

# YORK *mind-body* HEALTH

## Information Sheet

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# Carbohydrate

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## What Is Carbohydrate?

Carbohydrates are the body's main source of energy. Although fat and protein can also be metabolised for energy, carbohydrate metabolism is more straight forward. Moreover not all cells can utilise protein and fat. Brain cells, for example, can only derive energy from glucose (a simple sugar). All cells can metabolise glucose.

Carbohydrates are composed of the elements carbon, hydrogen and oxygen. They are "burned" in a complex and coordinated biochemical pathway, releasing energy and leaving carbon dioxide and water as end products. All carbohydrates ultimately derive from plants, which make them in the process of photosynthesis.

Carbohydrates are not just used as fuel. They can be attached to proteins and fats (lipids) to form glycoproteins and glycolipids, which perform physiological functions - for example glycoproteins are found in cell membranes and play a part in cell to cell interactions.

## Types of Carbohydrate

### Sugars

The simplest carbohydrates are sugars. The simplest sugars are called **monosaccharides**. Most of these have a chemical structure based around a ring of five or six atoms (one of which is oxygen, the rest carbon). Glucose, already mentioned, is a monosaccharide and is the body's basic currency of energy (at least in chemically stable form, as delivered to cells by the blood). It is one of eight monosaccharides believed to be essential for human health.

Fructose is another monosaccharide, and is present in most fruits (hence it is also known as fruit sugar). Unlike glucose, most cells can't metabolise fructose so it is processed by the liver.

Table sugar, or sucrose, is an example of a **disaccharide**. Disaccharides are, as you might guess, made up of two monosaccharides joined together. Sucrose is made up of a glucose unit and a fructose unit.

Another common disaccharide is lactose, found in milk, and made up of glucose and galactose. Lactose doesn't taste very sweet. Some people are unable to digest it.

### Complex Carbohydrates

Complex carbohydrates are found in vegetables, beans and grains. Structurally they are made up of many monosaccharides joined end to end, forming long chains or sheets, and are called polysaccharides. (Oligosaccharides are intermediate length chains, having 3 to 10 units.) Not all complex carbohydrates can be digested by humans. Non-digestible carbohydrate is known as dietary fibre, and even though it is not a source of energy it is still a vital component of the diet. (Actually, some of the essential bacteria inhabiting the gut can digest them for energy.)

## Digestion and Absorption

Sugars take little or no digestion and are easily and rapidly absorbed. Complex carbohydrates need to be broken down into component monosaccharides before being absorbed. This happens through the action of digestive enzymes, mainly in the small intestine.

## Blood Sugar Levels

As mentioned, the simple sugar glucose is the main form of energy delivered to the cells by the blood. Normally blood glucose concentration is quite tightly regulated. If it drops too low, cells can't create enough energy and you feel fatigued (a state called hypoglycaemia). Too high (hyperglycaemia) and you can feel wired and restless, and moreover, sugar starts to react

chemically with other molecules such as haemoglobin, rendering them useless or even toxic. (This process is called glycation and is the reason diabetes is such a dangerous illness.) So if you want to experience stable and high energy levels over the course of your day, it's very important to do a good job of regulating blood glucose. How well you do depends in part on your diet.

Blood glucose levels are controlled by hormones. Insulin is the hormone that reduces blood glucose when it is too high. It does this by instructing cells to open their doors to glucose. Insulin is secreted by the pancreas when blood glucose starts to rise (normally just after we've eaten).

Several hormones are capable of raising blood glucose levels, including the stress hormones adrenalin and cortisol.

### Diet and Blood Sugar

The most important factor is how quickly do carbohydrates enter the blood as sugars, particularly glucose.

Simple sugars are rapidly absorbed into the blood. Eating a sugary food such as a chocolate bar tends to lead to a spike in the blood glucose level. Insulin is secreted to bring this back down again, but high levels of insulin can lead to blood glucose dropping below normal within a couple of hours, i.e. a trough follows the spike. You are now hypoglycaemic (and so probably feeling tired and hungry).

Foods made from refined grains have a very similar effect because their carbohydrate is also highly available and rapidly absorbed. This includes all foods made from white flour, such as biscuits, cakes and pasta, but also white rice and most breakfast cereals.

Whole grains contain complex carbohydrate including dietary fibre, which slows down absorption. They have a much gentler effect on blood glucose, not necessitating so much insulin secretion. Vegetables, pulses and beans are the same.

### Glycaemic Index and Glycaemic Load

The concept of how rapidly carbohydrates raise blood glucose levels has been quantified in terms of glycaemic index (GI) and glycaemic load (GL), which you may have encountered in the context of weight loss diets. The two are slightly

different, and without going into the technical details, GL is the more useful concept. Suffice it to say that the GL of a food portion is a measure of how rapidly and by how much blood glucose concentration rises after its consumption.

Clearly, foods containing large amounts of simple sugars will have high GL, whereas those containing either little or carbohydrate, or complex carbohydrate in its natural state (i.e. with dietary fibre) have low GL.

Everyone can benefit from eating a low GL diet, not just those people wanting to manage their weight.

### Weight Management

Excess glucose in the blood can be stored, in the first place as glycogen in the liver and muscles, and in the second place it can be converted into fat. Two more important facts: first, our glycogen storage capacity is limited. Second, fat (unlike glycogen) cannot be converted back into glucose. You can begin to see why eating a low GL diet is so important for people who are overweight.

### Insulin Resistance

An increasingly common health concern is insulin resistance, a condition in which cells don't respond to the hormone insulin as they should, i.e. by absorbing glucose from the blood. This topic is covered in a separate article. Insulin resistance makes the job of regulating blood sugar levels harder. Insulin resistance is considered as a precursor phase to diabetes is closely related to the metabolic syndrome - a group of symptoms commonly occurring together, and including high blood pressure and obesity. It seems one of the causal factors for insulin resistance is a high GL diet over a period of years.

### Blood Sugar and Mood

Poorly regulated blood glucose levels (dysglycaemia) can not only cause fatigue and energy swings, but can also adversely affect your sleep and mood. Top selling author Patrick Holford says dysglycaemia is the most common underlying nutritional factor in mental health problems (1). The symptoms can include anxiety, depression and irritability. Since dysglycaemia affects brain function generally, cognitive deficits can also result, including poor focus, concentration and memory.

## Appetite

Blood glucose concentration is one of the main determinants of appetite. If your blood glucose drops you'll tend to feel hungry. Poorly regulated blood glucose levels or dysglycaemia is characterised by craving of sweet foods. Eating a sugary food, being normally followed by a drop in blood sugar within a couple of hours, sets you up for more craving. This is how sugar is such an addictive substance.

## More About Fructose

Fructose (fruit sugar) does not stimulate immediate secretion of insulin as glucose does (technically it has low GL). It may therefore be considered a good option for people wanting to lose weight or with insulin resistance. However quite the opposite is the case.

Firstly, fructose does not affect the hormones leptin and ghrelin, as does glucose. Both these hormones are involved in appetite control. So fructose has a far weaker satiating effect than glucose and other carbohydrates.

Fructose is metabolised in a very different way to glucose. Only the liver can process it (all cells can metabolise glucose). This puts a heavier strain on the liver to begin with. Fructose in general isn't converted to the storage form of sugar, glycogen, but is instead converted to fat. Fructose metabolism has several negative consequences:

- Levels of VLDL (an unhealthy form of cholesterol) in the blood rise.
- Research suggests that 30% of fructose ends up as fat.
- Some fructose ends up as uric acid, which is known to cause gout and hypertension.
- It causes inflammation and insulin resistance.

Fructose consumption has been found to correlate with hypertension, cardiovascular disease, pancreatitis, obesity and hepatic (liver) dysfunction.

Remember that half of table sugar (sucrose) is fructose. Fruit juice contains a lot of fructose. More insidious is a product called High Fructose Corn Syrup (HFCS) - used as an additive in a large number of processed foods, including breads, and especially soft drinks.

## **Dietary Fibre**

As we've already said, dietary fibre (which is non-digestible carbohydrate) is an important dietary component, having several benefits.

- Slows down the absorption of sugars.
- Inhibits absorption of free fatty acids.
- Helps to control appetite by inducing a sense of satiety.
- Speeds up the movement of matter through the digestive tract, making constipation, infection, even bowel cancer less likely.
- Helps speed the removal of toxins, both those secreted into the digestive tract as bile, and those secreted by micro-organisms living in the gut.

On the other hand insoluble fibre can reduce the absorption of essential nutrients such as zinc. (Not all fibre is insoluble.)

The best sources of dietary fibre are vegetables, beans, lentils and grains.

## **Dietary Recommendations for Carbohydrates**

How much carbohydrate should you consume? Not surprisingly, opinions vary widely. In terms of percentage of calories, most recommendations fall in the range from 30% of calories to around 70%. I think this uncertainty points to the fact that there isn't one amount that is ideal for all individuals. Rather, our biochemical and metabolic individuality means that we utilise carbohydrates, proteins and fats with variable efficiency. Just as some cars run on diesel and others on petrol, so some people will function better on a particular mix of these food components.

On the other hand, it seems safe to say that sugary foods, foods based on refined grains (i.e. high GL foods) and high fructose foods and drinks should be avoided as far as possible by everyone. Practically speaking this means eating foods in their natural, whole and unrefined forms - fruit rather than fruit juice, and brown grains rather than white products.

A good amount of fibre is probably about 35g and more per day. Again whole foods including fruit and vegetables have plenty of fibre, so you don't necessarily have to go out of your way to

get enough fibre. (It's thought our prehistoric ancestors consumed 100-300g per day.) Soluble fibre is probably better than insoluble - go easy on wheat bran which is insoluble.

### **Metabolic Typing**

The idea that no one diet is right for everyone has developed into the concept of metabolic types. Determining your metabolic type enables you to predict what kind of diet will optimise your physiological and metabolic functioning. More specifically it will help you determine what proportion of your calories should come in the form of carbohydrates. This topic is covered in a separate article available at [www.yorknutritionaltherapy.co.uk](http://www.yorknutritionaltherapy.co.uk).

### **Footnotes**

1. See Patrick Holford's 'New Optimum Nutrition for the Mind'.