PHOSPHATIDYLSTERINE
A well-studied cognitive solution for supplements and functional foods
Phosphatidylserine is a structural component of cell membranes, which can be found in all biological membranes. The human body contains about 30 g of phosphatidylserine, close to half (~13 g) of which is found in the brain. Phosphatidylserine is also found in the human diet, though levels of consumption are low.

Phosphatidylserine has been extensively studied as a dietary supplement, mainly for cognitive health in various populations, from children to elderly. Clinical studies demonstrated that oral administration of phosphatidylserine is safe, and can improve cognitive functions, as well as other benefits. The physical traits of phosphatidylserine make it especially suitable for functional foods.

Compared to most tissues, the brain is especially enriched with PS, which is up to 6 times more concentrated in the brain relative to other tissues [1]. This intriguing fact brought researchers to wonder about this excess of PS and led to many years of research. These studies show that PS is important to many brain functions.

As mentioned above, human milk contains PS and is the first source of dietary PS for humans [2]. The existence of PS in human breast milk may be linked to cognitive development of the infant, as animal studies show that consumption of PS at a young age helps to promote cognition during adulthood [3, 4]. Later in life, as a component of biological membranes, PS is ingested regularly as part of normal human diet. In principle, all foods of biological origin must contain at least some PS. The foods most rich in PS are certain fish as well as animal innards. In the last few decades human diet went through profound changes, and Western diet may now be the most prominent diet globally, at the expense of more traditional diets. One of the outcome of these changes is that consumption of PS through regular diet has declined from an average of 250 mg per day during the 1980’s, to less than 130 mg/day today [5]. Today, most people get their PS through supplementation.

Phosphatidylserine has characteristics making it suitable for many foods, but not all. For example, due to its amphipathic nature PS is mainly suitable for foods which are water and oil emulsions, such as dairy products or chocolates. On the other hand, PS is not water soluble and as such cannot be easily used in beverages. As with any ingredient of biological origin, stability can be an issue. Phosphatidylserine heat-stability is limited to low-heat foods (exact heat stability depends on the food matrix) and to those where heat exposure is relatively short. Nonetheless, PS is stable in pasteurization processes [exposure up to 100 degrees Celsius for 30 minutes led to less than 10% degradation when PS was added to milk (internal data)]. Furthermore, its acid-base stability is significant, from pH=3 to pH=11 (internal data). Phosphatidylserine is thus suitable for dairy products such as yogurts, fresh milk and dairy-based powders.
Phosphatidylserine as a dietary supplement

Origins and sources of PS as a dietary supplement

Phosphatidylserine has been available for human consumption since the 1980s [6, 7]. Historically, PS was extracted from bovine cortex, however, with the outbreak of the Bovine Spongiform Encephalopathy disease (BSE or “mad cow disease”), bovine cortex PS became unavailable and was replaced by PS from alternative sources such as soy, sunflower, fish or krill. These PS sources differ from one another by the fatty acid composition. For example, fish PS is enriched with the fatty acid DHA, an omega-3 FA, while plant sources of PS, namely soy PS and sunflower PS, contain the essential FA plant omega-3, alpha-linolenic acid (ALA).

For use in functional foods, mainly PS from plant sources is suitable, due to its almost neutral organoleptic properties. PS from animal sources has, due to the omega-3 content, organoleptic issues making it less suitable for food applications.

--

PS from soy or sunflower are most suitable to be included in functional foods

Clinical research shows that ingestion of PS has beneficial effect on the brain

Health benefits of PS consumption

The effects of PS consumption on the human body, especially on the brain, were investigated in a large number of clinical and pre-clinical studies. Clinical studies were conducted in various populations, from children, through young adults and all the way to elderly.

The main outcomes of these studies show that ingestion of PS has beneficial effect on the brain, leading to improved memory and cognitive capabilities. Ingestion of PS was also shown to reduce stress and to improve mood, to improve skin health and to improve various aspects of sport outcomes.

Consumption of PS leads to improved cognitive capabilities

A randomized, double-blind, placebo control study, was conducted in 79 Japanese elders with memory complaints. The efficacy of soy PS (100 mg/day or 300 mg/day) was evaluated over 6 month’s supplementation, followed by 3 months of non-supplemented follow-up period. The memory scores following PS treatment were significantly increased compared to baseline, while memory scores of the placebo group remained unchanged.

A dose of 100 mg/day was found to be sufficient for the noted improvement in memory. Interestingly, 3 months after termination of the supplementation period, the improvement in memory of those taking PS was maintained, demonstrating that the effects of PS are sustained (Figure 1).

The brain is especially enriched with PS, which is up to 6 times more concentrated in the brain relative to other tissues

www.frutaromhealth.com
The benefits of soy PS for cognition are not unique to the elderly. A dose of 100 mg/day soy PS was also demonstrated to improve cognitive performance in 120 students aged 17-18 who were randomized to receive either 250 ml milk supplemented with 100 mg PS (milk and other dairy products, an emulsion of oil in water, are especially suitable for inclusion of PS) or 250ml un-supplemented milk (placebo) for 40 days. Various aspects of memory and learning were improved in the PS supplementation group [9]. This study demonstrated that PS beneficial effect is not limited to the elderly population but may also lead to improved cognitive performance and, possibly, academic achievements in young populations as well. This study is an example that the inclusion of PS in milk-based products retains the effectiveness of PS and its beneficial properties.

**Figure 1:** Effects of soy PS supplementation on memory of elderly participants with memory complaints was tested over 6 months with 3 months follow-up. Ingestion of 100 mg/day soy PS was shown to be effective even 3 months after termination of the study (grey bars) [8].

Consumption of PS is beneficial for those dealing with sports

Sports nutrition may be one of the best examples for a functional food industry, as almost all sports nutrition products, either powders, bars, shakes or others, may be considered functional, pertaining to assist in muscle build up, to give energy, to allow trainers better performance, better recovery and more.

**Phosphatidylserine ingestion leads to reduced muscle damage following training**

Creatine kinase (CK) is an important enzyme in tissues requiring high energy consumption, such as the brain and muscles. When found in the blood, however, high levels of CK are indicative of muscle damage. The muscle-protective properties of soy PS consumption were demonstrated in a small clinical study which was part of an academic dissertation. In that double blind, placebo controlled, crossover study, participant consumed high level of soy PS (600 mg/day), low levels of soy PS (300 mg/day) or placebo, for a period of 15 days. Following 90-minute run blood samples were taken and CK levels measured. The findings of the study clearly point to a significant (about 66% reduction, p<0.01) reduction in CK levels following intake of PS (Figure 2) [10].
As we see, ingestion of soy PS may have a muscle protecting effect and may lead to improved recovery. Interestingly, however, the benefits of soy PS ingestion for those dealing with sports go beyond those of muscle protection, and studies have shown that ingestion of PS can help to improve endurance, reduce muscle soreness and more. Furthermore, many sports people can also benefit from the cognitive properties of PS, making this ingredient beneficial for body and mind alike.

To conclude, consumption of PS has been shown to be safe and to benefit many aspects of human health, first and foremost cognitive health.

Adding PS to foods to make them functional may have significant benefits for consumers whose current daily diet is low in this important nutrient, and who cannot, or will not, consume PS through regular diet or through supplementation of the regular diet with dietary supplements.

The properties of plant PS, such as lack of taste or smell as well as emulsifying properties, along with the many benefits for consumers, make PS an attractive ingredient for functional foods.

**REFERENCES**

3. Ammassari-Teule, M., et al., Chronic ad

**Figure 2:** Soy PS intake, either 300 mg/day or 600 mg/day, leads to reduction in blood levels of Creatine Kinase (CK), indicating a possible reduction in muscle damage [10].

**By Itay Shafat, PhD**

Frutarom Health, Israel

---

**About Frutarom Health**

As a manufacturer of natural, science-based and high quality ingredients for healthy nutrition and tasty solutions, Frutarom Health provides effective ingredients that match the increasing consumer demand for natural and safe alternatives to support health.

Taken together, Frutarom Health’s regulatory, application and formulation support, along with our proprietary science, comprehensive market knowledge and global capabilities, place us in the top tier of companies ready to help you, our customer, gain a competitive edge in a dynamic health landscape.

For further information, visit our website [www.frutaromhealth.com](http://www.frutaromhealth.com) or contact us at [health@frutarom.com](mailto:health@frutarom.com)