# Food and Nutrition

Macronutrients

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## Contents

# 1 Introduction

Macronutrients are nutrients that provide calories or energy, and are needed in large quantities (hence "macro", meaning large) for the body to function. Nutrients are substances which are needed for a variety of bodily functions, such as growth and metabolism. There are three macronutrients:

- Carbohydrate
- Protein
- Fat

All three macronutrients are needed as part of a healthy diet, so none of them should be excluded or seriously restricted.

Micronutrients, in comparison, are mostly vitamins and minerals. They are equally important, but only need to be consumed in very small amounts.

# 2 Carbohydrates

Carbohydrates are the body's main source of energy. In order for human cells to perform as they should, carbohydrates must be available. They are chemical compounds produced by plants during oxygenic photosynthesis, a process involving the conversion of water and carbon dioxide into complex organic molecules such as carbohydrates and oxygen.

Carbohydrates are made up of carbon, hydrogen, and oxygen, and can be divided into four different types, including: monosaccharides, or simple sugars, like glucose, fructose and galactose; disaccharides, such as sucrose, lactose and maltose; oligosaccharides, such as raffinose and stachyose; and polysaccharides, such as starch, glycogen and cellulose.

Unlike protein and fat, carbohydrates are easily digested and broken down into glucose which the body uses for a variety of functions, including energy.

Carbohydrate provides 4 calories per gram.

## 2.1 Functions

Carbohydrates broken down (mainly to glucose) are the preferred source of energy for our body, as cells in our brain, muscle and all other tissues directly use monosaccharides for their energy needs. Depending on the type, a gram of carbohydrate provides different amounts of energy:

- Starches and sugars are the main energy-providing carbohydrates, and supply 4 kilocalories (17 kilojoules) per gram.
- Polyols provide 2.4 kilocalories (10 kilojoules) (erythritol is not digested at all, and thus gives 0 calories).
- Dietary fibre provides around 2 kilocalories (8 kilojoules).

Carbohydrates are also a part of some connecting tissues, retain protein from being burned as an energy source, are important in intestinal health and waste elimination, and help to lower blood cholesterol through the fibre found in carbohydrates.

## 2.2 Sources

The World Health Organisation recommends getting half your energy from carbohydrates (around 45 to 65 percent of calorie intake should come from carbohydrates.). For a moderately active teenager, this is about 260g daily.

An adequate intake of carbohydrates is necessary for proper metabolism and optimal functioning of human body. A deficiency of carbohydrate can cause low blood glucose levels (and lead to hypoglycaemia), weight loss, lack of concentration, and can affect memory and learning abilities. Severe carbohydrate deficiency can lead to serious problems such as seizures or paralysis.

The United Kingdom's government's healthy eating advice, illustrated by the 'Eatwell Guide' (a policy tool used to define government recommendations on eating healthily and achieving a balanced diet), recommends that just over a third of the diet should be made up of starchy foods.

Simple carbohydrates can be found in foods such as:

- white pasta and bread,
- sugar,
- cookies,
- fresh fruits,
- milk,
- fruit juices.

Complex carbohydrates can be found in foods such as:

- beans,
- peas,
- whole grains,
- barley,
- oats,
- brown rice.

## 2.3 Simple and Complex Carbohydrates

Foods that are high in simple (or 'refined') carbohydrates are generally not as healthy as those with complex carbohydrates. Processed foods such as candy, cakes, and cookies are usually high in simple carbohydrates. These types of carbohydrates often lead to weight gain if eaten too often, as when people eat too many carbohydrates, often in the form of simple carbohydrates, the body stores the extra carbohydrates in adipose tissue (body fat).

Simple carbohydrates – those with one or two sugar units – are also simply known as sugars. They tend to spike blood sugar, as they enter the blood stream rapidly after they are eaten, while complex carbohydrates contain fibre, which slows the digestion of sugars and does not spike blood sugar. Complex carbohydrates keep blood sugar levels constant, because they enter the blood stream very slowly.

Complex carbohydrates (polysaccharides) are made of long chains of glucose units joined together in different ways. They tend to have higher amounts of fibre (found in the cell walls of foods that come from plants) than simple carbohydrates, and they also contain healthy amounts of vitamins and minerals.

### 2.3.1 Monosaccharides, Disaccharides, Oligosaccharides and Polysaccharides

Monosaccharides are the easiest form of carbohydrates for the body to digest. The monosaccharide sugars commonly found in food contain six carbon atoms. Common monosaccharides are glucose and fructose, which dissolve in water and are very sweet tasting.

Disaccharides are formed when two monosaccharide molecules combine with the elimination of a water molecule, and include lactose (milk's carbohydrate), maltose and sucrose.

Oligosaccharides are a type of carbohydrate formed when more than two monosaccharide molecules combine. They are normally present in foods only in small amounts, and include raffinose and stachyose.

Polysaccharides are the carbohydrates referred to as complex carbohydrates. They are condensation polymers of monosaccharides and are made up of many monosaccharide molecules joined together, with the elimination of one water molecule at each link. Starch polysaccharides include amylose, amylopectin and maltodextrins, whereas non-starch polysaccharides (dietary fibre) include cellulose (a type of carbohydrate found in plants that is not digestible when the plant is consumed), pectins, hemicelluloses and inulin.

### 2.3.2 Starch and Non-starch Polysaccharides

Starch is the major food reserve of plants. It is a mixture of two different polysaccharides: amylose and amylopectin.

Non-starch polysaccharides (NSPs) are complex carbohydrates, other than starches, that occur naturally in many foods. The physiochemical and biological properties of these compounds correspond to dietary fiber. They are large-sized carbohydrates that are not digested, but some are fermented once they reach the large intestine, and include cellulose, pectins, glucans, gums, mucilages and inulin.

Insoluble NSPs (cellulose and hemicellulose) are effective laxatives, whereas soluble NSPs lower plasma cholesterol levels and help to normalize blood glucose and insulin levels, making these kinds of polysaccharides a part of dietary plans to treat cardiovascular diseases and Type 2 diabetes.

The NSPs in wheat, maize, and rice are mainly insoluble and have a laxative effect, while those in oats, barley, rye, and beans are mainly soluble and have a cholesterol lowering effect.

### 2.3.3 Polyols

Polyols, also called sugar alcohols or bulk sweeteners, are popular as a sugar replacement. They include isomalt, maltitol, sorbitol, xylitol and erythritol. They are a type of carbohydrate found naturally in certain fruits and vegetables. They can also be manufactured to be used as food additives.

They contain fewer calories than ordinary table sugar, and are a FODMAP food. This means that they are short chain carbohydrates that are poorly absorbed in the small intestine and are prone to absorb water and ferment in

the colon. They may cause digestive discomfort in some people, potentially causing bloating, stomach pain and diarrhea (especially for those who have irritable bowel syndrome).

### 2.3.4 Free Sugars

Monosaccharide and disaccharide sugars tend to be added to foods by manufacturers, cooks and consumers and are referred to as 'added sugars'. They may also occur as 'free sugars' that are naturally in honey and fruit juices.

# 3 Proteins

An incredibly important group of nutrients, proteins are found in the cytoplasm of all living cells, both animal and plant. They are organic substances and resemble fats and carbohydrates in that they contain the elements carbon, hydrogen and oxygen. However, they also contain nitrogen, and most contain sulphur. Some also contain phosphorus.

Proteins show a greater variety and complexity of structure than fats and carbohydrates. They are long chains, or polymers, of alpha-amino acids. In chemistry, an amino acid is an organic compound that contains both an amino (-NH2) and carboxylic acid (-COOH) functional group, hence the name amino acid. They are unique as the amino and carboxylic acid functional groups are separated by only one carbon atom, which is usually a chiral carbon.

Animals, unlike plants, cannot synthesize protein from inorganic compounds, therefore protein is an essential nutrient in the diet of all animals.

Protein has a wide variety of functions in the body, and is known primarily for aiding in 'growth and repair' of body cells and tissues.

Protein, like carbohydrate, provides 4 calories per gram.

## 3.1 Functions

Amino acids are the basic building blocks of proteins, and they serve as the nitrogenous backbones for compounds like neurotransmitters and hormones.

Proteins provide many essential functions in the body, such as: supporting the regulation and expression of DNA and RNA; supporting muscle contraction and movement; helping to coordinate bodily function; moving essential molecules around the body; providing support to the body; making up the structural components of our cells and tissues as well as many enzymes, hormones and the active proteins secreted from immune cells.

It also provides a secondary source of energy.

## 3.2 Sources

The Department of Health advises adults to avoid consuming more than twice the recommended daily intake of protein (55g for the average man and 50g for the average woman).

After exercise, protein is particularly important since muscles need it to recover and grow, and thus, a portion of protein (15-25g) is recommended within 30 minutes of exercise, when your muscles are particularly receptive to protein synthesis.

It is also better to aim to spread your protein intake out throughout the day, instead of consuming lots of protein during one meal and not in any others.

There are three types of sources we can get protein from. These are animal, plant and novel.

Animal sources include meat (such as chicken or steak), fish, dairy foods (such as milk or cheese) and eggs. Plant sources include pulses (such as peas and beans), lentils, grains and nuts. 'Novel' sources include tofu, soya and TVP (Textured Vegetable Protein).

Some HBV (or 'high protein') foods are:

- eggs,
- fish and seafood,
- chicken and turkey,
- soya,
- nuts and seeds,
- beans and pulses.

## 3.3 Biological Value

Biological value (BV) is a scale of measurement used to determine what percentage of a given nutrient source is utilized by the body. It is most frequently applied to protein sources.

Proteins are the major source of nitrogen in food. BV is derived from providing a measure intake of protein, then determining the nitrogen uptake versus nitrogen excretion.

The body can not store excess amino acids. The daily diet should thus always provide enough protein, and protein of the proper quality, to fulfil the need of the body.

Proteins are the major source of nitrogen in food. Biological value assumes protein is the only source of nitrogen and measures the amount of nitrogen ingested in relation to the amount which is subsequently excreted.

A ratio of nitrogen incorporated into the body over nitrogen absorbed gives a measure of protein "usability" – the BV. Unlike some measures of protein usability, biological value does not take into account how readily the protein can be digested and absorbed.

### 3.3.1 Indispensable and Dispensable Amino Acids

In nutrition, the 20 amino acids that make up proteins are classified as either essential or non-essential. These classifications resulted from early studies on human nutrition, which showed that specific amino acids were required for growth or nitrogen balance even when there is an adequate amount of alternative amino acids.

Indispensable (essential) amino acids are those which humans and other vertebrates cannot synthesize from metabolic intermediates, and instead must come from the diet.

Dispensable (non-essential) amino acids are those which are produced by the body.

There may be variations depending on the metabolic state of an individual, but it is generally accepted that there are nine essential amino acids (phenylalanine, valine, tryptophan, threonine, isoleucine, methionine, histidine, leucine, and lysine).

All of these nine amino acids are obtainable by a single 'complete protein', which usually derive from animal-based sources of nutrition, except for soy (as these are HBV foods).

The essential amino acids are also available from incomplete proteins, which are usually plant-based foods. The term "limiting amino acid" is used to describe the essential amino acid present in the lowest quantity in a food protein relative to a reference food protein like egg whites. The term "limiting amino acid" may also refer to an essential amino acid that does not meet the minimal requirements for humans.

The most limiting amino acid determines the BV of the whole protein. If the body needs, for example, 1 gram of phenylalanine daily, and the food supplies 500 gram of protein, but only 0.5 gram of phenylalanine, the BV of the protein is very low. Only a fraction of the protein can be used, and the rest has to be excreted.

### 3.3.2 Protein Complementation

Protein complementing is a dietary theory for protein nutrition that purports to optimize the biological value of protein intake. Protein complementation occurs whenever two LBV proteins are eaten together.

By eating two LBV proteins in the same meal, you can make up for the lacking amino acids in each, therefore giving yourself a meal with a high biological value (HBV).

A common example of protein complementation would be eating beans on toast.

# 4 Fats and Oils (Lipids)

Fats and oils, also known as lipids, also contain carbon, hydrogen and oxygen. They are esters of glycerol and fatty acids.

Fats and oils are mixtures of triglycerides. A triglyceride consists of one molecule of glycerol combined with three fatty acid molecules. Diglycerides (consisting of glycerol combined with two molecules of fatty acid) and monoglycerides (where only one fatty acid molecule is present) are used as emulsifiers.

There are about 40 different types of fatty acids found in foods, and there are basically two types: saturated fatty acids, in which the hydrocarbon chain is saturated with hydrogen, and unsaturated fatty acids, in which the hydrocarbon chain is not saturated with hydrogen and therefore contains one or more double bonds.

Fat, unlike protein and carbohydrate, provides 9 calories per gram.

As fat has more than twice the calorific value of carbohydrates, it is therefore a more concentrated source of energy. For those whose energy requirements are high, it is useful to include a reasonable quantity of fat in the diet, as it reduces the bulk of food which must be eaten.

## 4.1 Functions

Fats have a variety of functions, such as:

- providing energy, as fat is broken down in the body by a process of oxidation and energy is released;
- the formation of adipose tissue, as excess fat that is not immediately required for energy is stored in the adipose tissue where it constitutes an energy reserve, forms an insulating layer and protects delicate organs from physical damage;

- provides essential fatty acids, needed for the maintenance of cell membranes and production of hormone-like substances known as eicosanoids;
- serves as a source of fat-soluble vitamins such as A, D and E.

## 4.2 Sources

Fats and oils are obtained from both animals and plants. They are formed from carbohydrate and represent a concentrated store of energy.

The American Heart Association (AHA) recommends that between 20 and 35 percent of total daily calories should consist of fat, but they also recommend that less than 5 to 6 percent of daily caloric intake consist of saturated fat.

Some sources are:

- meat and fish,
- butter and margarine,
- spreadable fats, cooking fats and oils,
- milk, cream and cheese,
- baked goods,
- eggs.

## 4.3 Saturated and Unsaturated Fats

Saturated fats can be found in a variety of foods, such as animal meat, certain plant oils (coconut, palm kernel), dairy products and processed meats.

Unsaturated fats are found in foods such as nuts, certain plant oils (canola, vegetable), olives, avocados and certain fish (tuna, salmon, anchovy).

Unsaturated fatty acids are said to maintain the cholesterol level in the body, and there have been conflicting studies as to the effect of saturated fat on the body. It is often accepted that saturated fats may increase the risk of heart disease or cardiovascular disease, and should therefore be limited in the diet.

### 4.3.1 Monounsaturated, Polyunsaturated, Cis and Trans Fats

Unsaturated fats may be either monounsaturated (containing one double bond, e.g. oleic acid) or polyunsaturated (containing more than one double bond, e.g. linoleic acid).

In addition, the arrangement of atoms may vary and both monounsaturated and polyunsaturated fatty acids can be either cis or trans fatty acids.

Cis fatty acids contain two hydrogen atoms on the same side of the double bond, whereas trans fatty acids contain hydrogen atoms on geometrically opposite sides of the double bond.

Concerns about trans fatty acids in the human diet were raised when they were found to be an unintentional by-product of the partial hydrogenation of vegetable and fish oils. While these trans fatty acids are edible, they have been implicated in many health problems, such as cardiovascular disease and obesity.

### 4.3.2 Essential Fatty Acids

Essential fatty acids, or EFAs, are fatty acids that humans and other animals cannot synthesize but instead must ingest, as the body requires them for good health.

The term "essential fatty acid" refers to fatty acids required for biological processes, but does not include the fats that only act as fuel.

Only two fatty acids are known to be essential for humans: alpha-linolenic acid (an omega-3 fatty acid) and linoleic acid (an omega-6 fatty acid).

EFAs have a variety of functions in the body, and are also found in a variety of foods. Oily fish like salmon, sardines, herring, mullet and shrimp are excellent sources of omega-3, alongside flax and chia seeds. Omega-6 is found in many foods, such as egg yolks, tofu, canola oil, walnuts, almonds, mayonnaise and sunflower seeds.

Omega-6 is often consumed in far greater amounts than omega-3, and balancing omega-6 intake better with omega-3 intake is generally advised.