

TREASURE FROM THE OCEAN

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Omega-3 fatty acids play a major role in the health of human organs such as the heart, the brain, and the eyes. However, more than 80 percent of people lack an adequate supply of these nutrients. Evonik aims to close this gap by tapping innovative sources—while protecting the world’s oceans

Beef stew, sausage salad, and cream of chicken soup—when Apollo 11 set its course for the moon 50 years ago, its crew was well supplied with down-to-earth cooking. For the USA’s National Aeronautics and Space Administration (NASA), food transportation and preparation technology was uncharted terrain. The astronauts’ meals—portioned, partially freeze-dried, and packed in plastic bags—became edible only when mixed with water. That was the diet of Neil Armstrong, Buzz Aldrin, and Michael Collins during their eight-day mission.

But even back then, NASA’s goal was more ambitious: space expeditions lasting several months, and someday maybe even missions to Mars. One important question to be answered was how to provide astronauts with healthy nutrition during such missions. In the mid-1980s, NASA formed numerous research partnerships in search of “superfoods”—vital nutrients

that space expeditions absolutely needed to have on board. In the course of their research, the scientists looked at marine microalgae in the North Pacific Ocean—and found a food source that could play a crucial role in global nutrition in the future.

The strain of algae they discovered, *Schizochytrium sp.*, is one of the richest sources of the essential omega-3 fatty acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). These microscopic single-cell organisms feed on plant residues and metabolize them to produce large amounts of EPA and DHA—polyunsaturated fatty acids that protect the human heart, brain, and eyes and have a positive effect on emotional well-being. During a pregnancy, they have an especially important influence on the embryo’s neural development.

Human beings, like most animals, cannot produce EPA and DHA on their own. They must obtain these nutrients directly through their food, especially fatty →



Fish farms like this one in Norway require large amounts of fish feed containing omega-3 fatty acids



In Blair, Nebraska, microalgae grow in vats. The oil they produce is then extracted (top photo) and processed to make fish feed

fish such as sardines, mackerel, and salmon. Plant-based oils such as rapeseed and linseed oil also contain an omega-3 fatty acid, in this case alpha-linolenic acid (ALA), but human beings can only transform this acid into EPA to a very limited extent.

The Food and Agriculture Organization (FAO) of the United Nations recommends that people cover their need for the omega-3 fatty acids EPA and DHA by eating fish once or twice a week in addition to using plant-based oils. According to recent scientific studies, we need to consume up to 500 milligrams of EPA and DHA per day. A blood test can reveal whether an individual

has sufficient reserves of omega-3 fatty acids by measuring the fatty-acid content of the cell membranes of red blood cells. A ratio of eight percent or more is ideal.

Only eight percent of people in the world reach this value. Most of them live in Norway, Japan, or Greenland, where people traditionally eat lots of fish. “In many Western countries, the EPA and DHA values of a large proportion of the population are too low,” says Clemens von Schacky, who heads the Preventive Cardiology unit at the clinic of the Ludwig-Maximilians-Universität München (LMU Munich). In these countries, industrially processed food dominates most people’s diet, and fish is seldom served. North America is just as undersupplied with omega-3 fatty acids as the UK and Germany. “Low levels of EPA and DHA are associated with numerous health problems, including shorter life expectancy, cardiovascular disorders, cognitive impairment such as attention deficit hyperactivity disorder (ADHD), and major depression,” says von Schacky, who developed the omega-3 blood test together with the US scientist Bill Harris.

STRESSED-OUT FISH STOCKS

In spite of the fatty acids’ importance for nutrition, it’s hard to maintain an adequate supply of them. In order to supply seven billion people with 500 milligrams daily, a total of 1.27 million tons of EPA and DHA would be needed. But if we add up all the sources of omega-3 fatty acids—rapeseed, walnuts, and fish—

only between 400,000 and 800,000 tons would be available, depending on the scenario we use.

Most importantly, the world’s fish stocks are already stressed out today. Aquaculture could help to close the supply gap—but only if it is operated sustainably. Salmon in particular can play a major role. This silvery, shimmering predatory fish is one of the richest sources of omega-3 fatty acids for human beings. One hundred grams of salmon can contain about 2.5 grams of EPA and DHA.

Wild salmon prey on smaller fatty fish such as sardines, anchovies, and herring, which in turn like to feed on krill. The krill feed on algae that produce omega-3 fatty acids. This is the route taken by the EPA and DHA that end up in salmon stomachs. In aquaculture, this popular food fish is fed with pellets containing fish meal and fish oil that is rich in omega-3 fatty oils.

This method is reaching its limits. About 16 million tons of wild fish are caught annually in order to be processed into five million tons of fish meal and one million tons of fish oil. In other words, two kilograms of wild fish are needed to produce one kilogram of salmon.

MICROALGAE FROM THE VAT

The world’s oceans already reached their limits a long time ago. According to the FAO, more than 60 percent of the world’s fish stocks are reaching their limits, and 30 percent are even considered to be overfished. Only about ten percent are still in a healthy condition. Today the fish stocks have been so decimated, and the price of wild fish has increased to such an extent, that the fish oil in the feed for aquaculture has largely been replaced with plant-based oils. And plant-based oils provide no EPA or DHA. As a result, the omega-3 content of salmon has already decreased by half in the last ten years. Salmon is providing less and less of the substances that make it so nutritious for human beings. In addition, the limited amount of available fish oil is slowing down the growth of aquaculture, and thus the overall availability of fish.

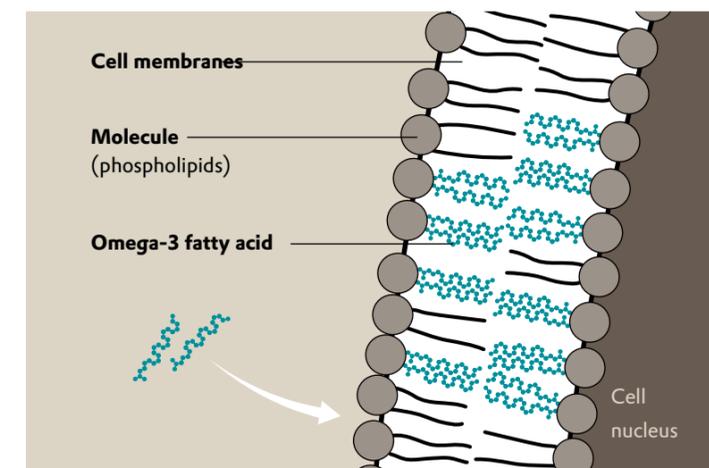
How can this supply gap be closed without putting further pressure on the oceans through industrial fishing? Researchers at the Evonik Group and the Dutch company DSM addressed this question by following up the findings of the NASA researchers who discovered the marine microalgae. Why not shorten the food chain and use this North Pacific algae strain to create an innovative and sustainable source of omega-3 fatty acids?

This was successfully accomplished for the first time on an industrial scale in a town located more than 2,000 kilometers from the North Pacific. In Blair, Nebraska, an ochre-colored algae brew is sloshing around in the huge vats. It’s the result of several years of work by Veramaris, a joint venture of DSM and Evonik.

Together, the researchers developed a fermentation process that produces EPA and DHA directly from the microalgae. The product is an algae oil with a more than 50 percent content of EPA and DHA. The percentage in fish oil varies between 14 and 28 percent, depending on the season and the fishing zone. “Our algae oil is the answer to the industry’s demand for a sustainable source of omega-3 fatty acids,” says Veramaris CEO Karim Kurmaly. “One kilo of our product contains the same amount of EPA and DHA as 60 kilos of fish.” →

How omega-3 fatty acids work

Once they have been absorbed by the body, the omega-3 fatty acids are incorporated into cell membrane as essential elements. Cell membranes contain molecules called phospholipids on their inner and outer surfaces. The omega-3 fatty acids diffuse into the phospholipid molecules, thus altering the fluidity and activity inside the membrane. They do this by producing various signaling molecules that in effect tell the body’s genes what proteins to produce. This results in a whole spectrum of effects inside the human body. Omega-3 fatty acids improve blood flow, reduce blood pressure, and have a positive effect on blood lipid levels by reducing the levels of cholesterol and triglyceride. They also have a beneficial effect on the immune system: They serve as the base materials for eicosanoids (signaling molecules similar to hormones), which influence the body’s inflammation and immune responses.





“Our algae oil production from Blair provides as much EPA and DHA as 1.2 million tons of wild fish”

KARIM KURMALY, CEO OF VERAMARIS

In order to produce this precious oil, the researchers must first propagate the algae cells—that is, get them to grow. For that, they need a nutrient fluid that contains various macroelements (such as nitrogen, phosphorus, potassium, and calcium), trace elements, and vitamins. The algae cells also need oxygen for respiration, as well as a sugar solution based on cornstarch as a source of energy and carbon. The algae brew stays in the fermenters for about a week. By that time it has generated so much oil that it can be extracted from the algae cells. Using a specially developed processing method, the researchers separate the oil from the watery fermentation fluid. The challenge lies in extracting extremely pure oil while keeping losses to a minimum and preventing the end product from going rancid.

THE AIM: FISH FEED WITHOUT FISH OIL

After the algae oil has been pumped into huge tanks, it is transported by truck and ship to the feed producers. Algae oil from Blair can cover about 15 percent of the worldwide salmon breeding industry’s demand for EPA and DHA. “In order to produce this amount, 1.2 million tons of wild fish would have to be caught annually,” says Kurmaly. The volume of fish that is spared in the world’s oceans thanks to this method is greater than the total annual fish catch in the Mediterranean Sea.



How much would you like? In countries where people eat lots of fatty fish such as mackerel and salmon, there’s no omega-3 fatty acid deficiency

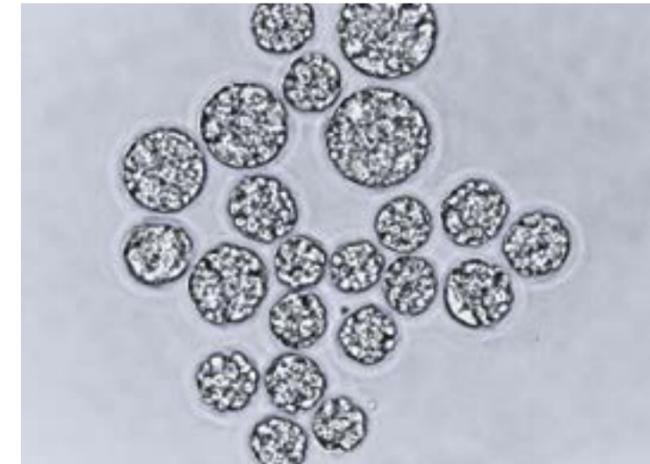
The algae oil that salmon like so much will soon be available to other kinds of fish as well. In the years ahead, Veramaris will supply this product to fish farms that raise trout, gilthead, bream, and shrimp. The ultimate aim is to one day produce fish feed for aquaculture that contains no fish oil at all.

In parallel, Evonik is using a second method to address the worldwide shortage of omega-3 fatty acids. People who don’t want to, or can’t, eat fish twice a week have the option of covering their need for omega-3 fatty acids through dietary supplements. Fish oil capsules dominate the dietary supplement market in drug stores and pharmacies.

ONE TABLET INSTEAD OF TWO CAPSULES

In order to also use the limited resource of fish oil in dietary supplements as efficiently as possible, Evonik has developed a method to improve the uptake of omega-3 in the human body. “This way people will need to consume less fish oil in order to get the same effect,” says Christopher Studte, who is responsible for New Health Ingredients at Evonik’s Health Care Business Line.

Evonik’s second-generation dietary supplement is called AvailOm®. It’s a powder that can be compressed into small tablets that are easy to swallow and are more easily tolerated by consumers. The researchers have combined omega-3 fatty acids with the essential amino acid lysine to form a complex. The powder can be processed into tablets or hard capsules on a large scale and contains at least 45 percent EPA and DHA. “That’s a bigger percentage than that of any other powdered product on the market,” says Studte. “One single small tablet provides the same effective uptake of omega-3 fatty acids as two big fish oil capsules.”



Under the microscope: *Schizochytrium sp* algae

This product’s effectiveness is due to its special composition. Unlike conventional fish oil capsules, in which the omega-3 fatty acids are present as esters, AvailOm® makes them directly available as a fatty acid-amino acid complex. The body does not have to convert the components of the tablet. “As a result, the body can absorb the EPA and DHA between three and four times more effectively,” says Studte. “AvailOm® is effective even if it’s taken on an empty stomach or as part of a low-fat diet.”

Today the omega-3 fatty acids in AvailOm® still come from fish provided by certified, sustainable fisheries. But by the end of this year, a product based on algae oil will also be available on the market—to help protect the oceans and their denizens. —