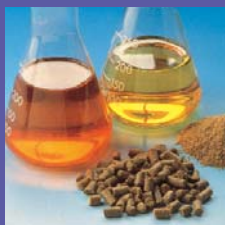


The healthiest omega-3s EPA & DHA are found mainly in fish oil and fishmeal



A guide to the long chain omega-3 fatty acids,
EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid)
in fish oil

INTERNATIONAL
FISHMEAL AND FISH OIL
ORGANISATION



An introduction to the essential omega fatty acids

Plants and animals can synthesise many different fatty acids which perform a wide variety of different functions. However, only plants can produce fatty acids in the omega-3 and omega-6 series, which is why these two groups have been called the essential fatty acids.

Animals depend on getting both these series of essential fatty acids through their diet. In general marine oils and plant leaves are the main source of omega-3 fats while seeds are the main source of omega-6 fats.

This guide is focused on eicosapentaenoic acid (EPA C20:5 n-3) and docosahexaenoic acid (DHA C22:6 n-3), which are the two main *long chain* (LC) highly unsaturated fatty omega-3 acids, or HUFAS. They are primarily marine-derived. EPA and DHA are synthesised by algae and marine plants, particularly in cold water. The algae are eaten by zooplankton, the zooplankton by fish and on up the food chain. At each stage the EPA and DHA are retained and utilised for their properties.

In this guide they are referred to as:

- **EPA & DHA,**
- **long chain omega-3s or**
- **LC omega-3s**

The *shorter chained* omega-3 fatty acid, alpha linolenic acid (18:3 n-3 ALA), which is plant derived, is described on page 14.

The healthiest omega-3s, EPA & DHA, are found mainly in fish oil and fishmeal



SUMMARY

The long chain omega-3 fatty acids, EPA & DHA, are essential in the human diet for proper growth, development and good health. Marine oils, especially fish oil, are the major natural dietary source.

However, most western human diets are deficient in LC omega-3s. There is strong and growing evidence that increased consumption of EPA & DHA would bestow many important and even vital health benefits on humans, not least in:

- reducing cardiovascular disease (CVD) and deaths from heart problems
- reducing obesity and related conditions, including type 2 diabetes
- improving children's brain development and maintaining good mental health



The rising incidence of some of these conditions represents an imminent physical and mental public health crisis. Health authorities worldwide advise adequate dietary consumption of EPA and DHA, preferably in the form of natural oily fish or fish oil. The benefits of EPA & DHA in fish oil hugely exceed any known contaminant risk.



There is escalating scientific, public and commercial interest in LC omega-3s. The benefits of consumption of oily fish, fish oil supplements and omega-3 enriched foods and beverages are being heavily promoted.

EPA and DHA are mainly marine-sourced. Plant-sourced shorter chain omega-3s do not confer the same health protection or benefits.



Long chain omega-3s, EPA & DHA, are vital for human biological functions

The long chain highly unsaturated omega-3s, EPA & DHA, are vital for human biological functions. They are in every cell of the human body where they directly affect human health, growth and well-being.

For example, around 25 per cent of the fat in the brain of humans and animals is DHA and a great deal of research is being published which shows the benefit of increased DHA intake on brain function. DHA is also the preferred fatty acid for the correct construction and functioning of all membranes in the body, particularly those in very active tissue such as nerves and active muscle.

Both EPA and DHA are important in the cardiovascular system. EPA in particular contributes to the anti-inflammatory response. It is the building block of a group of the cell messengers called eicosanoids. These affect blood pressure, blood clotting, immune function, allergic response, reproduction and gastric secretion.

We need a balance between the EPA-derived eicosanoids, which are anti-inflammatory, and those derived from omega-6 arachidonic acid (AA), which are highly inflammatory. Too much of the latter can make the system over-reactive, resulting in unwanted inflammation (as in coronary disease) and allergic responses such as asthma.

There are multiple benefits to human health from increased consumption of EPA & DHA

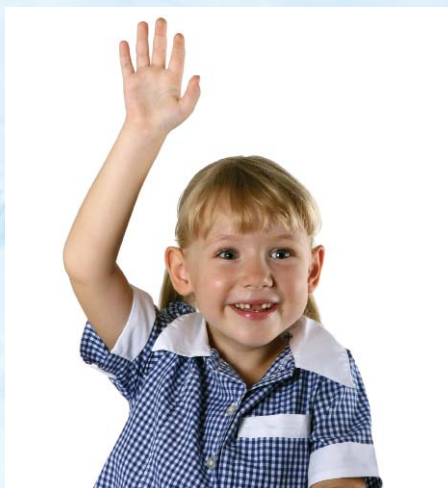


LC omega-3 fatty acids benefit the hearts of healthy people, as well as those at high risk of, or who already have, cardiovascular disease. They make the blood less likely to form clots that cause heart attack and protect against irregular heartbeats that cause sudden cardiac death. Three large control trials with LC omega-3s have shown they reduce cardiovascular events by 19 per cent to 45 per cent.

There is evidence that children exposed to LC omega-3 both during pregnancy and from an early age tend to be more attentive and better behaved in school and have improved academic ability.

Obesity is now prevalent throughout much of the Western world. This and associated diseases, such as cardiovascular disease and type 2 diabetes, represent an escalating public health crisis. Moderate increases in our consumption of the LC omega-3s found in fish oils would help avert these problems.

Professor John Stein, Professor of Physiology at Oxford University is among those who believe there is evidence that it was the inclusion of fish oils in the human diet which facilitated the great evolutionary cognitive leap forward by the human race.



Specific health benefits of EPA & DHA

Below is a list of just some of the conditions for which there is evidence of benefits.



Already endorsed by health authorities

- Prevention of reoccurrence of cardiac infarction
- Reduction in cardiovascular disease

Conditions where there is significant scientific evidence of preventative or therapeutic benefits include:

- Brain and nervous system development
- Rheumatoid arthritis
- Psychiatric disorders, including depression and schizophrenia
- Dementia and Alzheimer's Disease
- Psoriasis

Conditions for which there is some evidence of benefits include:

- Asthma in children
- Vision
- Averting progression towards Type 2 diabetes
- Behaviour and concentration, including ADHD (attention-deficit hyperactivity disorder) and dyslexia
- Obesity
- Cystic fibrosis

What role do the proteins, vitamins, minerals, & omega-3 fatty acids found in seafood play in human health?

Brain

- Aids in infant neurodevelopment and the building of brain tissue
- May reduce the incidence of depression
- May reduce the risk of Alzheimer's disease

Eyes

- Contributes to vision development and nerve growth in retina
- May reduce symptoms of dry eye syndrome

Heart*

- Reduces the risk of cardiovascular disease
- Reduces the risk of stroke
- Helps protect against heart attack and sudden death
- Decreases blood pressure slightly
- Decreases risk of heart arrhythmias
- Decreases blood triglyceride levels and increases HDL (good) cholesterol
- Improves circulation

Lungs

- May reduce symptoms of asthma and bronchitis
 - May decrease risk for COPD (chronic obstructive pulmonary disease)

Muscles

- Helps build muscles and tissues

Joints

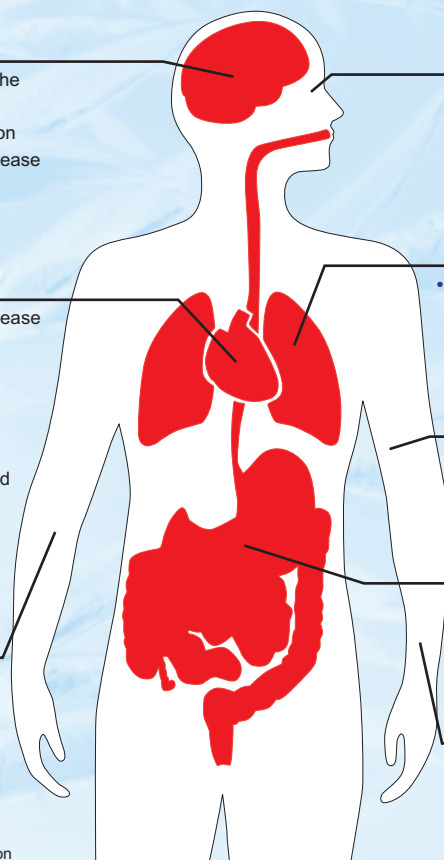
- May help relieve symptoms and inflammation caused by rheumatoid arthritis

Digestion

- May help relieve symptoms of ulcerative colitis and Crohn's disease

Skin

- May ease the effects of aging and sun damage
 - May help relieve symptoms of psoriasis and eczema



*Based on information from the American Heart Association

Source: Recreated from an illustration published by the US National Fisheries Institute 2007



The contemporary diet is deficient in LC omega-3s...



Humans require only about 1% of their fat intake to be LC omega-3s. But changes to our diets over time mean that most contemporary Western human diets are now seriously deficient in LC omega-3s.

Many believe that this is because mankind has reduced its intake of fish and other seafood and is eating more processed food containing omega-6 seed oils such as soya, sunflower and rapeseed/canola.

Others point to reduced direct consumption of dark green leafy vegetables and changes to the diets of the animals from which we obtain meat, milk and eggs - which has resulted in these products containing much less LC omega-3. For example, at one time most poultry ranged free collecting its own food which was more varied and contained a wide range of fatty acids. Chicken and pig diets were also more often supplemented with fishmeal which contains 6 to 10 per cent LC omega-3 rich fish oil.

Up to 75 per cent of the population in some countries do not eat any seafood, the main dietary source of EPA & DHA. Young people in particular are vastly under-consuming EPA & DHA.

RECOMMENDED v. ACTUAL INTAKE

Many national health authorities and physicians recommend an intake of around 500mg/day for healthy adults and more for those with known heart conditions or an excess of fatty triglycerides in the blood.

But actual intake is, according to recent studies, much lower – for example: North America 200mg/day, UK 244mg/day, Australia 100mg/day and Mid Europe 250mg/day. Japan is an exception at 900mg/day.

...and the balance between omega-6s and omega-3s has changed for the worse

Medical advice is, not only to consume plenty of LC omega-3s, but also to reduce intake of omega-6 fatty acids.

In the developed world most of us consume 10 to 20 times as much omega-6s as we do omega-3s. Reducing this to just four or five times as much would considerably improve the overall health and wellbeing of the population - for several reasons.

First, omega-6s compete with omega-3s for the limited supply of the vital enzymes which convert short-chained omega-3s into the essential and important long chain fatty acids. Second, it has now been clearly shown that omega-6 fatty acids, particularly arachidonic acid (AA) contribute to inflammation of tissues, while LC omega-3s are anti-inflammatory.

Third, DHA is the preferred fatty acid for the correct construction and functioning of membranes particularly those in very active tissue such as nerves and *active* muscle.

There is now increasing evidence that higher levels of DHA in membranes make them more mobile and porous and this leads to a higher metabolic rate and a more effective uptake of glucose from the blood. This probably explains why sufficient DHA in the diet can contribute to a reduction in obesity and a reduced incidence of non-insulin dependent diabetes (Type 2).

Ω6



Fish and seafood are the predominant source of EPA & DHA



Significant quantities of *long chain* omega-3s are found in very few unprocessed foods. Marine oils are the only significant natural dietary source of DHA and the major dietary source for EPA. A 2006 study in the UK showed that more than 80% of natural EPA & DHA in human diets came directly from fish and other seafood.

The American Heart Association (AHA) is among the many organisations and experts which advise adequate consumption of EPA and DHA. It recommends that they should be obtained “preferably from oily fish”.

The pelagic fish used to produce fish oil and fishmeal, such as anchovy and menhaden, are rich in EPA & DHA – often with between 1200mg and 2000mg EPA & DHA per 100g.

Long-chain omega-3 content of some common foods

Seafoods	mg/100g	Other Foods	mg/100g
King salmon *	> 2000	Omega-3 enriched foods	Varies
Greenshell/lipped mussels #	950	Eggs regular	80
Hoki (Blue grenadier)	410	Turkey	30
Gemfish	400	Beef	20
Blue eye cod	310	Milk regular	0
Sydney rock oysters	300	Vegetable oils & spreads	0
Tuna canned	230	Regular bread	0
Snapper	220	Cereals, rice, pasta, etc	0
Barramundi saltwater	100	Fruit	0
Giant tiger prawn	100	Vegetables	0

Source: Fatty acid database, RMIT University, Australia as quoted on www.omega-3centre.com spring 2008.

* Massey University analysis. # NZ Crop & Food analysis.



Fish oil is the key to increased intake of natural LC omega-3s

Humans can increase the amount of LC omegas-3s in their diets by consuming more:

1. Farmed fish and seafood fed on a diet including adequate levels of LC omega-3s, such as from marine oils.
2. Fish oil capsules or other LC omega-3 supplements.
3. Meat, eggs or milk from animals whose feed is supplemented with adequate levels of LC omega-3s, such as from marine oils.
4. Enriched foods – where LC omega-3 is added during manufacture.
5. Wild captured fish and seafood.
6. Meat, eggs or milk from animals whose diet is high in grass and certain other feeds available to free ranging animals.



For routes 1 to 4 above the main source of LC omega-3 is natural fish oil and fishmeal (6 to 10% oil content) from the processing of feed grade fish. Feed grade fish are predominantly oily fish, including anchovy and menhaden, which therefore have high EPA & DHA content. Trimmings from food fish processing are also converted to healthy fish oil and fishmeal.



Recommended intake of EPA & DHA



TYPICAL ADULT RECOMMENDED INTAKES of EPA and DHA mg/day

- For those without heart disease 500
- For patients with known coronary artery disease 1000
- For patients with hypertriglyceridemia, regardless of statin use 3000-4000

How much is 500mg/day?

- Two portions of fish per week, one of which is oily
- One tablespoon of standard liquid fish oil taken twice weekly
- One to two capsules standard fish oil per day

While the target can also be achieved by eating foods enriched with omega-3s, it would typically require consumption of 10 glasses of enriched milk per day or three cans of enriched baked beans in sauce per day to achieve the target intake.

LC omega-3 fatty acid supplements can be taken at any time, in full or divided doses, without raising concerns for interactions with any medications. Twice weekly intake of fish or fish oil provides the same benefits as daily consumption of lower doses. DHA and EPA should be consumed in roughly equal quantities.

Global production of liquid fish oil by the fish reduction industry is about 0.9 million tonnes a year. This annual production of fish oil contains in the region of 200,000 tonnes of LC omega-3s EPA and DHA – enough to meet the typical advised intake of 500mg/day of EPA & DHA for about one billion people.



“Omega-3 benefits of farmed salmon are almost 300 times greater than the contaminant risks”

- Fish oil is processed mainly from fish with a very short life span which means they absorb much less toxins such as dioxins, PCBs (Polychlorinated biphenyls) and mercury than large fish.
- Most commonly consumed omega-3-rich seafood - such as salmon, shrimp, sardines, trout, herring, and oysters - are very low in mercury. Farm-raised salmon and rainbow trout have mercury levels similar to their wild counterparts and as much, or more, omega-3 fatty acids. Mercury is water soluble and protein bound and is therefore not extracted into fish oils.
- “Evidence suggests that the benefits of farmed fish (e.g. salmon) consumption outweigh any perceived risks by almost 300-fold” – Douglas R. Tocher, University of Stirling, 2007.
- “91% of PCBs in the American diet come from beef, chicken, pork, dairy products, vegetables and eggs, and not fish. PCB intake from eating farmed salmon twice a week for 70 years would cause an extra six cases of cancer per 100,000 people...yet eating the salmon would prevent at least 7,000 deaths from heart disease” - *Harvard Heart Letter* 2007.



Plant-sourced *shorter chain* omega-3s do not confer the same health protection or benefits



There is a *shorter*-chain omega-3, known as alpha-linolenic (18.3 n-3 ALA), which is found in many land and water plants including seaweed, green vegetables, rapeseed/canola, linseed/flax, olives and walnuts.

In theory animals can convert simple ALA to the fatty acids EPA & DHA which the brain and body need. Some animals can perform this relatively efficiently. However other animals, particularly those that would normally obtain significant quantities of LC omega-3s from their diet, have a very low ability to do this. Fish and humans both fall into this latter category. In humans there is only about 5% conversion of ALA to EPA, and less than 0.5% to DHA.



So while fruits, vegetables and cereal grains make important contributions to a healthy diet, they do not supply significant quantities of the health-enhancing LC omega-3s.

SUBSTITUTING FISH OIL REDUCES EPA & DHA

For several years there has been a move to replace fish oil and fishmeal in farmed carnivorous fish diets with vegetable alternatives. However work by Seierstad of the Norwegian School of Veterinary Science published in 2005 has shown that the fat composition of the salmon meat affected the fatty acid profile of the patients' blood and that the advantageous marine omega-3 fatty acids (EPA & DHA) increased markedly in those patients who ate fish fed on feed containing pure fish oils.

It was also shown that the levels of marker substances for heart and blood vessel diseases in these patients were much better than in patients eating fish fed pure vegetable (rapeseed) oil.

Escalating scientific, public and commercial interest in omega-3s



There is strong and growing consumer, business and professional medical interest in the avoidance of lifestyle diseases and maintenance of quality of life.

For example, among the ageing population there is special concern about heart, brain and eye health; and parents seek out diets for their children that promise improvements in health, intelligence and behaviour.

EPA & DHA are a major focus of this interest. Nearly 1000 scientific papers on these two LC omega-3s were published between 1970 and 2007 and tens of thousands of newspaper, magazine and on-line articles have focused on the same topic.

Omega-3 has emerged as a very important element in the international functional foods market. The United States market for foods and drinks fortified with omega-3 fatty acids grew from \$100 million in 2002 to \$2 billion in 2006, according to the market research company, Packaged Facts. Sales of fish oil supplements in the US are reported to have doubled between 1995 and 2007.



Omega-3 product marketing



Foods supplemented with EPA & DHA from fish oil are being promoted by food manufacturers and retailers across the world with creative product marketing messages - for example:

“Can improve your child’s brain function, attention, concentration and self-control”

“Assists in the development of your baby’s brain, nervous system, vision and intelligence”

“Helps reduce heart disease – the leading cause of death in many countries”

“Relieves joint inflammation”

“Maintains a healthy immune system”

“Improves flexibility of blood vessels to improve circulation”

“Supports the normal development of the brain, the eyes and the nerves”

“A little fish your heart will love”



However, much of the marketing propaganda fails to differentiate between the directly utilised healthy *long chain* omega-3s EPA & DHA (mainly from fish or marine oils) and the *shorter chain* omega-3s like ALA (from plants) which are less easily utilised by humans and so do not provide such health benefits.

Health and welfare benefits for farmed animals and pets

Fish oil, whether in the form of the pure oil or the fish oil content of fishmeal, is an important ingredient in many diets for both farmed animals and domestic pets.

There is evidence that EPA & DHA in fish oil and fishmeal confer a range of health benefits to farm animals, notably in modern production systems, and to pets. Animal welfare organisations recognise welfare benefits to livestock from LC omega-3s.



Benefits for which there is evidence include:

FARMED FISH

Most fish cannot digest carbohydrates well and therefore oils are an important part of their diet to provide energy. In their natural environment fish, particularly marine fish, obtain a lot of EPA and DHA in their normal diet. It is therefore particularly important when farming fish that adequate levels of these essential fatty acids are included in the diet. Recommended daily intakes vary depending on the species but they have been shown to play an important role in:

- Normal growth and development particularly in young fish
- Healthy egg production and development
- Disease resistance and recovery after illness

SHEEP

- Decreased mortality in hill lambs and ewes
- Reduced losses in sheep challenged with worms



continues over



Benefits to animals *continued*



PIGS

- Reduced tail biting among pigs
- Higher numbers of piglets per litter
- Stimulation of the immune system in young pigs
- Reduced effects of sepsis (*E.coli*) in young pigs

POULTRY

- Increasing specific immunity in poultry
- Reduced performance loss due to coccidiosis in broiler chicks
- Resisting the challenge of ascites in broilers
- Reduced pecking
- Improved growth rates among broilers
- Reduced carcass condemnations in broilers
- More fertile cockerels



CATTLE and HORSES

- Improved fertility in the dairy cow
- Decreased risk of colic and laminitis in horses

The preventative and protective qualities of adequate LC omega-3s become even more important when producers of farmed livestock wish to decrease the use of drugs, including antimicrobials, in feed.

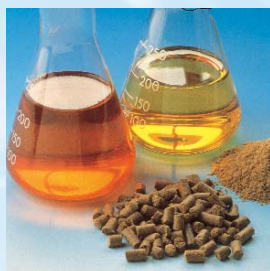


PETS

A growing body of scientific research continues to show that omega-3 fatty acids benefit dogs and cats throughout the various stages of life including pregnancy, lactation, foetal development, growth and aging. The benefits extend to helping companion animals when they suffer from certain disease conditions.

Omega-3 fatty acids are essential for maintaining healthy organ systems and physiological functions. Deficiencies in omega-3 fatty acids may lead to a range of health problems, such as dry itchy skin, recurring skin and ear infections, autoimmune disorders, joint inflammation and arthritis, and loss of mental alertness and inactivity. Omega-3 fatty acids are recognised by veterinarians as important nutrients to incorporate in diets for daily consumption by companion animals.

Production and use of fishmeal and fish oil



Fishmeal and fish oil are produced by processing mainly small, bony, oily fish, such as anchovy, herring, capelin & menhaden, for which there is little demand for human consumption. A smaller percentage is manufactured from fish offal, trimmings or cuttings, and other wastes principally from the filleting and canning of edible fish such as tuna, cod, haddock, hake, and pollock.



The usual process is for the raw material to be cooked, pressed, dried and ground. Pressing removes the liquor which is a mixture of fish oil, water, and soluble protein. The liquor is centrifuged to remove the oil, which is often further refined before being transported to storage tanks. Great care is taken to maintain oil quality during storage.

The solids are dried and ground to produce fishmeal. This usually contains 6 to 10% fish oil, but can be higher or lower.

Fishmeal is a natural, balanced high protein feed ingredient used in diets for farmed fish, as a high protein supplement in nutritionally demanding periods in the life cycles of pigs and poultry, and in pet food.



Most fish oil is used in feeds for farmed fish and there is an expanding market for fish oil for human nutritional supplements and functional foods.

Approximately five million tonnes of fishmeal are produced each year globally, together with just under one million tonnes of fish oil. This varies somewhat year to year and dips significantly during the El Niño phenomenon every few years.

The largest producer of fishmeal and fish oil is Peru followed by Chile. Other important producing countries include Thailand, China, USA, Japan, Denmark, Norway and Iceland.



International Fishmeal and Fish Oil Organisation

The International Fishmeal and Fish Oil Organisation represents the fishmeal and fish oil industry worldwide. It has almost 200 members in approximately 40 countries. IFFO members account for two-thirds of world production and 80 per cent of fishmeal and fish oil traded internationally.

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This guide's contents are supported by a referenced paper, *The importance of increasing dietary levels of EPA and DHA omega-3 fatty acids in both animals and humans*, by Dr Andrew Jackson of IFFO and Anne Chamberlain, which can be accessed in the Benefits section of the IFFO web site, www.iffo.net.

More information on LC omega-3s

www.omega-3centre.com -
Information centre for Australia and New Zealand.

www.goedomega3.com -
Global (Trade) Organisation for EPA & DHA.

www.nutrition.org.uk -
British Nutrition Foundation.

www.dpag.ox.ac.uk -
Oxford University Department of Physiology Anatomy and Genetics.

www.ucd.ie/lipgene -
A project on diet, genomics and the metabolic syndrome: an integrated nutrition, agro-food, social and economic analysis. Funded by the EU.

www.americanheart.org
American Heart Association