Chapter 16

Vitamins and minerals in fish

Dr. G. Usha Rani
Technical Officer (T6)
Biochemistry & Nutrition Division
Central Institute of Fisheries Technology, Cochin - 682 029

Fish is a food of excellent nutritional value, providing high quality protein and a wide variety of vitamins and minerals. Vitamins are organic substances (made by plants or animals), minerals are inorganic elements that come from the soil and water and are absorbed by plants or eaten by animals. Human body needs larger amounts of some minerals, such as calcium, to grow and stay healthy. Other minerals like chromium, copper, iodine, iron, selenium, and zinc are called trace minerals because body needs only very small amounts of them each day.

Vitamins are natural substances found in food that are necessary to keep the body healthy and they are very important in controlling critical metabolic processes. Vitamins fall into two categories: fat soluble and water soluble. The fat soluble vitamins A, D, E and K dissolve in fat and can be stored in the body. The water soluble vitamins C and the B – complex vitamins such as B_6, B_{12}, niacin, riboflavin and foliate need to dissolve in water before the body can absorb them and hence, body cannot store these vitamins. Any vitamin C or B that body does not use as it passes through the system is lost. So we need a fresh supply of these vitamins every day.

In general, both water soluble and fat soluble vitamins are present in fish. Fat soluble vitamins A, D, and E are present in fish in varying amounts often in higher concentration than in land animals. The livers of many fish species contain relatively large concentrations of oil soluble vitamins, and sterols. Vitamins A, D and E are major components of the unsaponifiable portion of fish oils. The amounts vary widely both within and between species and also vary with age, size, sex, nutritional condition, and spawning stage of the

fish, as well as the geographical locale and season of catch. Variation in feeding and the reproductive cycle are most likely responsible for seasonal differences observed in vitamin content of fish oil.

Fat Soluble Vitamins

Vitamin A

Vitamin A has a number of functions in the body - it is needed in the eye for the transmission of light stimuli to the brain and is important for night vision. It promotes the growth and health of all cells and is particularly important for endothelial cells. It is important for reproduction and embryo development and acts as an antioxidant, helping to reduce risks of some cancers and heart disease.

Vitamin A can occur in two different forms - as retinol, which is easily absorbed by the body, or as carotenoids, which are less easily absorbed and have only 50% of the absorption rate of retinol. Carotenoids are converted to vitamin A once absorbed by the body. Fish derive vitamin A from their diet.

The biologically active forms of vitamin A in fish oils are retinol (vitamin A1) and 3-dehydroretinol (vitamin A2). In marine fish, retinol is the major form, and in freshwater fish dehydroretinol is more predominant. Marine oils vary markedly in vitamin A content even within species. Vitamin A is concentrated in the fish liver and is accumulated as the fish ages. Elasmobranchs, or cartilaginous fish, accumulate vitamin A in the liver and much less in other body tissues. In teleosts accumulation is in the liver as well as in other body tissues.

The flesh of lean white fish, such as Cod, Haddock, and Pollock, contains from 25 to 50 IU of vitamin A per 100g, while in the fatty species such as Herring and Mackeral, 100 to about 4500 IU of this vitamin is present in 100g of meat.

Vitamin D

Vitamin D promotes the absorption of calcium and phosphorus from the intestine and regulates blood calcium levels. Without vitamin D the small intestine absorbs no more than 10 to 15% of dietary calcium. Vitamin D is also important in bone metabolism, helping to control bone formation and resorption and it may also play a role in preventing some cancers.

Predominant form of vitamin D in fish oils is vitamin D_3. The flesh of oil-rich fish is a better source of vitamin A and D than white fish, but the liver of both white fish and oil-rich fish are high in both vitamins A and D. Although vitamin D is concentrated in fish liver oils, most oils contain only moderate amounts. The content of vitamin D in Sardines and Pilchards and in Tuna is in the range of 530 to 5400 and 700 to 2000 IU per 100g, respectively. Some Tuna species have highest concentration of vitamin D ie. Up to 2,50,000 IU/g liver oil.

The variation of vitamin D content between and within species is much less than that of vitamin A. Freshwater fish oils contain much lower amounts of vitamin D than oils from marine fish.

Vitamin E

Vitamin E acts as an antioxidant protecting poly unsaturated fats and Low Density Lipoprotein (LDL) cholesterol from oxidation by free radicals and may also have anti-inflammatory effects. Alpha-tocopherol is the most abundant form of vitamin E in fish oils.

Vitamin E is present in significant amounts in many seafoods, for example Salmon and some shellfish, providing up to 15% of the RDA for vitamin E in a 4oz/100g portion. The contents of vitamin E in the edible parts of fish and marine invertebrates range from about 0.2 to 270 mg/100g. The content of tocopherol in fish body oil ranges from less than 1 mg/100g oil to 75 mg/100 g oil. Fish flesh is also a good source of vitamin E. The tocopherol content is directly related to fat content.

Since fish do not synthesize vitamin E, the measurable levels of tocopherol in fish oil are directly related to the fish's diet of algae and seaweed. Content varies greatly among and within fish species, and in almost all species it is higher in fish liver oil than in body oil. The tocopherol content of fish flesh is related to geographic locale, sexual maturity, and seasonal factors, which include diet and temperature. Tocopherol levels in tissues peak during spawning season. Marine fish have higher levels of alpha-tocopherol than freshwater fish of the same species.

Some potential deleterious problems attributed to fish oils are related to their oxidation potential and a subsequent increase in peroxides. Since tocopherols are naturally occurring antioxidants, their presence may enhance the stability of fish oils. Constituent tocopherol can protect living fish from free radical peroxidation, but that residual tocopherol may not provide adequate protection from post mortem auto oxidation in frozen muscle.

Water Soluble Vitamins

Fish is a good source of B vitamins. The red meat has higher content of vitamin B than white meat. Fish liver, eggs, milt and skin are good sources of thiamine (B_1), riboflavin (B_2), niacin (B_3), patothenic acid (B_5), pyridoxine (B_6), biotin (B_7) folic acid (B_9), and cobalamin (B_{12}). Fish do not supply significant amounts of ascorbic acid. A 4oz/100g portion of most fish will provide approximately 10% of the RDA for these vitamins. Fish are especially rich in vitamin B_{12}, supplying 100% or more of the adult RDA in a 4oz/100g portion.

It is found that certain geographical and climatic factors influence the content of B vitamins. Between individuals of the same species the vitamin B_{12} content varies considerably depending on locality, season of capture etc. Dark flesh however contains much more of this vitamin than does white flesh. Cod fish from northern areas contain more B_1 and B_2 than specimens from warmer areas.

Most B vitamins are intimately connected with the basic metabolic activities of the fish. B_{12} is important for the formation of red blood cells. Vitamin B_6 plays vital function in general fat metabolism, conversion of carbohydrates and proteins to fats, B_3 is found in

every cell of the body and is necessary for energy production. Fish generally provide little or no vitamin C. It is reported that fish hold in their eye balls a greater amount of thiamin (B_1). Amount of riboflavin in eyeballs of fish varies widely from one species to another.

Vitamin content of fish and shellfish (per 100g raw edible portion unless otherwise specified)

Type of seafood	Vitamin A μg	Vitamin D μg	Vitamin E mg	Vitamin B_1 mg	Vitamin B_2 mg	Vitamin B_6 mg	Vitamin B_{12} μg
Cod	2	Tr	0.44	0.04	0.05	0.18	1
Haddock	Tr	Tr	0.39	0.04	0.07	0.39	1
Plaice	Tr	Tr	N	0.20	0.19	0.22	1
Herring	44	19	0.76	0.01	0.26	0.44	13
Mackerel	45	8.2	0.43	0.14	0.29	0.41	8
Tuna	26	7.2	N	0.10	0.13	0.38	4
Salmon	13	5.9	1.91	0.23	0.13	0.75	4
Trout (Rainbow)	49	10.6	0.71	0.20	0.11	0.34	5
Oyster	75	1	0.85	0.15	0.19	0.16	17
Mussel	N	Tr	0.74	0.02	0.35	0.08	19
Lobster (boiled)	Tr	Tr	1.47	0.08	0.05	0.08	3
Crab (boiled)	Tr	Tr	N	0.07	0.86	0.16	Tr
Prawn	Tr	Tr	2.85	0.04	0.12	0.05	7

Tr* trace amounts only; N* data not available; mg* milligrams;

Source: Holland, B., Brown, J. & Vyssm D.H. 1993. Fish and fish products; the third supplement to McCance & Widdowson's. The composition of foods (5th edition), HMSO, London. Food Standards Agency (2002) McCance & Widdowson's. The composition of foods sixth summary edition, Cambridge: Royal Society of Chemistry

Estimation of Vitamins

Vitamins often are accompanied by an excess of compounds with similar chemical properties. Thus not only quantification but also identification is mandatory for the detection of vitamins in food. Vitamins generally are labile compounds that should not be exposed to high temperature, light or oxygen.

In recent years, high pressure liquid chromatography (HPLC) has been shown to be a powerful tool for determination of various compounds including water soluble and fat soluble vitamins. HPLC methods have the advantage of being more specific, fast, sensitive, non-

destructive and are capable of differentiating between different forms of a vitamin with varying biological activity.

An extraction and cleanup step prior to chromatographic determination is required for concentration of vitamin. The instrument is calibrated using appropriate dilutions of standard vitamin mixture to obtain a linear graph. The vitamin content in the unknown sample is determined from the linear graph drawn for the standards.

Minerals

Fish are better known for the dietary minerals they supply than for the vitamins. This is because minerals such as iodine and selenium, which are supplied by fish, are found in much lower amounts in non-marine foods. The total mineral content in the raw flesh of fish and aquatic invertebrates is in the range of 0.6 to 1.5% of wet weight. Fish is a good source of almost all the minerals present in seawater. Certain seafood such as snails and tuna are good source of the macro mineral magnesium. Fish contributes appreciable amounts of dietary calcium, iron and zinc. Fish contains copper and those who relish fish bones get a fair share of calcium and phosphorous. The iodine in marine fish ranges from 300 – 3000 μ g/kg. Eating one or two fish meals every week provides the equivalent of 100 to 200 μg of iodine a day, enough to meet the RDA of 130 μg for adults. Tuna is an important source of the essential antioxidant trace element selenium, which provides protection against heavy metal poisonings and a variety of carcinogens. The RDA for selenium is 55 μg for adults. Fish, on average, supplies 20 to 60 μg of selenium per 4oz/100g, whereas cereal and meat sources of selenium only provide about 10 to 12 μg per 4oz/100g.

Selenium

Selenium is incorporated into a number of enzymes in the body; the best known is glutathione peroxidase. This enzyme plays an important role in protecting cell membranes from damage by free radicals. Free radicals are substances formed in the body as part of normal metabolism. They can be very damaging to the body and are linked with increased risk of heart disease and cancer. Selenium also plays key roles in the functioning of the immune system, in thyroid metabolism and in reproduction.

Calcium

Most fish contain only small amounts of calcium although sardines, oysters and shrimps are exceptions, supplying 10 to 20% of the adult RDA in a 4oz/100g portion. The softened bones found in tinned salmon can be eaten, and when they are eaten, the salmon provides up to 300 mg of calcium per 4oz/100g portion, almost half of the adult RDA. Calcium is important for bone health.

Iron

Iron levels are not high in white or oil-rich fish, but since the iron present is easily absorbed, especially from white fish, it is a useful dietary source. Shellfish has high levels of

iron, similar to that of red meat. Iron is essential for carrying oxygen around the body shortage of which leads to weakness of body.

Zinc

Shellfish, in particular oysters, is a rich source of zinc. The reputed aphrodisiac qualities of oysters are commonly attributed to the high level of zinc present, as zinc is important for reproduction. Zinc is needed for body's immune system to properly work. It plays a role in cell division also. With the adult RDA for zinc at 9.5 mg, most shellfish can make a contribution of up to 50% to this, though for other fish, the contribution is between to 5 and 10%.

Iodine

Fish is one of the reliable sources of iodine. Iodine is used to make thyroid hormones, which control many of the body's processes. Iodine is also required for normal neurological development and for energy metabolism.

Mineral content of fish and shellfish (per 100g raw edible portion unless otherwise specified)

Type of seafood	Sodium mg	Potassium mg	Calcium mg	Iron mg	Zinc mg	Iodine μg	Selenium μg
Cod	60	340	9	0.1	0.4	110	28
Haddock	67	360	14	0.1	0.4	250	27
Plaice	120	280	45	0.3	0.5	33	37
Herring	120	320	60	1.2	0.9	29	35
Mackerel	63	290	11	0.8	0.6	140	30
Tuna	47	400	16	1.3	0.7	30	57
Salmon	45	360	21	0.4	0.6	37	26
Trout (Rainbow)	45	420	18	0.3	0.5	13	18
Oyster	510	260	140	5.7	59.2	60	23
Mussel	290	320	38	5.8	2.5	140	51
Crab (boiled)	420	250	N	1.6	5.5	N	84
Prawn	190	330	79	1.6	1.5	21	16

N* data not available; mg* milligrams

Source: Holland, B., Brown, J. & Vyssm D.H. 1993. Fish and fish products;; the third supplement to McCance & Widdowson's. The composition of foods (5th edition), HMSO,

London. Food Standards Agency (2002) McCance & Widdowson's. The composition of foods sixth summary edition, Cambridge: Royal Society of Chemistry.

Estimation of minerals

Atomic absorption spectroscopy is the technique used for the quantitative detection of minerals. It is very reliable and simple to use. The technique is based on the fact that ground state metals absorb light at specific wavelength. Metal ions in a solution are converted to atomic state by means of a flame. Radiation of appropriate wavelength is directed over the flame/graphite furnace and the amount of light absorbed can be measured against a standard curve.