytosterol are absorbed into micelles than cholesterol more readily. They are not available for resorption and excreted with faeces (AbuMweis, 2008).

The cholesterol-lowering mechanism attributed to both free sterols and their fatty acid esters primarily centres on the inhibition of cholesterol absorption in the intestines, as detailed[6]. Phytosterols, given their capacity to reduce serum total cholesterol and LDL cholesterol levels, hold particular significance in the prevention of arteriosclerotic diseases.

Phytosterol are components of plant that have a chemical structure similar to cholesterol. It can be found as free sterols or as their fatty acid esters. The structure of phytosterol and cholesterol are differed from that of an additional alkyl substitute at C-24 and a double bond at C-22. (Brufau *et al.*, 2008).

Phytosterols, which share a chemical structure similar to cholesterol, exist as either free sterols or their fatty acid esters. The key distinction between the structure of phytosterols and cholesterol lies in the presence of an additional alkyl substitute at C-24 and a double bond at C-22 in phytosterols (Trautwein *et al.*, 2003). These structural differences are noteworthy when considering their effects on cholesterol levels and their role in preventing arteriosclerotic diseases.

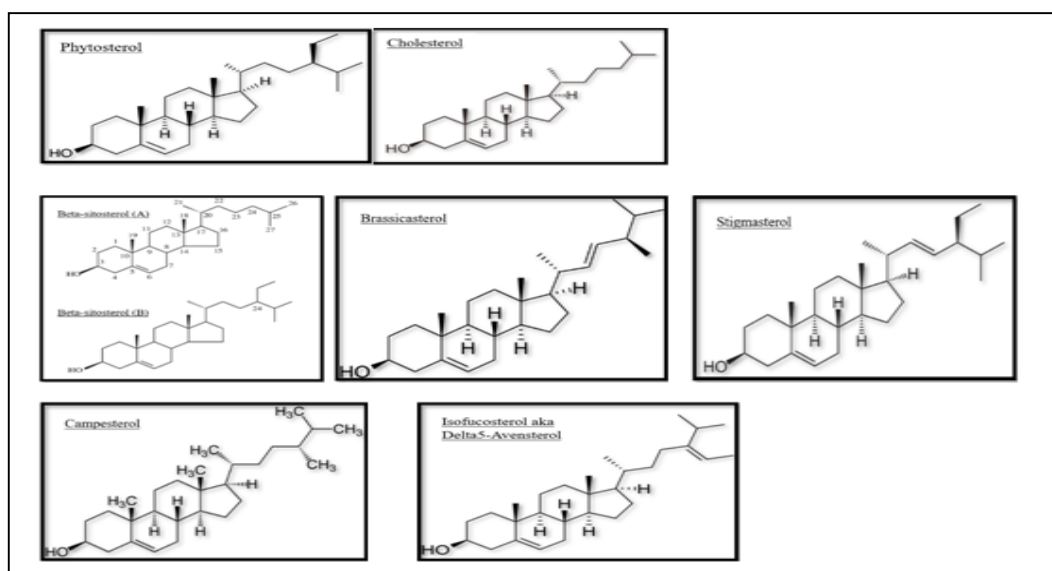


Fig2: Different types of Sterols

Indeed, there are several types of phytosterols found in nature, primarily in seeds. Among these, notable examples of plant sterols include β -sitosterol, campesterol, and stigmasterol. These phytosterols are known for their cholesterol-lowering properties and are valuable.

Absorption of phytosterol:

Indeed, there are several types of phytosterols found in nature, primarily in seeds. Among these, notable examples of plant sterols include β -sitosterol, campesterol, and stigmasterol. These phytosterol was initially introduced as a therapeutic agent for the treatment of hypercholesterolemia, a condition characterized by elevated cholesterol levels in the bloodstream (Ostlund *et al.*, 2007). Phytosterols, in general, work by reducing the absorption of cholesterol, as they are not efficiently absorbed on their own (Delaney *et al.*, 2004). It's worth noting that when phytosterols are consumed orally, they exhibit minimal potential for adverse effects due to their low bioavailability (Feng *et al.*, 2022)

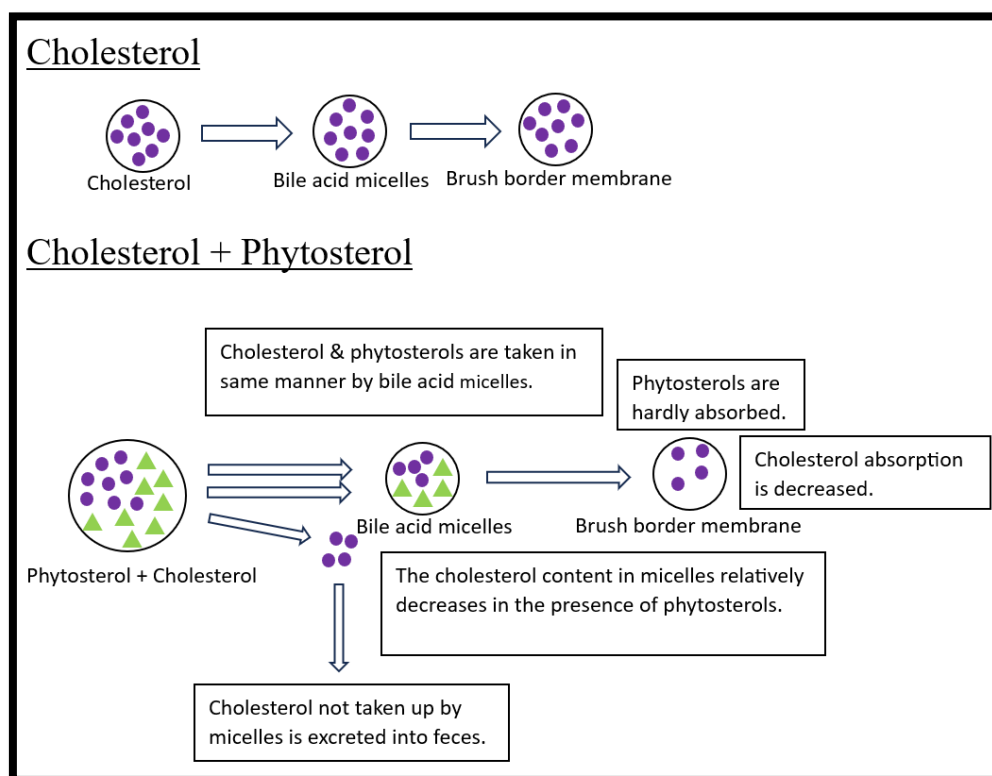


Fig-8: Absorption of phytosterols

Health benefits of phytosterol:

Phytosterols have a well-established safety record and have been deemed effective in their role as cholesterol-lowering agents. They have been used for a considerable period for this purpose and have also been associated with anti-inflammatory, antioxidant, and other beneficial activities (Feng *et al.*, 2022; Rocha *et al.*, 2016)

While some studies have indicated that phytosterols may have an impact on the reproductive system, primarily through their influence on estrogenic activity (Baker *et al.*, 1999) it's important to note that no adverse reactions have been reported in healthy individuals. Moreover, there is a lack of studies examining the effects of phytosterol ingestion on postmenopausal women to date. In this review article an initiative has been made to refer the method parameters for the preparation of mayonnaise enriched with phytosterol (PS) and to draw the awareness about the significance of PS enriched mayonnaise.

Different Methods for the Preparation of Mayonnaise:

Various methods can be followed for the preparation of low- fat mayonnaise. To make mayonnaise, eggs are a key ingredient, and they can be purchased from a retail shop as required (Gaipova *et al.*, 2022) The egg yolk is separated from the egg white. For the fatty phase, various vegetable oils like sunflower, corn, or soybean oil can be used. Following the method proposed by Jung *et al.*, the initial step involves creating a dispersion by mixing egg yolk with water at room temperature. To thicken the mixture, corn starch, sesame seeds, and mustard powder are added (Gaipova *et al.*, 2022)

To form an aqueous mixture, the egg yolk is first emulsified with oil and then further emulsified with vinegar, resulting in an oil-in-water emulsion. Additionally, Shakhnozakhon Gaipova *et al.* suggested using EDTA as an antioxidant, while sodium benzoate and citric acid are employed as preservatives.

In the experiment, a specific amount of water is added to the mixture to prepare mayonnaise with minimal fat content (Jung *et al.*, 2008). To ensure the production of stable mayonnaise, the mixture is processed through a blender, and afterward, all the mayonnaise is stored in the refrigerator at 7°C for 10 minutes.

Preparation of PS enriched mayonnaise: Following the experiment, the experimental mayonnaise is divided into groups, some of which are treated with phytosterol. The groups of mayonnaise are further subdivided based on the amount of phytosterol added, with variations of 0.5%, 1.0%, 1.5%, and 2.0%.

Discussion:

It has been observed that the total serum cholesterol level can be significantly reduced by at least 10% (Katan *et al.*, 2003). Ishizaki *et al.* reported that mixing phytosterols into mayonnaise (equivalent to 884 mg of free phytosterols per 15 g) resulted in the reduction of total serum cholesterol levels and LDL cholesterol levels (Ishizaki, *et al.*, 2003). Furthermore, when phytosterols were combined with diacylglycerol and mayonnaise at a dose of 400 mg per day, they contributed to lowering serum cholesterol and LDL cholesterol levels (Saito *et al.*, 2006; Meguro *et al.*, 2001). Elevated cholesterol levels pose a risk for heart diseases like arteriosclerosis, myocardial infarction, and cerebral infarction, which can lead to a shortened life expectancy. Thus, it is of paramount importance to manage cholesterol levels.

Numerous recent studies have highlighted the cholesterol-lowering effects of phytosterols (Meguro *et al.*, 2001; Zhang, *et al.*, 2022; Poli, *et al.*, 2021; Köhler *et al.*, 2017]. Additionally, phytosterols exhibit anti-inflammatory and anti-diabetic properties, contributing to the prevention of cardiovascular diseases (Prasad *et al.*, 2022; Jayaraman *et al.*, 2021; Vilahur *et al.*, 2019).

To optimize dietary cholesterol reduction, blending phytosterols with other ingredients or functional foods has proven to be an effective approach (Trautwein *et al.*, 2007). An example of this is the "Portfolio Diet," which combines phytosterols with other components like psyllium and soy protein. Phytosterol enriched mayonnaise has demonstrated the ability to lower cholesterol levels in individuals with hypercholesterolemia by approximately 30% in just one month. (Jenkins *et al.*, 2005)

Conclusion

It has been established that phytosterol (PS) enriched mayonnaise is both safe for consumption and effective in reducing cholesterol levels. Its capacity to lower LDL cholesterol and serum cholesterol levels makes it a valuable tool in preventing cardiovascular diseases. We anticipate and encourage its widespread adoption in the food industry, food processing, food formulations, and the development of innovative food products in the near future.

Future scope:

This study seeks to promote the incorporation of phytosterol-enriched mayonnaise into everyday diets as a means of obtaining the health benefits associated with phytosterols, particularly in managing cholesterol levels. Such research can be valuable in promoting healthier dietary choices and potentially reducing the risk of heart-related issues. We wish its extensive adoption in the food industry, food processing, food formulation, and the advancement of innovative food products in the coming years.

Conflict of Interest: There is no conflict of interest between the authors in publication of this paper.

Author's Contribution: Baisakhi Ghosh and Ishita Bhowmik undertook the entire literature review. Sagniki Dey was responsible for creating all the figures and handling the references. Dr. Rupali Dhara Mitra conceptualized the idea and title of this paper and also provided comprehensive editing for the entire manuscript.

Acknowledgement:

We sincerely appreciate and extend our heartfelt gratitude to Swami Vivekananda University for their consistent guidance and unwavering support during the course of our research.

Reference

1. AbuMweis, S. S., Jones, P. J. (2008). Cholesterol-lowering effect of plant sterols. *Current Atherosclerosis Reports*, 10(6), 467-472.
2. Baker, V. A., Hepburn, P. A., Kennedy, S. J., Jones, P. A., Lea, L. J., Sumpter, J. P., Ashby, J. (1999). Safety evaluation of phytosterol esters. Part 1. Assessment of oestrogenicity using a combination of in vivo and in vitro assays. *Food and Chemical Toxicology*, 37(1), 13-22.
3. Brufau, G., Canela, M. A., Rafecas, M. (2008). Phytosterols: physiologic and metabolic aspects related to cholesterol-lowering properties. *Nutrition Research*, 28(4), 217-225.
4. Delaney, B., Stevens, L. A., Schmelzer, W., Haworth, J., McCurry, S., Hilfinger, J. M., Kritchevsky, D. (2004). Oral absorption of phytosterols and emulsified phytosterols by Sprague-Dawley rats. *The journal of nutritional biochemistry*, 15(5), 289-295. Engel, R., Schubert, H. (2005). Formulation of phytosterols in emulsions for increased dose response in functional foods. *Innovative Food Science & Emerging Technologies*, 6(2), 233-237.
5. Feng, S., Wang, L., Shao, P., Sun, P., Yang, C. S. (2022). A review on chemical and physical modifications of phytosterols and their influence on bioavailability and safety. *Critical Reviews in Food Science and Nutrition*, 62(20), 5638-5657. .
6. Gaipova, S., Abdurakhimov, A. Ruzibayev, A. (2022). Formulation of Mayonnaise Recipe Enriched with ω -6 and ω -3 Acids and Stabilization of its Storage Period. *Journal of Pharmaceutical Negative Results*, 476-486.
7. Ishizaki, T.; Wakabayashi, M.; Tanimoto, H.; Shima, A.; Yabune, M.; Kajimoto, O.; Itakura, H.(2003). Effects of long-term intake of mayonnaise containing phytosterolester on blood cholesterol concentration in Japanese with borderline or mild cholesterolemia. *J. Clin. Biochem. Nutr.*, 33, 75–82.
8. Jayaraman, S. Roy, A. Vengadassalopathy, S. Sekar, R. Veeraraghavan, V.P. Rajagopal, P.; Rengasamy, G.; Mukherjee, R.; Sekar, D.; Manjunathan, R. (2021)An Overview on the Therapeutic Function of Foods Enriched with Plant Sterols in Diabetes Management. *Antioxidants*, 10, 1903.
9. Jenkins DJ.; Kendall CW.; Marchie A. (2005).Direct comparison of dietary portfolio of cholesterol-lowering foods With a statin in hypercholesterolemia participants. *AM J Clin Nutr.* 81: 380-7.
10. Jung, T. H. Ha, H. J. Ahn, J. J. Kwak, H. S. (2008). Development of cholesterol-reduced mayonnaise with crosslinked β -cyclodextrin and added phytosterol. *Food Science of Animal Resources*, 28(2), 211-217.
11. Katan, M. B., Grundy, S. M., Jones, P., Law, M., Miettinen, T., Paoletti, R., Participants, S. W. (2003). Efficacy and safety of plant stanols and sterols in the management of blood cholesterol levels. In *Mayo Clinic Proceedings* (Vol. 78, No. 8, pp. 965-978).
12. Köhler, J.; Teupser, D.; Elsässer, A.; Weingärtner, O.(2017) Plant sterol enriched functional food and atherosclerosis. *Br. J. Pharmacol.*, 174, 1281–1289.
13. Matsuoka, R. (2022). Property of phytosterols and development of its containing mayonnaise-type dressing. *Foods*, 11(8), 1141.
14. Matsuoka, R. Masuda, Y. Takeuchi, A. Marushima, R. Onuki, M. (2004) Minimal effective dose of plant sterol on serum cholesterol concentration in Japanese subjects and safety evaluation of plant sterol supplemented in mayonnaise. *J. Oleo Sci.* 53, 17–27.
15. Meguro, S.; Higashi, K.; Hase, T.; Honda, Y.; Otsuka, A.; Tokimitsu, I.; Itakura, H. (2001) Solubilization of phytosterols in diacylglycerol versus triacylglycerol improves the serum cholesterol-lowering effect. *Eur. J. Clin. Nutr.*, 55, 513–517.
16. Ostlund Jr, R. E. (2007). Phytosterols, cholesterol absorption and healthy diets. *Lipids*, 42(1), 41-45.
17. Prasad, M.; Jayaraman, S.; Eladl, M.A.; El-Sherbiny, M.; Abdelrahman, M.A.E.; Veeraraghavan, V.P.; Vengadassalopathy, S.; Umapathy, V.R. (2022). Jaffer Hussain, S.F.; Krishnamoorthy, K. A Comprehensive Review on Therapeutic Perspectives of Phytosterols in Insulin Resistance: A Mechanistic Approach. *Molecules*, 27, 1595.
18. Poli, A.; Marangoni, F.; Corsini, A.; Manzato, E.; Marrocco, W.; Martini, D.; Medea, G.; Visioli, F. (2021) Phytosterols, Cholesterol Control, and Cardiovascular Disease. *Nutrient*, 13, 2810.
19. Rocha, V.Z.; Ras, R.T.; Gagliardi, A.C.; Mangili, L.C.; Trautwein, E.A.; Santos, R.D. (2016)Effects of phytosterols on markers of inflammation: A systematic review and meta-analysis. *Atherosclerosis* 2016, 248, 76–83.
20. Saito, S.; Takeshita, M.; Tomonobu, K.; Kudo, N.; Shiiba, D.; Hase, T.; Tokimitsu, I.; Yasukawa, T.(2006). Dose-dependent cholesterol-lowering effect of a mayonnaise-type product with a main component of diacylglycerol-containing plant sterol esters. *Nutrition* **2006**, 22, 174–178 .

21. Trautwein, E. A., Duchateau, G. S., Lin, Y., Mel'nikov, S. M., Molhuizen, H. O., Ntanios, F. Y. (2003). Proposed mechanisms of cholesterol-lowering action of plant sterols. *European Journal of Lipid Science and Technology*, 105(3-4), 171-185.
22. Trautwein, E. A., & Demonty, I. (2007). Phytosterols: natural compounds with established and emerging health benefits. *Oléagineux, Corps Gras, Lipides*, 14(5), 259-266.
23. Vilahur, G.; Ben-Aicha, S.; Diaz-Riera, E.; Badimon, L.; Padró, T. (2019) Phytosterols and Inflammation. *Curr. Med. Chem.*, 26, 6724–6734.
24. Zhang, R.; Han, Y.; McClements, D.J.; Xu, D.; Chen, S. (2022) Production, Characterization, Delivery, and Cholesterol-Lowering Mechanism of Phytosterols: A Review. *J. Agric. Food. Chem.*, 70, 2483–2494.