The nutritional benefits of Shellfish

A report commissioned by the Shellfish Association of Great Britain

About the SAGB

The Shellfish Association of Great Britain (SAGB) is a science based trade association representing the shellfish industry in the UK. It works towards the sustainable development of the industry, through lobbying government, by bringing together buyers & sellers and other sea users. The SAGB also strives to promote the high value that shellfish represents in terms of UK seafood landings and in terms of health benefits.

Shellfish
Association of Great Britain

Shellfish Association of Great Britain
Fishmongers' Hall
London Bridge
London
EC4R 9EL

Telephone: 020 7283 8305
www.shellfish.org.uk

About the author

This report was prepared by Dr Andrew Woolmer, a marine biologist specializing in shellfish fisheries and cultivation. Dr Woolmer has a particular interest in the culinary and dietary applications of shellfish.

Important note

All the information in this report has been highly condensed and simplified to make it suitable for a wide audience with varying levels of knowledge. It is not intended to provide personal medical advice and you should not rely upon it for this purpose. The information, opinions and advice contained in this report may not be appropriate for, or be relevant to, your personal circumstances. If you are seeking authoritative advice or information about your personal diet you are advised to consult a medical practitioner.

The SAGB and those who have assisted in the production of this report have used all reasonable endeavours to ensure that its content, the data that has been compiled and the methods of calculation and research are consistent with normally accepted standards and practices. Because this report only provides general guidance and relies upon research results from a variety of sources, no warranty can be given that the information contained in it is free from errors or omissions.

THE NUTRITIONAL BENEFITS OF SHELLFISH

Foreword by Dr Tom Pickerell, Director, Shellfish Association of Great Britain

There's no doubt that healthy eating habits contribute to a healthy body. It has been known for decades that heart health, weight control, illness prevention and overall body functioning are all affected by the food we eat. Although no single food alone can make a person healthy, eating more shellfish is one way that most of us can help improve our diets - and our health.

Shellfish provide protein, vitamins and minerals, are low in fat and a wonderful source of the Omega-3 fatty acids.
Shellfish are excellent sources of protein; a 100 g serving of shellfish provides about 10-25 g of protein, roughly a third to half of the average UK recommended protein intake. The protein in shellfish is of high quality, containing many essential amino acids and very digestible for people of all ages. Shellfish are also generally lower in fat, less than 5%, and accordingly contain fewer calories than beef, poultry or pork. For example, a 100 g portion of prawns (a typical prawn cocktail amount) contains only 0.2 g of saturated fat and 76 calories, whilst 100 g of beef mince contains 6.9 g and 225 calories.

Shellfish are also loaded with vitamins and minerals. Half a dozen oysters provide approximately 10% of the recommended daily amount of vitamin A while a cocktail amount of prawns provide around 50% of the recommended daily amount of vitamin E. There is little Vitamin C found in shellfish, but all shellfish are good sources of the B complex vitamins, particularly B12 with most species exceeding the recommended daily amount by at least 200%. While seafood in general is an excellent source of minerals shellfish are especially valuable sources of copper, iodine and zinc. Other minerals found in shellfish include iron (cockles, oysters and mussels) and selenium (crab, octopus, squid, lobster, shrimps and mussels). Shellfish are also high in potassium, with most species providing 10% of the recommended daily amount per 100 g serving.

Contrary to the 'old wives tale' that certain shellfish (such as prawns) raise cholesterol we now understand that the amount of saturated fat in the diet has a greater effect in raising blood cholesterol than the amount of cholesterol in the diet. A recent trial has shown that even eating 225 g (half a pound) of prawns a day does not raise blood cholesterol. So while dietary cholesterol is present in prawns, crabs and lobsters, as well as in squid and octopus, they contain very little saturated fat and for most people do not cause a rise in the level of cholesterol in the blood. Shellfish such as cockles, mussels, oysters, scallops and clams are very low in cholesterol, about half as much as chicken, and contain much less cholesterol than red meats.

Shellfish are also good sources of 'long chain' Omega-3 fatty acids. These are much more beneficial to our health than the short chain forms found in vegetable foods and oils because the short chain form must first be converted into the long chain form and our bodies are generally not very good at doing that. Different shellfish contain different amounts of omega 3; on average shellfish contain similar amount to whitefish, but crab, oysters and mussels are particularly rich sources, a 100 g portion of each providing a third of the UK recommended weekly intake of omega 3!

Different shellfish have different health benefits so, to make the most of these, we should vary the types we eat. With over 20 species available from UK shores, there's no excuse not to try something new – furthermore 10 of these UK species now appear on the Marine Conservation Society's "Fish to Eat" list so we can be assured that these species are being harvested responsibly.

We hope that you find this report useful and if you are not already including shellfish in your diet, we feel some of the astonishing facts and figures contained in this report will maybe steer you to choosing them. Adding more shellfish to your diet is easy. To help you on your way why not view the Shellfish Association's "how to" videos **www.youtube.com/ShellfishGB** for practical advice on shellfish preparation and for recipes.

GLOSSARY OF TERMS

Alpha-linolenic acid (ALA): a short-chain n-3 fatty acid common in vegetable oils such as rapeseed, flaxseed, hemp and walnut oils. Synthesis of the beneficial long-chain n-3 fatty acids DHA and EPA from ALA is restricted in the body and marine sources such as shellfish are therefore considered to be the best dietary source.

Antioxidant: vitamins or minerals that can slow or prevent cell damage from free radicals produced during normal body metabolism. Shellfish are good sources of antioxidants such as vitamin E, copper, selenium and zinc.

Dietary Reference Values (DRVs): a series of estimates of the amount of energy and nutrients needed by different groups of healthy people in the UK population (source British Nutrition Foundation).

Docosahexaenoic acid (DHA): is an essential long-chain n-3 fatty acid important that can only be obtained from seafood sources the diet. DHA is a major structural component of cell membranes, the brain and nervous system, and is important for maintaining neurological and mental health. Shellfish such as brown crab, mussels and oysters are rich in DHA.

Eicosapentaenoic acid (EPA): is an essential long-chain n-3 fatty acid important that can only be obtained from seafood sources the diet. EPA is a precursor of a group of substances called prostaglandins, which control blood clotting and other arterial functions, and is important along with DHA in maintaining cardiovascular health. Shellfish such as brown crab, mussels and oysters are rich in DHA.

Eicosanoids: are hormone-like substances derived from n-3 and n-6 fatty-acids which function as signalling molecules involved in the regulation of many of the body's systems particularly in inflammation or immunity and as messengers in the central nervous system. Ecosinoids derived from DHA and EPA have anti-inflammatory properties.

Epidemiological study: is a study of factors affecting the health and incidence of disease in a population or country.

Guideline Daily Amounts GDA: UK Guideline Daily Amounts (GDAs) are guidelines for healthy adults and children about the approximate amount of calories, fat, saturated fat, carbohydrate, total sugars, protein, fibre, salt and sodium required for a healthy diet.

High quality dietary protein: a protein source containing all of the essential amino acids are those that are necessary for good health but cannot be synthesized by the body and so must be found in diet. Shellfish are a very good source of high quality dietary protein.

n-3 fatty acid: commonly referred to as omega-3 fatty acids. A family of nutritionally important polyunsaturated fatty acids including DHA and EPA that can only be obtained from the diet. Shellfish such as brown crab, mussels and oysters are rich sources of n-3 fatty acids.

Prospective study: is a study that follows a group or cohort of people over time in order to determine factors affecting long-term health or disease incidence.

Recommended Daily Allowance RDA: Recommended Daily Allowance for vitamins and minerals are based on Department of Health figures for adults leading normal lifestyles.

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Protein

Shellfish are a good source of easily digestible high quality dietary protein (containing all of the essential amino acids). Protein is essential for the body to function and for growth and repair. Protein is constructed of amino acid chains, the amount and type of amino acids in a protein varies between dietary sources. The human body cannot produce certain amino acids through its own metabolism but has to acquire them from the diet; these are known as essential amino acids. Shellfish protein contains high levels of essential amino acids giving shellfish protein a high biological value.

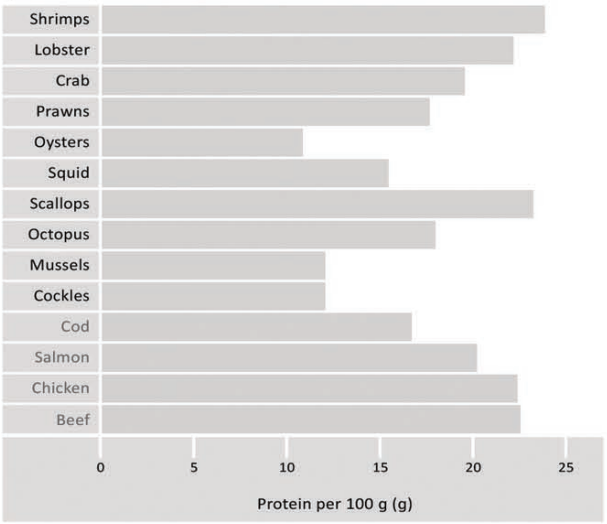
Essential Amino Acids Present in Shellfish

Soleucine	Threonine	Valine	Leucine
Tryptophan	Phenylalanine	Lysine	Methionine

A 100 g serving of shellfish such as lobster, prawns or scallops can provide up to 50% of the GDA for protein for adult men and women. 100 g of shrimps provides 24 g of protein (43% GDA for adult men or 53% GDA for adult women). 100 g of scallops provides 23 g of protein (42% GDA for adult men or 52% GDA for adult women). 100 g of lobster provides 22 g of protein (40% GDA for adult men or 49% GDA for adult women).

A 100 g serving of shrimps can provide more high quality dietary protein than an equivalent serving of beef or chicken.

Figure 1. Chart showing the protein (g) content per 100 g of common shellfish species compared to other foods.

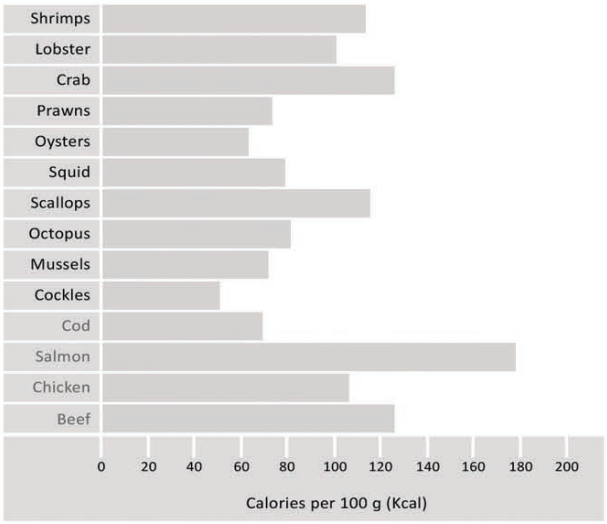


Calories

The energy contained in food is measured in kilocalories (kcal) (commonly referred to as 'calories') or kilojoules (kj). The amount of calories in food varies with the amounts of carbohydrates, fats, proteins and sugars in them. Food containing high levels of fats, such as fatty meats and meat products, are high in calories.

The UK GDA for men is 2500 kcal and for women is 2000 kcal and regularly exceeding these intakes can lead to weight gain and obesity. Shellfish are a low calorie food and especially when compared to other high protein foods; 100 g of cockles contains just 53 kcal (226 kj) and 100 g mussels contains 74 kcal (312 kj) compared to 180 kcal in 100 g of salmon or 129 kcal in 100 g of beef.

Figure 2. *Chart showing the energy (kcal) content per 100 g of common shellfish species compared to other foods .*



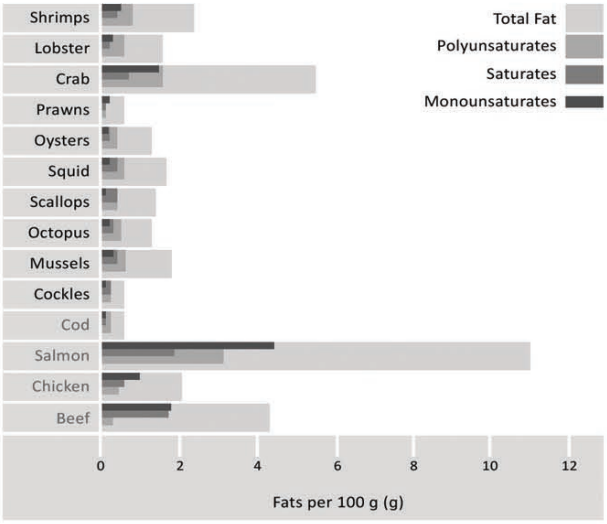
Fats

Although having sufficient fat in the diet is essential for the absorption of some vitamins and as a source of essential fatty acids it is very high in energy and high consumption in the Western diet is generally recognised as being one of the factors in increased rates of obesity.

There are two main types of fat in food; saturated and unsaturated. Saturated fat in the diet is linked high blood cholesterol levels and cardiovascular diseases; the UK Food Standards Agency (FSA) has established RDAs for the average man of 30 g per day and 20 g per day for women.

Saturated fat is found in foods such as fatty cuts of meat and meat products such as sausages and pies. The FSA recommends that more foods containing polyunsaturated fat are included in the diet as that can act to reduce the risks of heart disease and lower cholesterol. The fats found in shellfish are predominantly polyunsaturated fatty acids (PUFA) with a small proportion of monounsaturated and saturated fatty acids.

Figure 3. *Chart showing the fat content per 100 g of common shellfish species compared to other foods*



The fat content of shellfish varies with species but in general they all have a low total fat content. Molluscan shellfish such as cockles, oysters, mussels, and squid have a low fat content of less than 2%. Crustacean shellfish such as prawns, shrimps, lobsters and crabs have a lipid content of between 0.5% – 5.5%.

The fats found in shellfish are predominantly polyunsaturated fatty acids (PUFA) with a small proportion of monounsaturated and saturated fatty acids. Polyunsaturated lipids found in shellfish contain high levels of the nutritionally important long chain n-3 fatty acids (also known as Omega-3s).

The human body is very poor at synthesising the n-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and so it is essential that these are obtained from the diet. Shellfish are particularly good sources of n-3 fatty acids.

A 100 g serving of prawns contains over 18 times less total fat than an equivalent serving of salmon, and a 100 g portion of cockles contains over 7 times less fat than the equivalent serving of beef.

Omega-3 and Omega-6 polyunsaturated lipids (n-3 and n-6 fatty acids)

n-3 and n-6 fatty acids (omega-3 and omega-6) are the two most important polyunsaturated fats in the diet as these cannot be synthesized in the body and have to be obtained from food. The most important dietary source of the long-chain n-3 fatty acids docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are seafood such as oily fish and shellfish. Although both DHA and EPA can be synthesised within the body from Alpha-linolenic acid (ALA) obtained from plant sources the conversion rate is very low, around a 5% conversion from ALA to EPA, and less than 0.5% from ALA to DHA, highlighting the importance of regular intake of shellfish and seafood in the diet.

Figure 4. *common dietary sources of long- and short-chain n-3 and n-6 fatty acids.*

	Name	Shellfish and other dietary sources
Omega-3	Alpha-linolenic acid (ALA)	Walnuts, flaxseed oil, soybean and canola oil
	Eicosapentaenoic acid (EPA)	All shellfish especially crab and oysters, oily fish
	Docosahexaenoic acid (DHA)	All shellfish especially crab and oysters, oily fish
Omega-6	Linoleic acid (LA)	Corn, soybean, cornseed and sunflower oils
	Gamma-linolenic acid (GLA)	Evening primrose, borage and blackcurrent seed oils
	Arachidonic acid (ARA)	Meat, poultry and eggs

There are a number of health benefits to be derived from a diet high in n-3 fatty acids, particularly EPA and DHA. These include protection from cardiovascular disease, particularly sudden cardiac death, protection from certain types of cancer, and the reduction of the symptoms of rheumatoid arthritis [1-7]. In addition, a number of psychiatric disorders, particularly schizophrenia, major depressive disorder (MDD), and attention-deficit hyperactivity disorder (ADHD), have shown positive results when increased n-3 fatty acid intake has been used in conjunction with standard drug therapy [2, 8, 9].

More recently, increased n-3 fatty acid consumption has been suggested to be therapeutic in conditions such as eczema, diabetes, and inflammatory bowel disease [6-10]. n-3 fatty acids have been demonstrated to have a preventative or delaying effect on age related conditions such as Alzheimer's disease and dementia [10, 11]. Recent research suggests that dietary n-3 fatty acids may provide protection from the onset of Parkinson's disease [12, 13]. n-3 fatty acids are important for the visual, cognitive and neurological development of the foetus and infants; in addition n-3 fatty acids may also provide protection against premature deliveries and low birth-weight infants [14-17]. The ratio of n-6 to n-3 fatty acids in the Western diet is currently estimated to be between 8-20:1, (between 8 – 20 parts n-6 fatty acids to 1 part n-3 fatty acids). Historically the ratio was closer to between 1-2:1 and the human body has evolved to function most effectively with low dietary n-6:n-3 ratios. High levels of n-6 fatty acids and a very high n-6:n-3 ratios such as those found in current Western diets can promote the progression of many diseases, including cardiovascular disease, cancer, and inflammatory and autoimmune diseases. Conversely, increased levels of n-3 fatty acids and a corresponding low n-6:n-3 fatty acid ratio, have suppressive effects [18, 19]. Both n-3 and n-6 fatty acids are required by the human body but the correct balance is required for good health.

The polyunsaturated fatty acids present in cell membranes are the basis for the synthesis of hormone-like substances called eicosanoids which function as signalling molecules. Eicosanoids have a key role in the regulation of many of the body's systems particularly in inflammation or immunity and as messengers in the central nervous system. Eicosanoids derived from n-6 fatty acids are generally pro-inflammatory, whereas those derived from n-3 fatty acids are much less so. The more powerful n-6 derived eicosanoids can drive the body into an over reactive state where it can exhibit extreme reactions to stimuli [20].

In this state the human body is more susceptible to cardiovascular disease, high triglycerides levels, high blood pressure and inflammatory conditions such as arthritis [19, 21]. The level of n-3 and n-6 derived eicosanoids in the body is primarily dependent on the availability of n-3 and n-6 fatty acids in the diet; in people with diets high in n-3 fatty acids, particularly from seafood sources, EPA and DHA partially replace the n-6 fats which are normally part of all cell membranes. Increased consumption of foods such as shellfish rich in n-3 fatty acids can reduce the levels of proinflammatory eicosanoids and their effects.

Figure 5 . *The molecular structure of DHA*

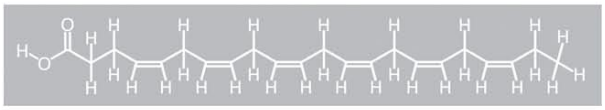
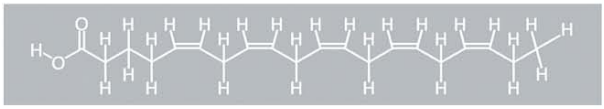


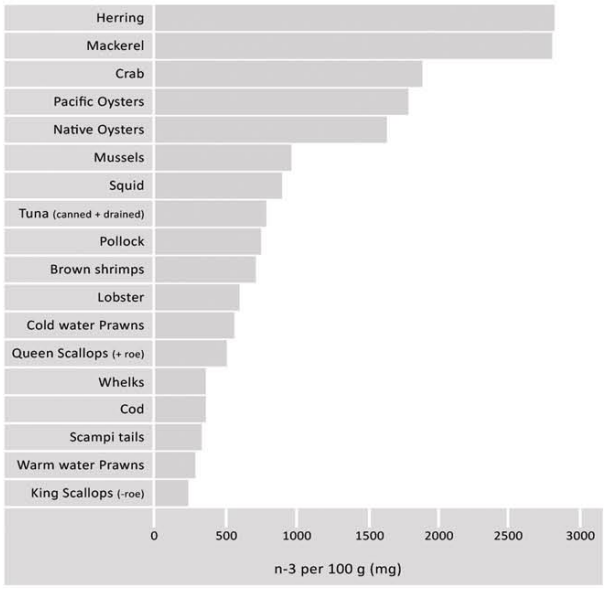
Figure 6. *The molecular structure of EPA*



Recent research has identified a new group of eicosanoid-related compounds derived from the n-3 fatty acids DHA and EPA termed docosanoids which possess both anti-inflammatory and neuroprotective properties [22]. Production of these compounds is promoted in the brain during experimental stroke and in Alzheimer's disease patients and they are believed to be important targets for therapeutic intervention [23, 24]. The discovery of these compounds may go some way to explain the molecular basis in understanding the beneficial effects of these fatty acids.

High n-6 to n-3 fatty acid ratios in the diet can be addressed by avoiding foods high in n-6 fatty acids and consuming more high n-3 fatty acid containing food; ideally foods should have a n-6:n-3 ratios of less than 4:1. Foods high in n-6 fatty acids include many vegetable oils, especially sunflower, olive and corn oils. Certain shellfish contain high levels of n-3 fatty acids and their inclusion in the diet can help to redress the n-6:n-3 balance.

Figure 7. *Chart showing the n-3 (omega 3) content per 100 g of common shellfish species compared to other seafoods .*



Brown crab and oysters are especially rich sources of n-3 fatty acids and shellfish such as mussels, squid, shrimps, cockles and lobsters are considered to be a good source.

There is currently no official recommended daily amount for omega-3 either for adults or children although the Scientific Advisory Committee on Nutrition (SACN) and the Committee on Toxicity (COT) consider that consumption a minimum of 450 mg of long-chain fatty acids per day as part of a healthy, balanced diet, is sufficient to maintain health. Regular inclusion of shellfish in the diet can address these recommendations.

Figure 8. *Chart showing the macronutrient content per 100 g of common shellfish species compared to other foods .*

per 100g	Shrimps (boiled)	Lobster (boiled)	Crab (boiled)	Prawns (raw)	Oysters (raw)	Squid (raw)	Scallops (steamed)	Octopus (raw)	Mussels (raw)	Cockles (boiled)	Cod*	Salmon*	Chicken*	Beef*
Energy (kcal)	117.0	103.0	128.0	76.0	65.0	81.0	118.0	83.0	74.0	53.0	72.0	180.0	108.0	129.0
GDA (M)	4.7%	4.1%	5.1%	3.0%	2.6%	3.2%	4.7%	3.3%	3.0%	2.1%	2.9%	7.2%	4.3%	5.2%
GDA (F)	5.9%	5.2%	6.4%	3.8%	3.3%	4.1%	5.9%	4.2%	3.7%	2.7%	2.7%	9.0%	5.4%	6.5%
Energy (kj)	493.0	435.0	535.0	321.0	275.0	344.0	501.0	352.0	312.0	226.0	306.0	750.0	457.0	542.0
GDA (M)	4.7%	4.1%	5.1%	3.0%	2.6%	3.2%	4.7%	3.3%	3.0%	2.2%	2.9%	7.2%	4.3%	5.2%
GDA (F)	5.9%	5.2%	6.4%	3.8%	3.3%	4.1%	5.9%	4.2%	3.7%	2.7%	2.7%	9.0%	5.4%	6.5%
Protein (g)	23.8	22.1	19.5	17.6	10.8	15.4	23.2	17.9	12.1	12.0	16.7	20.2	22.3	22.5
GDA (M)	43.3%	40.2%	35.5%	32.0%	19.6%	28.0%	42.2%	32.6%	22.0%	21.8%	30.4%	36.7%	40.6%	40.9%
GDA (F)	52.9%	49.1%	43.3%	39.1%	24.0%	34.2%	51.6%	39.8%	26.9%	26.7%	37.1%	44.9%	49.6%	50.0%
Fat (g)	2.4	1.6	5.5	0.6	1.3	1.7	1.4	1.3	1.8	0.6	0.6	11.0	2.1	4.3
GDA (M)	2.5%	1.7%	5.8%	0.6%	1.4%	1.8%	1.5%	1.4%	1.9%	0.6%	0.6%	11.6%	2.2%	4.5%
GDA (F)	3.4%	2.3%	7.9%	0.9%	1.9%	2.4%	2.0%	1.9%	2.6%	0.9%	0.9%	15.7%	3.0%	6.1%
Polyunsaturates (g)	0.8	0.6	1.6	0.1	0.4	0.6	0.4	0.5	0.6	0.2	0.2	3.1	0.4	0.2
Monounsaturates (g)	0.5	0.3	1.5	0.2	0.2	0.2	0.1	0.2	0.3	0.1	0.1	4.4	0.1	1.8
Saturates (g)	0.4	0.2	0.7	0.1	0.2	0.4	0.4	0.3	0.4	0.2	0.1	1.9	0.6	1.7
GDA (M)	1.3%	0.7%	2.3%	0.3%	0.7%	1.3%	1.3%	1.0%	1.3%	0.7%	0.3%	6.3%	2.0%	5.8%
GDA (F)	2.0%	1.0%	3.5%	0.5%	1.0%	2.0%	2.0%	1.5%	2.0%	1.0%	0.5%	9.5%	3.0%	8.7%
Carbohydrates (g)	Trace	1.1	Trace	0.0	Trace	1.2	3.4	Trace	2.5	Trace	0.0	0.0	0.0	0.0
GDA (M)	-	-	-	-	-	0.4%	1.1%	-	-	-	-	-	-	-
GDA (F)	-	-	-	-	-	0.5%	1.5%	-	-	-	-	-	-	-
Sugars (g)	Trace	Trace	Trace	0.0	Trace	Trace	Trace	Trace	Trace	Trace	0.0	0.0	0.0	0.01

The nutritional composition data used in this table are drawn from the Food Standards Agency's benchmark, Holland B., Brown, J. & Buss, D.H. (1993). Fish and Fish Products. Third supplement to 6th edition of McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry, Cambridge.
**(Beef, average, trimmed lean, raw)*
**(Chicken, meat only, average, raw)*
**(Salmon raw)*
**(Cod frozen raw)*

THE VITAMINS AND MINERALS COMPOSITION OF SHELLFISH

Shellfish are a good source of essential vitamins and minerals and particularly vitamin B12, copper, iron, iodine selenium and zinc. Shellfish are particularly good sources of antioxidant minerals such as copper, selenium and zinc.

B Vitamins (Thiamin B1, Riboflavin B2, Niacin, Vitamins B6 and B12)

Shellfish are a source of the B vitamins particularly niacin (B3), B6 and B12. Although chemically distinct, these water soluble vitamins share certain characteristics and frequently coexist in the same foods. The B vitamins act as 'co-factors' in different enzyme systems in the body and are necessary for the release and utilisation of energy from food, the metabolism of protein and fat, cell and blood cell formation and the maintenance of a healthy nervous system. As the B vitamins are water soluble they are not stored in the human body and therefore have to be obtained daily from the diet.

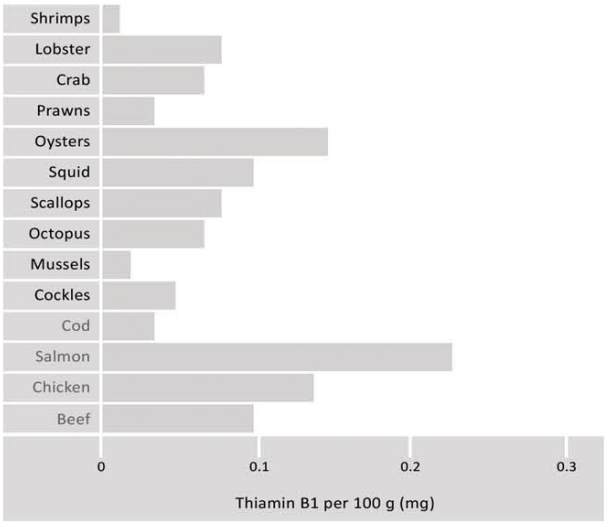
Thiamin (Vitamin B1)

Oysters are a useful source of thiamin, also known as vitamin B1. Thiamin is a key coenzyme with other B-vitamins in the breakdown and release of energy from the diet. Thiamin also has a role in the function of neuronal cells and muscle tissues. Thiamin cannot be produced by the human body and has to be obtained from the diet daily. Thiamin deficiency causes the malnutrition disease beriberi and Wernicke-Korsakoff syndrome associated with chronic alcoholism [25].

100 g of oysters provides 150 µg of thiamin (15% RDA for adult men and 19% for adult women).

Oysters contain 50% more thiamin than beef and nearly 4 times more than is found in cod.

Figure 9. *Chart showing the thiamin content per 100 g of common shellfish species compared to other foods .*



Riboflavin (Vitamin B2)

Molluscan shellfish such as mussels and oysters are a source of riboflavin, also known as vitamin B2. Riboflavin has a variety of important roles in the production of steroids and red blood cells, the promotion of normal growth, and the maintenance of the skin, eyes, nervous system and mucous membranes. Riboflavin may also play a role in iron absorption in the digestive tract and support the activity of antioxidants. Riboflavin cannot be produced by the human body and has to be obtained from the diet daily.

Turnover of riboflavin in the human body is thought to be related to energy expenditure, and therefore physically active peoples may have an increased requirement of riboflavin in their diet [26].

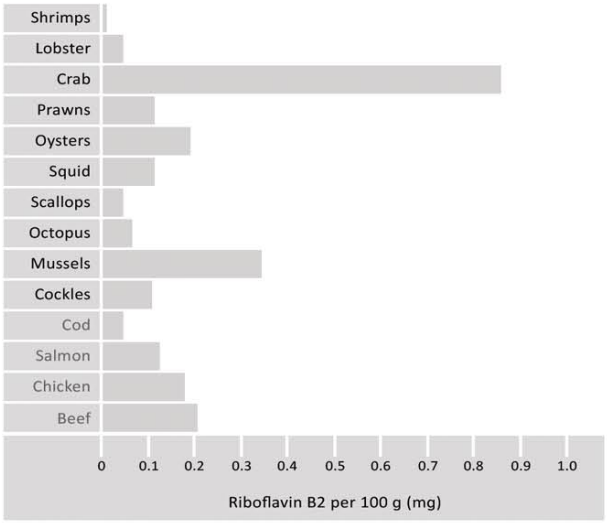
Riboflavin deficiency may result in a variety of symptoms including dry and cracked skin, itching, dizziness, insomnia, and a sensitivity to bright light.

Riboflavin deficiency can also cause inflammation of the mucous membranes in the mouth and of the tongue, a sore throat and anaemia.

100 g of mussels provides 350 µg of riboflavin (27% RDA for adult men and 32% for adult women). 100 g of oysters provides 190 µg of riboflavin (15% RDA for adult men and 17% for adult women).

Mussels contain nearly 3 times the amount of riboflavin than salmon and nearly twice that found in chicken.

Figure 10. *Chart showing the riboflavin content per 100 g of common shellfish species compared to other foods .*



Niacin (Vitamin B3)

Molluscan shellfish such as octopus and squid are a source of niacin. Niacin has a variety of key functions including the conversion of food to energy and the function of the nervous and digestive system.

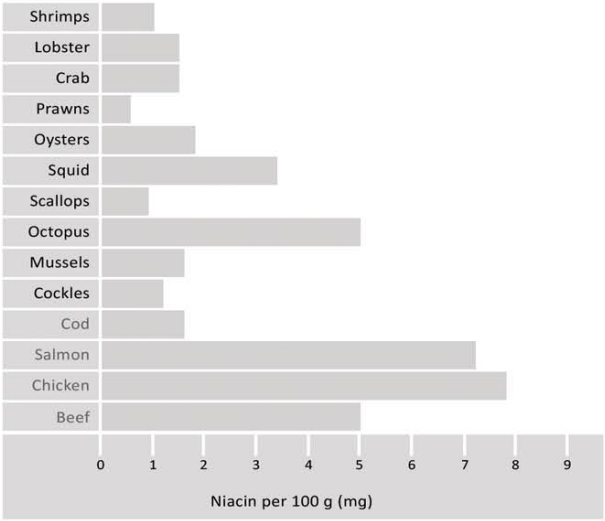
Niacin deficiency can cause changes to the skin, mucous membranes of the mouth, stomach and intestinal tract and the nervous system. These symptoms are characteristic of the deficiency disease 'pellagra'.

Niacin cannot be produced by the human body and has to be obtained from the diet daily.

100 g of octopus provides 5 mg of niacin (29% RDA for adult men and 38% for adult women). 100 g of squid provides 3.4 mg of niacin (20% RDA for adult men and 29% for adult women).

Octopus contains over 3 times the amount of niacin than cod and the same amount as found in beef.

Figure 11. Chart showing the niacin content per 100 g of common shellfish species compared to other foods .



Vitamin B6

Molluscan shellfish such as octopus and squid are a source of vitamin B6. Vitamin B6 acts as a coenzyme to other enzymes and is necessary for a variety of metabolic functions.

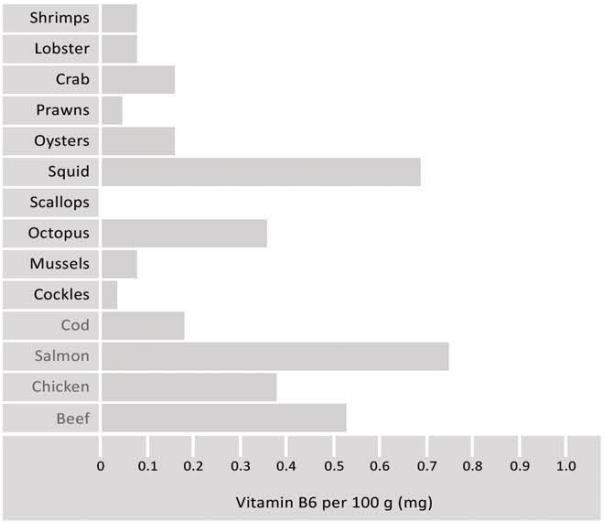
Vitamin B6 is involved in cellular replication and antibody production as well as being required for the function of the nervous system. The vitamin has a role in the biosynthesis of several neurotransmitters including serotonin, gamma amino-butyric acid (GABA), dopamine and noradrenaline; it therefore plays a key role in the regulation of mental processes and health [27].

Vitamin B6 is also involved in the sodium-potassium balance, histamine metabolism, and the production of niacin. In the gastrointestinal tract vitamin B6 plays a role in the absorption of vitamin B12 and the production of hydrochloric acid.Vitamin B6 cannot be produced by the human body and has to be obtained from the diet daily.

100 g of squid provides 690 µg of vitamin B6 (49% RDA for adult men and 58% for adult women). **100 g of octopus provides 360 µg of vitamin B6 (26% RDA for adult men and 30% for adult women).**

Squid contains nearly twice the amount of vitamin B6 than chicken and nearly 4 times more than cod.

Figure 12. Chart showing the vitamin B6 content per 100 g of common shellfish species compared to other foods .



Vitamin B12

Molluscan shellfish such as cockles, oysters, and mussels are a particularly good source of B12. Vitamin B12 is important for the normal functioning of the brain and nervous system and plays a key role in the formation of red blood cells. B12 cannot be produced by the human body and has to be obtained from animal sources in the diet such as meat (liver), milk and eggs.

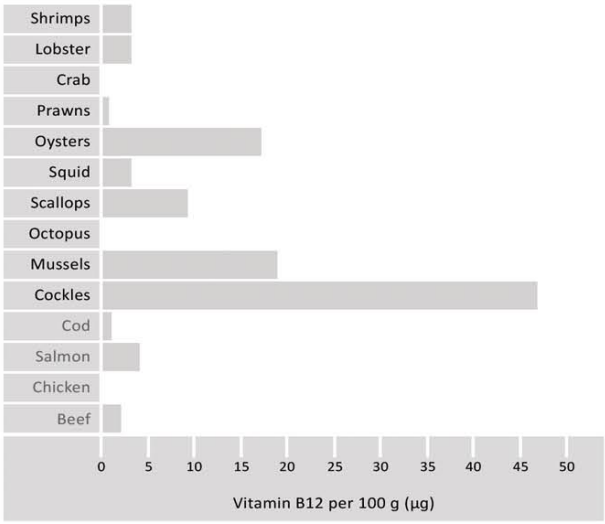
Deficiency of vitamin B12 may result in anaemia, fatigue, weakness, constipation, loss of appetite and weight loss [28-30]. B12 deficiency can also result in neurological problems such as numbness and tingling in the extremities [31, 32]. Depression, confusion, dementia, poor memory [33] and Alzheimer's Disease [32, 34] have also been implicated in vitamin B12 deficiency.

100 g of cockles provides 47 µg of vitamin B12 (3133% RDA for adult men and women). **100 g of mussels provides 19 µg of vitamin B12 (1267% RDA for adult men and women).** 100 g oysters provides 17 µg of vitamin B12 (1133% RDA for adult men and women).

Crustacean shellfish such as lobsters, prawns and shrimps are also rich in vitamin B12. **100 g lobster or shrimps provides 3 µg of vitamin B12 (200% RDA for adult men and women).** 100 g of prawns provides 0.70 µg of vitamin B12 (47% RDA for adult men and women).

Cockles contains over 23 times the amount of vitamin B12 than beef and nearly 12 times more than salmon. Mussels contain over 9 times the amount of vitamin B12 than beef and nearly 5 times more than salmon.

Figure 13. Chart showing the vitamin B12 content per 100 g of common shellfish species compared to other foods .



Vitamin E

Shellfish such as prawns, lobster, squid, oysters and mussels are a good source of vitamin E. Vitamin E is the name given to a group of eight lipid-soluble compounds primarily synthesised by plants but stored in shellfish from their diet..

Vitamin E is an important antioxidant and plays a key role in the maintenance of membrane integrity in practically all cells in the human body [35]. The different forms of Vitamin E may have a variety of antioxidant functions and be protective against cardiovascular disease and some forms of cancer.

Vitamin E deficiency is rare but may occur in people with underlying health problems affecting their ability to absorb it from their diet. Vitamin E deficiency has been related to cystic fibrosis, chronic liver disease, short-bowel syndrome, and other malabsorption syndromes which may lead to varying degrees of neurologic deficits.

100 g of prawns provides 2.9 mg of vitamin E (71% RDA for adult men and 95% for adult women).
100 g of lobster provides 1.47 mg of vitamin E (37% RDA for adult men and 49% for adult women).
100 g of squid provides 1.2 mg of vitamin E (30% RDA for adult men and 40% for adult women).
100 g of oysters provides 850 µg of vitamin E (21% RDA for adult men and 28% for adult women).
100 g of mussels provides 740 µg of vitamin E (19% RDA for adult men and 25% for adult women).

Prawns contain nearly 22 times the vitamin E found in beef and 19 times that of chicken

Figure 14. *Chart showing the vitamin E content per 100 g of common shellfish species compared to other foods .*

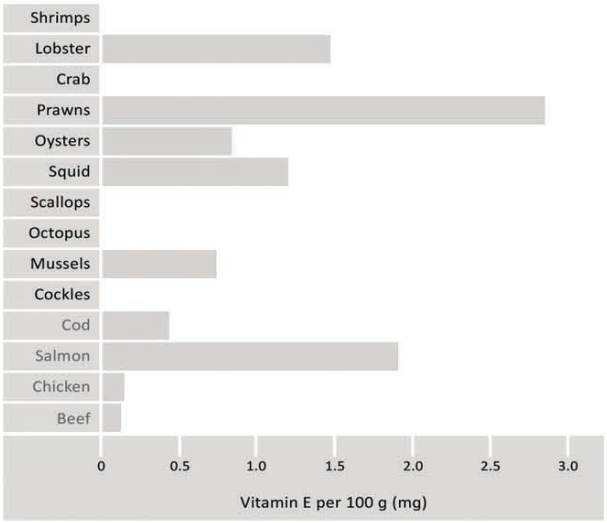


Figure 15. *Chart showing the vitamin content per 100 g of common shellfish species compared to other foods .*

per 100g	Shrimps (boiled)	Lobster (boiled)	Crab (boiled)	Prawns (raw)	Oysters (raw)	Squid (raw)	Scallops (steamed)	Octopus (raw)	Mussels (raw)	Cockles (boiled)	Cod*	Salmon*	Chicken*	Beef*
Vitamin A (ug) (Retinol)	0.0	Trace	Trace	Trace	75.0	15.0	Trace	5.0	0.0	40.0	2.0	13.0	11.0	Trace
RDA (M)	-	-	-	-	10.7%	2.1%	-	0.7%	-	5.7%	0.3%	1.9%	1.6%	-
RDA (F)	-	-	-	-	12.5%	2.5%	-	0.8%	-	6.7%	0.3%	2.8%	1.8%	-
Vitamin C (mg)	Trace	Trace	Trace	Trace	Trace	0.0	Trace	0.0	Trace	Trace	Trace	Trace	0.0	0.0
Vitamin D (ug)	Trace	Trace	Trace	Trace	1.0	Trace	Trace	Trace	Trace	Trace	Trace	5.9	0.1	0.5
RDA (M)	-	-	-	-	20.0%	-	-	-	-	-	-	118.0%	2.0%	10.0%
RDA (F)	-	-	-	-	20.0%	-	-	-	-	-	-	118.0%	2.0%	10.0%
Vitamin E (mg)	0.0	1.5	0.0	2.9	0.9	1.2	0.0	0.0	0.7	0.0	0.4	1.9	0.2	0.1
RDA (M)	-	36.8%	-	71.3%	21.3%	30.0%	-	-	18.5%	-	11.0%	47.8%	3.8%	3.3%
RDA (F)	-	49.0%	-	95.0%	28.3%	40.0%	-	-	24.7%	-	14.7%	63.7%	5.0%	4.3%
Thiamin B1 (mg)	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
RDA (M)	1.0%	8.0%	7.0%	4.0%	15.0%	10.0%	8.0%	7.0%	2.0%	5.0%	4.0%	23.0%	14.0%	10.0%
RDA (F)	1.3%	10.0%	8.0%	5.0%	18.8%	12.5%	10.0%	8.8%	2.5%	6.3%	5.07%	28.8%	17.5%	12.5%
Riboflavin B2 (mg)	0.1	0.1	0.9	0.1	0.2	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.2	0.2
RDA (M)	0.7%	3.9%	66.2%	9.2%	14.6%	9.2%	3.8%	5.4%	26.9%	8.5%	3.9%	10.0%	13.8%	16.2%
RDA (F)	0.9%	4.6%	78.2%	10.9%	17.3%	10.9%	4.5%	6.4%	31.8%	10.0%	4.6%	11.8%	16.4%	19.1%
Niacin (mg)	1.0	1.5	1.5	0.5	1.8	3.4	0.9	5.0	1.6	1.2	1.6	7.2	7.8	5.0
RDA (M)	5.9%	8.9%	8.8%	2.9%	10.6%	20.0%	5.3%	29.4%	9.4%	7.1%	9.4%	42.4%	45.9%	29.4%
RDA (F)	7.7%	11.5%	11.5%	3.8%	13.8%	26.2%	6.9%	38.5%	12.3%	9.2%	12.3%	55.4%	60.0%	38.5%
Vitamin B6 (mg)	0.1	0.1	0.2	0.1	0.2	0.7	0.0	0.4	0.1	0.1	0.2	0.8	0.4	0.5
RDA (M)	5.7%	5.7%	11.4%	3.6%	11.4%	49.3%	-	25.7%	5.7%	2.9%	12.9%	53.6%	27.1%	37.9%
RDA (F)	6.7%	6.7%	13.3%	4.2%	13.3%	57.5%	-	30.0%	6.7%	3.3%	15.0%	62.5%	31.7%	44.2%
Vitamin B12 (ug)	3.0	3.0	Trace	0.7	17.0	3.0	9.0	0.0	19.0	47.0	1.0	4.0	Trace	2.0
RDA (M)	200.0%	200.0%	-	46.7%	1133.3%	200.0%	600.0%	-	1266.7%	3133.3%	66.7%	266.7%	-	133.2%
RDA (F)	200.0%	200.0%	-	46.7%	1133.3%	200.0%	600.0%	-	1266.7%	3133.3%	66.7%	266.7%	-	133.2%
Folic acid (ug)	9.0	9.0	20.0	0.0	0.0	13.0	18.0	0.0	37.0	0.0	6.0	16.0	19.0	19.0
DRV (M)	4.5%	4.5%	10.0%	-	-	6.5%	9.0%	-	18.5%	-	3.0%	8.0%	9.5%	9.5%
DRV (F)	4.5%	4.5%	10.0%	-	-	6.5%	9.0%	-	18.5%	-	3.0%	8.0%	9.5%	9.5%

The nutritional composition data used in this table are drawn from the Food Standards Agency's benchmark, Holland B., Brown, J. & Buss, D.H. (1993). Fish and Fish Products. Third supplement to 6th edition of McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry, Cambridge.
**(Beef, average, trimmed lean, raw)*
**(Chicken, meat only, average, raw)*
**(Salmon raw)*
**(Cod frozen raw)*

Iodine

Shellfish such as cockles, mussels, oysters, lobsters and shrimps are a particularly good source of iodine. Iodine is a naturally occurring element present in seawater, some rocks and soils. Iodine is a key constituent of the thyroid hormones thyroxine and tridothyronine involved in the maintenance of metabolic rate, cellular metabolism and the connective tissue. The thyroid hormones are necessary during the development of the nervous system in the foetus and infants.

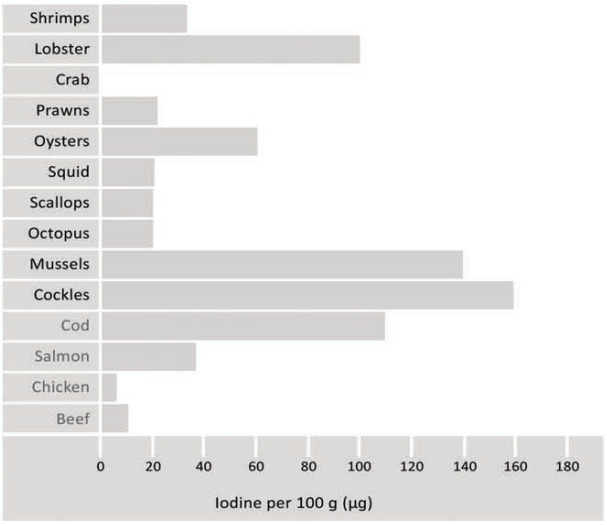
Iodine deficiency can cause hypothyroidism which manifests as a series of symptoms including low energy levels, dry or yellowish skin, tingling and numbness in extremities, weight gain, forgetfulness, depression, anaemia, and prolonged and heavy periods in women. Iodine deficiency during pregnancy is associated with an increased risk of miscarriage, stillbirth and congenital abnormality. Iodine deficiency in the developing foetus and children in early infancy can result in mental retardation, deaf mutism and severe motor impairments [36].

100 g of cockles provides 160 µg of iodine (114% DRV for adult men and women). 100 g of mussels provides 140 µg of iodine (100% DRV for adult men and women). 100 g of lobster provides 100 µg of iodine (71% DRV for adult men and women). 100 g of oysters provides 60 µg of iodine (43% DRV for adult men and women). 100 g of shrimps provides 33 µg of iodine (24% DRV for adult men and women).

Cockles contain nearly 4 times the iodine found in salmon and 23 times that found in chicken.

Iodine interacts with selenium in the synthesis of thyroid hormones and it is important that these elements are equally available in the body.

Figure 16. *Chart showing the iodine content per 100 g of common shellfish species compared to other foods .*



Selenium

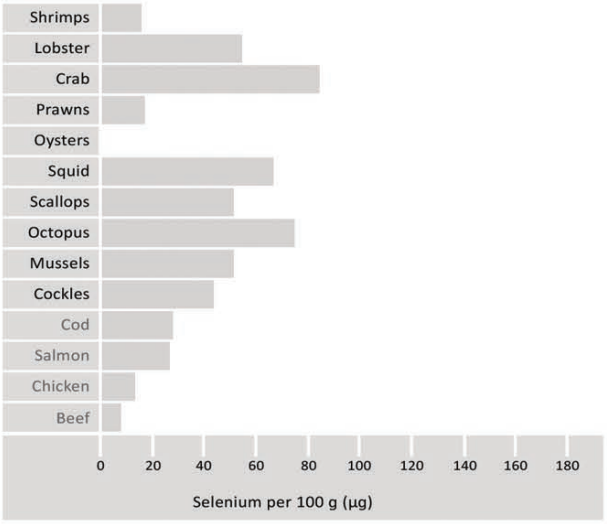
All shellfish are a good source of selenium. Shellfish such as crabs, octopus, squid, mussels and scallops are particularly rich in selenium. Selenium is a naturally occurring element present in soils and rocks. Selenium plays an important role in the function of the immune system, in thyroid hormone metabolism and synthesis and in reproduction. Selenium also plays a key role in the human body's antioxidant defence system, preventing damage to cells and tissues [37].

Selenium deficiency is associated with Keshan disease, a congestive heart muscle disease which affects children and women of child-bearing age.

100 g of crab meat provides 84 µg of selenium (112% DRV for adult men and 140% DRV for adult women). 100 g of octopus provides 75 µg of selenium (100% DRV for adult men and 125% DRV for adult women). 100 g of squid provides 66 µg of selenium (88% DRV for adult men and 110 DRV for adult women). 100 g of lobster provides 54 µg of selenium (72% DRV for adult men and 90% DRV for adult women). 100 g of mussels or scallops provides 51 µg of selenium (68% DRV for adult men and 85% DRV for adult women).

Crab meat contains 3 times the amount of selenium than cod and 12 times that of beef.

Figure 17. *Chart showing the selenium content per 100 g of common shellfish species compared to other foods .*



Copper

All shellfish are a good source of copper. Shellfish such as oysters, crabs, lobsters, shrimps, octopus, and cockles and mussels are a particularly good source of copper.

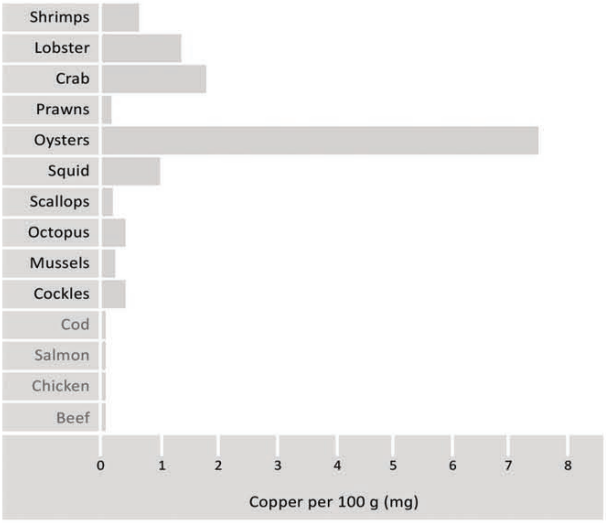
Copper is a naturally occurring element present in the form of mineral salts and organic compounds. Copper plays a role in the function of a number of enzymes which are involved in cellular metabolism and respiration, and antioxidant defence.

Copper is important for infant growth, host defence mechanisms, bone strength and health, red and white cell synthesis and maturation, iron transport, cholesterol and glucose metabolism, myocardial contractility and brain development [38].Copper deficiency is rare but is associated with anaemia, neutropenia and bone abnormalities.

100 g of crab meat provides 1.8 mg of copper (148% DRV for adult men and women). 100 g of octopus provides 0.4 mg of copper (33% DRV for adult men and women). 100 g of squid provides 1.0 mg of copper (82% DRV for adult men and women). 100 g of lobster provides 1.4 mg of copper (113% DRV for adult men women). 100 g of mussels or scallops provides 0.2 mg of copper (18% DRV for adult men and women).

Crab meat contains nearly 30 times the copper found in cod and over 56 times that found in salmon, chicken and beef.

Figure 18. *Chart showing the copper content per 100 g of common shellfish species compared to other foods .*



Phosphorus

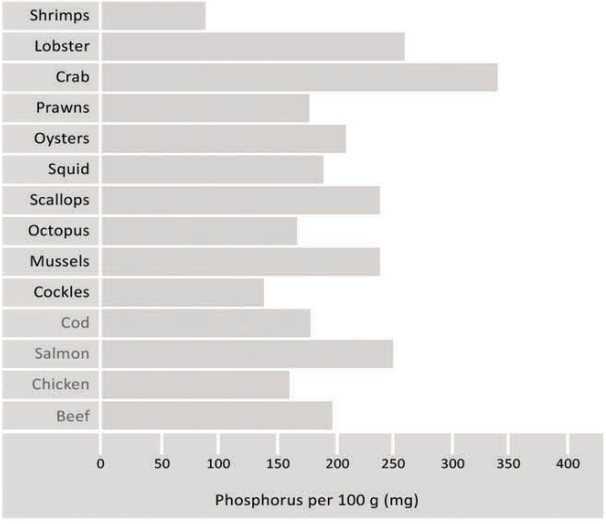
All shellfish are a source of phosphorus. Shellfish such as crabs, lobsters, mussels, scallops and prawns are good sources of phosphorus.

Phosphorus is a naturally occurring element found as phosphate in all plant and animal cells and is a component of all important classes of biochemical compounds. Phosphorus is a constituent of phospholipids which are key structural components of biological membranes and is also a constituent of nucleotides and nucleic acids. Phosphorus plays a key role in cellular respiration and metabolism and is important in skeletal health and development [39].

100 g of crab provides 340 mg of phosphorus (62 % DRV for adult men and women). 100 g of lobster provides 260 mg of phosphorus (47 % DRV for adult men and women). 100 g of mussels or scallops provides 240 mg of phosphorus (44 % DRV for adult men and women). 100 g of oysters provides 210 mg of phosphorus (38 % DRV for adult men and women). 100 g of prawns provides 180 mg of phosphorus (33 % DRV for adult men and women).

Crab meat contains over twice the phosphorus found in cod and 41% more than beef.

Figure 19. *Chart showing the phosphorus content per 100 g of common shellfish species compared to other foods .*



Zinc

Zinc is present in all shellfish, but oysters are a particularly good source.

Zinc is a naturally occurring element found in all plant and animal tissues and in seawater and is a key constituent or cofactor in over two hundred metalloenzymes.

Zinc has an important role in the production and stabilisation of genetic material and is vital for cell division and the synthesis and metabolism of carbohydrates, lipids and proteins. Zinc also promotes wound healing [40].

Zinc deficiency has a number of symptoms and effects including poor foetal development, growth and mental retardation in infants.

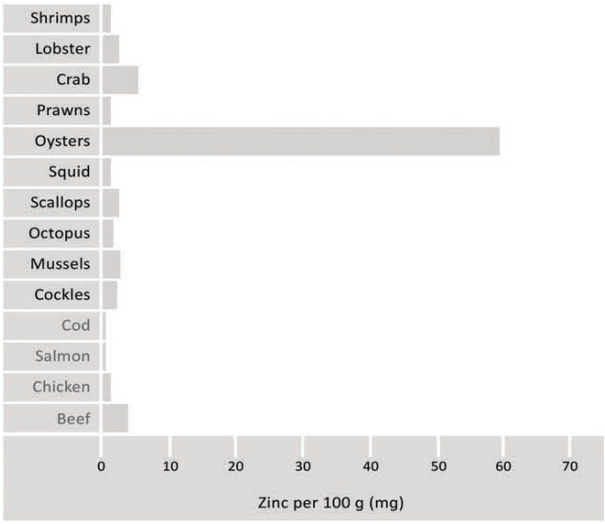
Neurological effects of zinc deficiency include impaired nerve conduction and nerve damage.

Other symptoms are reproductive failure, dermatitis and hair loss, diarrhoea, loss of appetite with loss of taste and smell, and anaemia. Zinc deficiency also leads to increased susceptibility to infections, delayed wound healing and macular degeneration.

100 g of oysters provides 59.2 mg of zinc (623 % DRV for adult men and 846 % for adult women). 100 g of crab provides 5.5 mg of zinc (58 % RDA for adult men and 79% for adult women). 100 g of scallops provides 2.6 mg of zinc (27 % RDA for adult men and 37 % for adult women). 100 g of lobster or mussels provides 2.5 mg of zinc (26 % RDA for adult men and 36 % for adult women).

Oysters contain over 14 times the zinc found in beef and nearly 50 times more than chicken.

Figure 20. *Chart showing the zinc content per 100 g of common shellfish species compared to other foods .*



Iron

All shellfish are sources of iron but cockles are a particularly good source. Iron is a naturally occurring element found widely in nature and many plant and animal tissues. Iron is a key constituent of haem-containing proteins such as haemoglobin and myoglobin, which are responsible for oxygen transport in the blood, and cytochromes which are involved in electron transfer in the mitrochondia.

Iron deficiency results in iron-deficiency anaemia, the condition where there is too few red blood cells or not sufficient haemoglobin in the blood.

The symptoms of iron-deficiency anaemia include breathlessness, tiredness, dizziness, headaches, palpitations or a rapid weak pulse, and feeling cold.

100 g of cockles provides 28 mg of iron (322% DRV for adult men and 190% for adult women). 100 g of mussels provides 5.8 mg of iron (67 % RDA for adult men and 39% for adult women). 100 g of oysters provides 5.7 mg of iron (67% RDA for adult men and 39% for adult women).

Cockles contain over 10 times the amount of iron found in beef and mussels and oysters contain over 8 times more iron than chicken.

Figure 21. *Chart showing the iron content per 100 g of common shellfish species compared to other foods .*

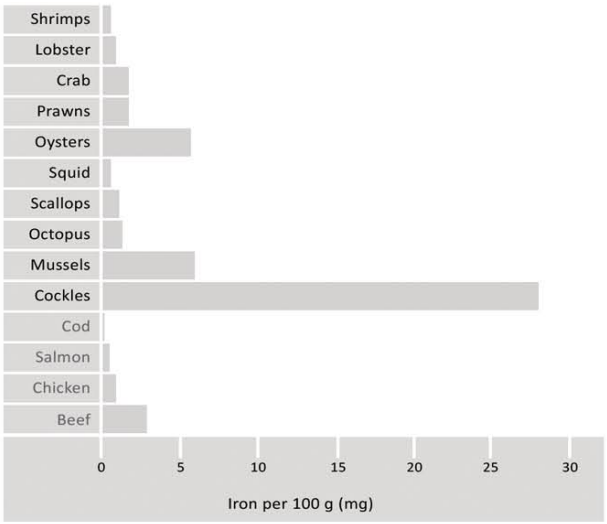


Figure 22. *Chart showing the mineral content per 100 g of common shellfish species compared to other foods .*

per 100g	Shrimps (boiled)	Lobster (boiled)	Crab (boiled)	Prawns (raw)	Oysters (raw)	Squid (raw)	Scallops (steamed)	Octopus (raw)	Mussels (raw)	Cockles (boiled)	Cod*	Salmon*	Chicken*	Beef*
Sodium (mg)	1270.0	330.0	420.0	190.0	510.0	110.0	180.0	0.0	290.0	490.0	71.0	45.0	77.0	63.0
DRV (M)	79.4%	20.6%	26.3%	11.9%	31.9%	6.9%	11.3%	-	18.1%	30.6%	4.4%	2.8%	4.8%	3.9%
DRV (F)	79.4%	20.6%	26.3%	11.9%	31.9%	6.9%	11.3%	-	18.1%	30.6%	4.4%	2.8%	4.8%	3.9%
Potassium (mg)	130.0	260.0	250.0	330.0	260.0	280.0	240.0	230.0	320.0	110.0	340.0	360.0	380.0	350.0
DRV (M)	3.7%	7.4%	7.1%	9.4%	7.4%	8.0%	6.9%	6.6%	9.1%	3.1%	9.7%	10.3%	10.9%	10.0%
DRV (F)	3.7%	7.4%	7.1%	9.4%	7.4%	8.0%	6.9%	6.6%	9.1%	3.1%	9.7%	10.3%	10.9%	10.0%
Calcium (mg)	110.0	62.0	0.0	79.0	140.0	13.0	29.0	33.0	38.0	91.0	8.0	21.0	6.0	5.0
DRV (M)	15.7%	8.9%	-	11.3%	20.0%	1.9%	4.1%	4.7%	5.4%	13.0%	1.1%	3.0%	0.9%	0.7%
DRV (F)	15.7%	8.9%	-	11.3%	20.0%	1.9%	4.1%	4.7%	5.4%	13.0%	1.1%	3.0%	0.9%	0.7%
Magnesium (mg)	36.0	34.0	58.0	0.34	42.0	28.0	38.0	0.0	23.0	46.0	22.0	27.0	26.0	22.0
DRV (M)	12.0%	11.3%	19.3%	0.1%	14.0%	9.3%	12.7%	-	7.7%	15.3%	7.3%	9.0%	8.7%	7.3%
DRV (F)	13.3%	12.6%	21.5%	0.1%	15.6%	10.4%	14.1%	-	8.5%	17.0%	8.2%	10.0%	9.6%	8.1%
Phosphorus (mg)	89.0	260.0	340.0	180.0	210.0	190.0	240.0	170.0	240.0	140.0	180.0	250.0	160.0	200.0
DRV (M)	16.2%	47.3%	61.8%	32.7%	38.2%	34.5%	43.6%	30.9%	43.6%	25.5%	32.7%	45.5%	29.1%	36.4%
DRV (F)	16.2%	47.3%	61.8%	32.7%	38.2%	34.5%	43.6%	30.9%	43.6%	25.5%	32.7%	45.5%	29.1%	36.4%
Iron (mg)	0.6	0.8	1.6	1.6	5.7	0.5	1.1	1.2	5.8	28.0	0.1	0.4	0.7	2.7
DRV (M)	6.9%	9.2%	18.4%	18.4%	65.5%	5.7%	12.6%	13.8%	66.7%	321.8%	1.2%	4.6%	8.0%	31.0%
DRV (F)	4.1%	5.4%	10.8%	10.8%	38.5%	3.4%	7.4%	8.1%	39.2%	189.2%	0.7%	2.7%	4.7%	18.2%
Copper (mg)	0.6	1.4	1.8	0.2	7.5	0.1	0.2	0.4	0.2	0.4	0.1	0.1	0.1	0.1
DRV (M)	52.5%	112.5%	147.5%	11.7%	625.0%	81.7%	11.7%	33.3%	18.3%	31.7%	5.0%	6.7%	2.5%	2.5%
DRV (F)	52.5%	112.5%	147.5%	11.7%	625.0%	81.7%	11.7%	33.3%	18.3%	31.7%	5.0%	6.7%	2.5%	2.5%
Zinc (mg)	0.8	2.5	5.5	1.5	59.2	1.1	2.6	1.7	2.5	2.1	0.4	0.6	1.2	4.1
DRV (M)	8.4%	26.3%	57.9%	15.8%	623.2%	11.6%	27.4%	17.9%	26.3%	22.1%	4.2%	6.3%	12.6%	43.2%
DRV (F)	11.4%	35.7%	78.6%	21.4%	845.7%	15.7%	37.1%	24.3%	35.7%	30.0%	5.7%	8.6%	17.1%	58.6%
Chloride (mg)	1930.0	530.0	640.0	0.0	820.0	0.0	410.0	0.0	460.0	750.0	120.0	58.0	95.0	51.0
DRV (M)	72.2%	21.2%	25.6%	-	32.8%	-	16.4%	-	18.4%	30.0%	4.8%	2.3%	3.8%	2.0%
DRV (F)	72.2%	21.2%	25.6%	-	32.8%	-	16.4%	-	18.4%	30.0%	4.8%	2.3%	3.8%	2.0%
Manganese (mg)	0.1	0.1	0.2	0.1	0.3	0.1	0.1	0.1	0.2	0.8	0.1	0.1	0.1	0.1
Selenium (ug)	15.0	54.0	84.0	16.0	0.0	66.0	51.0	75.0	51.0	43.0	27.0	26.0	13.0	7.0
DRV (M)	20.0%	72.0%	112.0%	21.3%	-	88.0%	68.0%	100.0%	68.0%	57.3%	36.0%	34.7%	17.3%	9.3%
DRV (F)	25.0%	90.0%	140.0%	26.7%	-	110.0%	85.0%	125.0%	85.0%	71.7%	36.0%	43.3%	21.7%	11.7%
Iodine (ug)	33.0	100.0	0.0	21.0	60.0	20.0	20.0	20.0	140.0	160.0	110.0	37.0	6.0	10.0
DRV (M)	23.6%	71.4%	-	15.0%	42.9%	14.3%	14.3%	14.3%	100.0%	114.3%	78.6%	26.4%	4.3%	7.1%
DRV (F)	23.6%	71.4%	-	15.0%	42.9%	14.3%	14.3%	14.3%	100.0%	114.3%	78.6%	26.4%	4.3%	7.1%

The nutritional composition data used in this table are drawn from the Food Standards Agency's benchmark, Holland B., Brown, J. & Buss, D.H. (1993). Fish and Fish Products. Third supplement to 6th edition of McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry, Cambridge.
**(Beef, average, trimmed lean, raw)*
**(Chicken, meat only, average, raw)*
**(Salmon raw)*
**(Cod frozen raw)*