The Power of Phospholipids: The Superior Source of Omega-3s

Sponsored by

AkerBioMarine™

Essential Omega-3s

Long-chain omega-3 poly unsaturated fatty acids (PUFAs) are indisputably essential to maintaining a healthy body. Multiple clinical trials have demonstrated that omega-3 fatty acids play a pivotal role in early retinal and brain development, as well as in promoting cognitive and immune system functions and they have been linked to the prevention of cancer and cardiovascular disease. But a typical western diet is inadequate for supplying enough of the omega-3 eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) that have been linked to numerous health benefits. As a result many consumers have turned to dietary supplements to make up the difference between what their bodies need and what their diets provide.

Recent studies have suggested that not all omega-3s are equal. There are two primary sources for EPA and DHA: fish oil, which provides triglyceride omega-3s; and krill oil, which provides phospholipid omega-3s. Krill oil is extremely well tolerated, is certified sustainable, and its phospholipid omega-3s are more efficiently utilized by the body.

Krill oil is rich in phospholipid omega-3s

In krill oil the majority of the omega-3 fatty acids EPA and DHA are bound to phospholipids. There are several different types of phospholipids, and EPA and DHA are particularly enriched in phosphatidylcholines (PC). A study of the contents of Superba™ krill oil has found EPA and DHA in most of the 69 identified choline-containing phospholipid classes [1]. In PC, two fatty acid chains are attached to a glycerol group that is connected to choline over a phosphate group (Figure 1A). This structure allows the formation of phospholipid bilayer, which is essential to the formation of cell membranes in all existing life on earth. Dietary phospholipid carriers might help the efficient transport of omega-3 fatty acids through the body and subsequent integration into cell membranes (Figure 2). As part of cell membranes, EPA and DHA have the ability to influence fluidity of the membranes, signaling processes, and metabolic parameters in the cell.

Fish oil provides triglyceride omega-3s and is well established as a reliable source of omega-3 supplementation. In the triglyceride form, three fatty acid chains are attached to a glycerol group (Figure 1B). Dietary triglycerides have different physiological functions in the body than phospholipids. Triglycerides are mainly used as either energy or as energy storage in fat tissues. When omega-3s are delivered in triglyceride form, a portion of the beneficial omega-3s are burned as energy or are stored in the body's fat reserves, and as a result the dosage of triglyceride omega-3 oils must be large enough to compensate for that loss and to ensure that sufficient omega-3s are available on a cellular level.

Recent human clinical studies have shown that phospholipid omega-3s may be a more desirable form of omega-3s. When compared with triglyceride omega-3s, we see that less phospholipid omega-3s are required to reach equal bioavailability in the body's cells and organs. The result is that krill oil capsules are smaller than their fish oil counterparts. And krill oil is dispersible in the stomach fluids, eradicating the repeating so common among consumers who take fish oil capsules.

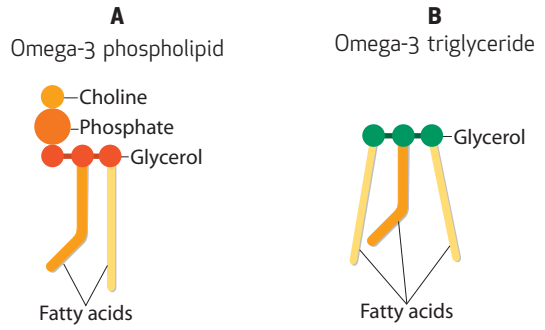


Fig 1. Illustration of (A) phosphatidylcholine and (B) triglyceride.

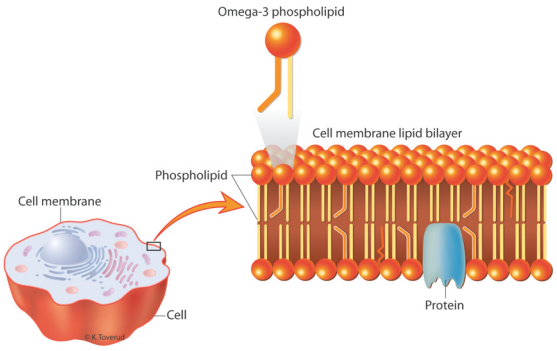


Fig 2. Illustration of cell membrane and phospholipid bilayer.

Krill as an abundant and sustainable source of nutrition

Euphausia superba, Antarctic krill, are zooplankton invertebrates that float in huge swarms in the Southern Ocean and feed on microscopic algae. Because krill feed on algae that produce omega-3 fatty acids, the krill themselves become rich in accumulated fatty acids which can be then extracted in krill oil. The same algae that provides the krill's diet with such a robust source of omega-3s is also the

source of the antioxidant astaxanthin, which gives krill oil its distinctive red color. Moreover, the astaxanthin acts a natural preservative protecting the oil from oxidation and keeping it fresh on the shelf. Furthermore, as *Euphausia superba* are at the very bottom of the food chain and can only be found in the pristine waters around Antarctica, there is no accumulation of contaminants as can be found in marine life higher on the food chain.

Krill is one of the most abundant species on earth with a biomass of around 500 million tons. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) restricts the annual krill harvest to 4 million tons in order to ensure sustainability and that no harmful effects on availability for whales, birds, seals, or any other species can occur. Currently, the annual catch of 200,000 tons per year from all krill fisheries is far below this margin.

Aker BioMarine is the only krill harvester that has been awarded the prestigious Marine Stewardship Council certification for its eco-friendly harvesting and traceability from sea to shelf.

CERTIFIED SUSTAINABLE SEAFOOD MSC www.msc.org ™ MML-C-1211

MARINE STEWARDSHIP COUNCIL (MSC) CERTIFICATION

The Marine Stewardship Council (MSC) is an international nonprofit organization with an independent certifying body and a public assessment process. The MSC focuses on the health of ocean stocks and how they are managed, in addition to assessing the effect of the fishery on the wider ecosystem, which includes a range of marine mammals, birds, and fish. In May 2010, Aker BioMarine's krill fishing operations received MSC Certification as a sustainable fishery, making Aker BioMarine the first and only MSC Certified krill fishery in the world. Aker BioMarine products carry the exclusive MSC eco-label, providing consumers with a guarantee of sustainability, effective fisheries management, and full traceability from sea to shelf.

Phospholipid EPA and DHA are clinically proven

Studies demonstrate that increased blood levels of EPA and DHA is accompanied by health-promoting benefits in humans. The bioavailability of these omega-3 fatty acids in the blood is therefore of great importance. The term "bioavailability" accounts for how much of a substance reaches the blood and describes absorption and survival rate of the substance in the body.

Recently, two human intervention studies investigated if the molecular form (phospholipid versus triglyceride) of omega-3 fatty acids is of importance for the bioavailability of EPA and DHA in blood plasma. The study performed by Kevin C. Maki and co-workers at the Provident Clinical Research, in Bloomington, IN, and the Meridien Research Centers, in St. Petersburg, FL, was set up as a randomized, double-blind, parallel arm trial [2]. Within this setup, 76 overweight and obese men and women were randomly distributed into three groups to take Superba™ Krill Oil, fish oil, or olive oil for four weeks. To avoid any influence, the supplementation given was unknown to both the study subjects and researchers.

While the received daily amount of EPA was similar in the krill oil and fish oil groups, the DHA quantity was approximately half as much in the krill oil group compared to the fish oil group. Nevertheless, at the end of the study period, plasma analysis showed that the mean EPA concentrations were higher in the krill oil group compared to the fish oil group, and the mean DHA concentrations were similar in both groups. Both sources of omega-3 fatty acids were safe and mostly well-tolerated and significantly increased EPA and DHA levels in plasma as compared to the control group.

But most importantly krill oil supplementation (2g/d) resulted in increased plasma EPA bioavailability and revealed equal bioavailability in the case of DHA, but at half the dosage in comparison to fish oil [2]. Overall, after dose adjustment, we saw that the total increase of EPA and DHA in the plasma of the subjects who received Superba™ Krill Oil for 4 weeks was 24% higher than of the subjects who received fish oil (Figure 2).

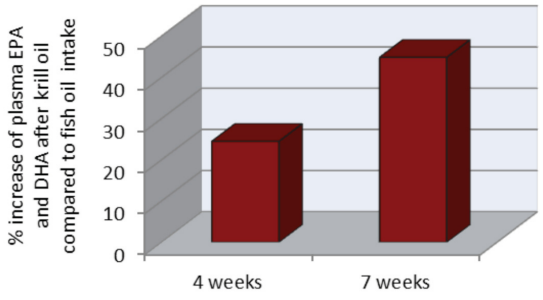


Fig 2. This figure illustrates the percent increase in plasma of total EPA and DHA after either 4 or 7 weeks of Superba™ krill oil in comparison to fish oil supplementation. The values have been dose adjusted and the studies are described in more detail in [2, 3].

In the same study, the blood level of the endocannabinoid 2-Arachidonoylglycerol (2AG) was measured in all participants [4]. The results confirmed data in the literature that describe increased levels of endocannabinoids in overweight and obese subjects compared to healthy weight subjects. Endocannabinoids are signaling molecules that can bind to receptors and influence, for example, appetite and emotional state.

Krill oil, but not fish oil or control olive oil, was able to significantly decrease 2-AG levels in obese subjects. In addition, the decrease of 2-AG was linked to the plasma phospholipid omega-6/omega-3 fatty acid ratio. These data showed for the first time in humans that relatively low doses of omega-3 fatty acids as provided in krill oil can decrease plasma 2-AG levels in obese subjects in correlation with decreasing plasma phospholipid omega-6/omega-3 fatty acid ratio. This effect was not linked to any changes in metabolic syndrome parameters but was most likely due to a decrease of 2-AG biosynthesis caused by the replacement of its precursor, arachidonic acid, with omega-3 fatty acids.

The second study performed by researchers at Akershus University College and University of Oslo, Norway investigated if a lower dose of EPA and DHA provided in phospholipids compared to omega-3 fatty acids provided in triglycerides shows equal bioavailability of these fatty acids in plasma[3].

In this study, 113 subjects with normal or slightly increased total blood cholesterol and/or triglyceride levels were randomized into three groups and given Superba™ Krill Oil, fish oil, or placebo for seven weeks. The daily supplementation of total EPA and DHA was approximately 37% less in the krill oil group than in the fish oil group. The results showed that dietary omega-3 administration led to a similar increase of plasma omega-3 fatty acids in both the krill and fish oil groups compared to the control group.

These findings suggest that a lower dosage of EPA and DHA in phospholipid form is required to obtain plasma EPA and DHA levels comparable to the triglyceride form of omega-3 supplementation. After adjustment of EPA and DHA levels to the daily dose given, the results from the krill oil group suggest an impressive 45% higher total EPA and DHA plasma level than in the fish oil group after seven weeks of administration (Figure 2). Moreover, the subjects with the highest baseline values of triglycerides further benefited from krill oil supplementation and showed decreased plasma triglyceride levels. Additionally, the HDL-cholesterol/triglyceride ratio, a risk predictor for heart disease, was significantly decreased only after Superba™ Krill Oil and not fish oil treatment.

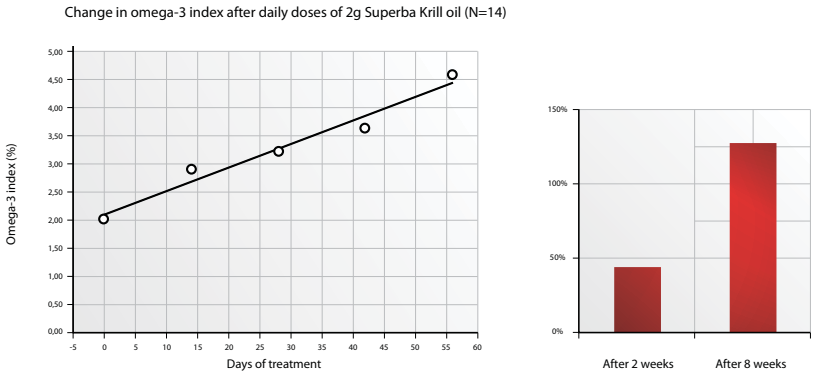
These human clinical studies demonstrate that the intake of krill oil is more potent than fish oil in increasing total plasma EPA and DHA values, suggesting that there is a higher bioavailability of omega-3 fatty acids bound to phospholipids than there is with the triglyceride bound omega-3s.

OMEGA-3 INDEX

The Omega-3 Index is a reliable diagnostic tool that presents the combined EPA and DHA concentration as a percentage of total fatty acids in red blood cell membranes.

This graph shows that the participants in one Aker BioMarine study started out with an average Omega-3 Index of 2.0, a relatively low value. After 8 weeks with daily intake of 2 g Superba Krill™ Oil, the average index increased to 4.5, or up 125 %. An increase of 45% in the Omega-3 Index was seen after just two weeks. These observations prove that the omega-3 fatty acids from Superba™ Krill Oil are taken up from the gut to the blood stream and that EPA & DHA are incorporated into cells. An improvement of the ratio of EPA & DHA to other fatty acids in red blood cell membranes is a strong indicator of cardiovascular health benefit.

Superba Krill more than doubles the omega-3 index (level of omega-3 in the red boodcells)



Conclusion

The phospholipid composition of krill oil provides benefits in key areas. First, because krill oil provides more efficiency in smaller dosing, krill oil supplements are easy to swallow. And because phospholipids are dispersible in fluids, as opposed to triglycerides which are hydrophobic and sit on top of stomach fluids, krill oil is more easily digested and is free of digestive discomfort and fishy repeating.

Krill oil's benefits extend beyond its unique formulation. Due to krill's position low on the food chain and its habitat in the pristine Antarctic waters, contamination issues that occur with marine life higher on the food chain are not possible with krill. While not a health consideration, the sustainable nature of krill as a source of nutrition will become an issue with consumers who are increasingly sensitized to environmental concerns. Finally, new harvesting techniques and chain of custody programs are allowing suppliers and marketers of krill oil ingredients to trace and verify the quality and purity of these ingredients – a practice not common with the production of traditional fish oils. This practice will allow for consistency and quality of products that will engender the confidence of consumers.

These factors, combined with the efficiency of krill oil as a delivery agent for omega-3s, are evidence that krill is a rich and sustainable source of the superior phospholipid omega-3 fatty acids essential for human health.

References

1. Winther B, Hoem N, Berge K, Reubsaet L: **Elucidation of Phosphatidylcholine Composition in Krill Oil Extracted from Euphausia superba.** *Lipids* 2010, 46(1):25-36.

2. Maki KC, Reeves MS, Farmer M, Griinari M, Berge K, Vik H, Hubacher R, Rains TM: **Krill oil supplementation increases plasma concentrations of eicosapentaenoic and docosahexaenoic acids in overweight and obese men and women.** *Nutr Res* 2009, 29(9):609-615.

3. Ulven SM, Kirkhus B, Lamglait A, Basu S, Elind E, Haider T, Berge K, Vik H, Pedersen JI: **Metabolic Effects of Krill Oil are Essentially Similar to Those of Fish Oil but at Lower Dose of EPA and DHA, in Healthy Volunteers.** *Lipids* 2011, 46(1):37-46.

4. Banni S, Carta G, Murru E, Cordeddu L, Giordano E, Sirigu A, Berge K, Vik H, Maki K, DiMarzo V, Griinari M: **Krill Oil significanly decreases 2-arachidonoylglyerol plasma levels in obese subjects.** *Nutrition & Metabolism* 2011, 8:7

AkerBioMarine™
Antarctic US

Aker BioMarine Antarctic US
2025 First Avenue, Suite 830, Seattle, WA 98121
info.us@AkerBioMarine.com
phone (206) 855-6736 or fax (206) 855-6727

Aker BioMarine ASA
Fjordallèen 16, 0115 Oslo, Norway
Phone: +47 24 13 00 00

US Contacts
Todd Norton • todd.norton@akerbiomarine • (206) 855-6736 x215
Eric Anderson • eric.anderson@akerbiomarine.com • (206) 855-6736 x217

Europe Contact
Roar Hernes • roar.hernes@akerbiomarine.com • +47 24 13 00 00

Asia Contact
Chris McReynolds • chris.mcreynolds@akerbiomarine.com • (206) 660-6756

www.superbakrill.com