IOCCC

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EDIBLE FATS AND OILS in relation to sugar confectionery, chocolate and fine bakery wares

1. INTRODUCTION

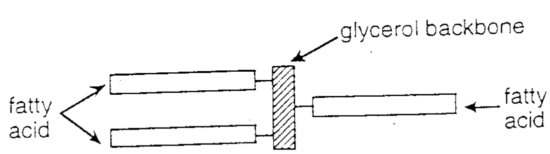
Edible fats are commonly thought of as the components of food which are greasy in texture and not soluble in water. The term "fat" is generally used to describe fats which are solid at room temperature while liquid fats are known as "oils". Fats are one of the three main energy sources in the diet but they are a more concentrated source of energy (9kcal/g) than either carbohydrates or proteins (both 4kcal/g).

IOCCC products, more specifically sugar confectionery, chocolate and fine bakery wares can contain various amounts of edible fats. This is the reason for this fact sheet which will discuss edible fats and oils in themselves and in relation to IOCCC products.

2. CHEMISTRY OF FATS

Fats are composed of molecules called triacylglycerols (TAG, formally known as triglycerides). There can be many different types of triacylglycerols making up a fat. Triacylglycerols consist of a glycerol molecule to which are attached three fatty acids (Figure 1). The three fatty acids making up a triacylglycerol are rarely all the same.

Figure 1
Structure of a triacylglycerol

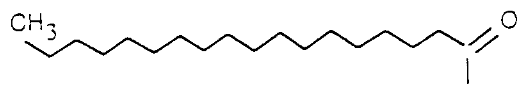


Fatty acids are made up of chains of carbon atoms. At one end of the chain there is a carboxyl group (COOH) and at the other end a methyl group (CH_3). Fatty acids in triacylglycerols are attached to the glycerol backbone at the carboxyl end of the molecule.

2.1 *Saturated fatty acids (SFA)*

When the carbon atoms in the fatty acid chain have as many hydrogen atoms attached to them as possible, the molecule is known as 'saturated'. Fatty acids are often represented as a zigzag chain, with the individual carbon atoms bent at each end. Figure 2 shows the structure of stearic acid, a saturated fatty acid with an 18 carbon chain, referred to as C18:0.

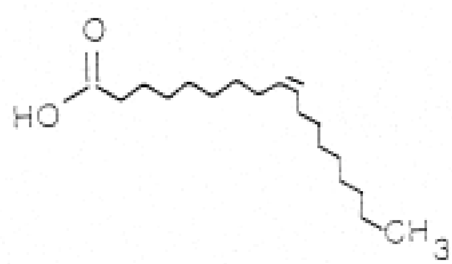
Figure 2
Stearic Acid



2.2 *Mono-unsaturated Fatty Acids (MUFA)*

Sometimes the carbon chain has a 'double bond', in other words a bond which joins two carbon atoms each of which has only one bound hydrogen atom. Therefore the chain is not saturated as the carbon atoms have as few hydrogen atoms attached as is possible. The double bond introduces a 'kink' into the molecule and the conformation of the molecule is known as *cis.* Figure 3 shows oleic acid which has 18 carbons in its chain with one double bond (C18:1). Oleic acid is the most widely distributed MUFA in nature. The best known source is olive oil.

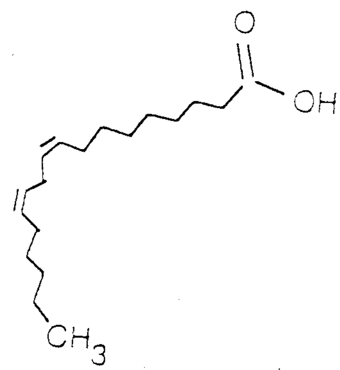
Figure 3
Oleic Acid *(cis*)



2.3 *Polyunsaturated Fatty Acids (PUFA)*

Fatty acids that contain two or more double bonds are referred to as polyunsaturated fatty acids (PUFA). Figure 4 shows linoleic acid, an 18 carbon fatty acid with two double bonds (C18:2).

Figure 4
Linoleic Acid (*cis*)

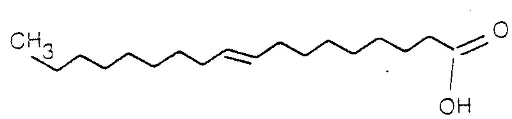


The position of the first double bond relative to the methyl end group is used to establish the PUFA class. There are three different classes of PUFA of particular biological interest: n-3, n-6 and n-9. This classification depends upon the position of the first double bond counting back from the methyl end of the molecule. For example, linoleic acid is referred to as an n-6 fatty acid.

2.4 *Trans Fatty Acids (TFA)*

Certain processing may cause the double bonds in mono- and polyunsaturated fatty acids to change their orientation, making the kinked molecule almost straight again. This configuration of the molecule is known as *trans*. Such processing is generally necessary to improve the technological structure of the fatty acids involved. For example, the hardening of the fats by hydrogenation.
Figure 5 shows the *trans* configuration of mono-unsaturated oleic acid, known as elaidic acid.

Figure 5
Elaidic Acid (*trans)*



2.5 *Other fatty substances*

Edible fats are mainly comprised of triacylglycerols but there are other fatty substances present in foods: Sterols such as cholesterol, phospholipids, mono- and diacylglycerols and free fatty acids.

3. OCCURRENCE

Fats occur in all foods though often only as traces. Their presence may be obvious, such as the visible intra muscular fat (marbling) of meat. More often fats are less visible, such as those in lean meat, fish, cakes and biscuits, dairy products, chocolate, eggs, nuts, etc.

Foods of terrestrial animal origins such as meat and dairy products contain saturated and mono-unsaturated fatty acids, with few polyunsaturated fatty acids. Fish oils contain more polyunsaturated fatty acids than animal fats. Foods of vegetable origin can include the whole spectrum of fatty acids from coconut oil which contains a high proportion of saturated fatty acids to rapeseed oil which is mainly comprised of mono- and polyunsaturated fatty acids. Almost all natural fats, when unsaturated, are in the cis form, the trans forms being relatively rare.

Fats used in the IOCCC industries include milk fat (present in dried or condensed milk or in the form of butter or butterfat), a wide variety of vegetable fats including cocoa butter, an indispensable ingredient in chocolate, as well as various fats and oils in biscuits, pastries and other baked goods. Cocoa butter is unique in that its melting point is almost identical to normal human body temperature, so cocoa butter is hard at room temperature but melts in the mouth, hence the creamy texture of chocolate.

Typical levels of fat in IOCCC products :

Per 100 grammes	Fat (grammes)	Saturated	MUFA	PUFA
Biscuits	27	16	8	2
Ginger bread/honey cake	1	0	0	1
Cakes	24	10	8	4
Milk chocolate	33	19	10	1
Plain chocolate	32	19	10	1
Sugar Confectionery	0	0	0	0

4. CONSUMPTION

Dietary fat is often expressed as a percentage of total energy consumed (calories or kcal), rather than by weight. This may allow more meaningful comparisons to be made between different diets or foods. A gram of fat contains 9 kcal (or 37 kjoules) of energy.

Within the developed world dietary fat intakes in general vary from 35-40 percent of energy. In these same countries the contribution of fat to total energy intake is mostly considered to be too high (see also the chapter on fat and health for the reasoning behind this) and should be reduced to 30-35 percent of energy. There are slight differences in recommended fat intakes but on the whole the 30-35 percent tends to be an acknowledged average objective underwritten by most advisory bodies in the various countries concerned.

Most of these countries also have recommendations with regard to PUFA's, MUFA's, saturated fats and, sometimes, trans fatty acids. Again, generally speaking it is recommended to consume more PUFA's and MUFA's and less saturated fats and trans fats. For further information see the chapters on fat and health and the nutritional and functional role of fats and oils.

IOCCC products contribute relatively little fat to the typical diet, to the major sources of fat being meat, dairy products and spreads.

In the Netherlands for example cakes, pastries and biscuits contribute app. 8% of total fat intake while sugar, confectionery, sweet fillings and sweet sauces contribute 3.0%, compared to the contribution of meat (19% of total fat intake), dairy products incl. cheese (18%), and fats and oils, including margarine, as such (28%).

In the UK the figures are slightly different, but again it can be stated that the contribution of IOCCC products in total fat intake is relatively small. Biscuits and cakes contribute 10% to total fat intake, confectionery (incl. chocolate) and desserts app. 6%. Fat spreads contribute 16%, meat 24% and milk/cheese 15%.

In Finland the contribution of all IOCCC products (incl. biscuits) to total fat intake is only 6%.

5. <u>THE NUTRITIONAL AND FUNCTIONAL ROLE OF FATS</u>

5.1 *Energy*

Fat, carbohydrate and protein are the three main energy-providing macronutrients. Fat supplies more than twice as much energy per gram (9 kcal/g) as carbohydrate or protein (both 4kcal/g). As mentioned in the preceding chapter, most countries in the developed world make recommendations to reduce fat intake from 35-40% of energy to 30-35%.

5.2 *Other nutritional functions of fat*

The primary role of dietary fat is to supply energy but fat has other nutritional functions. For example, phospholipids are essential components of all cell membranes and important structural components of brain and nerve tissues.

Cholesterol is important for the transport of fat around the body.
Fat in the diet is also the carrier for the essential fat soluble vitamins in the diet.

5.3 *Essential fatty acids*

Palmitic acid and fatty acids with fewer than 16 carbons can be made in the human body. The body also has the ability to elongate and desaturate palmitic acid to produce longer chain fatty acids such as stearic (C18:0) and oleic (C18:1) acids. Because the body can make these fatty acids, they are termed 'non-essential'.

Certain PUFA's cannot be produced in the body; it is essential that these are included in the diet for optimum health. These are termed essential fatty acids or EFA's. Essential fatty acids which cannot be synthesised in the body include linoleic (C18:2) and linolenic (C18:3) acid.

5.4 *Dietary recommendations for essential fatty acids*

It is recommended that linoleic acid provides at least 2-3 % of energy in the diet to prevent an essential fatty acid deficiency; this level will also meet the requirement for arachidonic acid. Consumption of diets that provide >10 % of energy from PUFA's are not recommended because the health consequences of such diets are uncertain.

There is no dietary recommendation established for n-3 PUFA such as linolenic acid (C18:3). However, it is clear that both n-3 and n-6 PUFA are important in early neural development. Current assessments put n-3 PUFA requirements for babies and infants at about one-fifth of requirements for n-6 PUFA. This is based upon analysis of breast milk which has an n-6: n-3 ratio of 5:1. For adults, increased consumption of the n-3 PUFA is considered to be beneficial in reducing thrombosis and coronary heart disease (CHD) risk.

The richest source of linoleic acid in the diet is vegetable oils (for example, corn, safflower and soybean oils). Canola oil, linseed, flax and soybean oils are good sources of linolenic acid as well as fish oils, which are also rich sources of dietary n-3 PUFA.

6. OTHER ROLES OF FAT IN FOOD

Another important function of fat in food is that fat has important organoleptic properties. This function is especially important for so-called "pleasure products" as IOCCC products generally tend to be.

1. Fat is an important determinant of food texture. For example, it is largely responsible for the shortness or crumbliness of biscuits, the melt-in-the-mouth properties of chocolate, the different but characteristic textures of nuts and chocolate, and the smoothness of mayonnaise or various creams used for the filling of cakes and tart.

2. Fats are also important for contributing to and generating of flavours in foods in which they are used, for example butter and olive oil used in cooking or baking (butter fat in cakes and biscuits has a distinct aroma and flavour).

   The ability of fat to be heated to temperatures above the boiling point of water without decomposition is responsible for the characteristic texture and flavour of all fried foods. Many flavours are fat-soluble, hence fat also plays a crucial role in flavour delivery.

7. FAT AND HEALTH

7.1 *Obesity*

Obesity and overweight are measured by the Body Mass Index or Quetelet Index. The BMI is weight (kg) / height^2 (m). A BMI > 25 is considered overweight, while a BMI of > 30 is obese. Obesity results from a constant intake of energy (as food or drink) in excess of requirements. Obesity has become more common in recent years in industrialised nations, mainly, it is believed, because of the reduced activity levels and hence lower energy requirements, associated with modern lifestyles.

Of the diseases linked to fat consumption, obesity is probably the most obvious in the minds of many people. Studies with obese patients have shown that their diets are high in fatty foods.

Fat provides more than twice as many calories gram for gram as either protein or carbohydrate. This means that the quantity which needs to be eaten to provide the same number of calories as from protein or carbohydrate, is much smaller; approximately half as much in grams. This can be illustrated by making portions of high fat foods comparable in calorific value to portions of high-carbohydrate foods: the “fatty” portions will be much smaller. Seemingly however, people will tend to think they have eaten much less as the volume is so small. In real life therefore (where such portions are not made comparable in such a way but usually sized out according to volume) people tend to eat much more of high fatty foods than of high carbohydrate foods. This phenomenon is called “passive overconsumption”.

There is also evidence that dietary fat cannot regulate its own use as a metabolic fuel as well as either protein or carbohydrate . For example, if the diet contains excess of carbohydrates, the body prefers to burn these off immediately, rather than storing them for use later. Partly because of the fact that the volume of storage depots for carbohydrates is limited, and furthermore because storing carbohydrate as fats is rather inefficient. An excess of fat is not treated in the same way and is more likely to be stored. The volume of fat depots is practically unlimited (as is obvious from the many examples of grossly obese people in the world). This unlimited storage capacity tends to strengthen the notion of passive overconsumption.

Recent studies have also discovered that fat does not promote satiety (the feeling between meals when an individual does not want to eat again) as strongly as protein or carbohydrate. Hence a diet high in fatty foods will leave the individual feeling hungry more often.

IOCCC products are often seen as conducive to obesity, as they contain both fats and sugars. However, as stated in the chapter on consumption, in real life food consumption patterns IOCCC products cannot be considered as important contributors to total fat intake. The role of sugars is discussed in another fact sheet, but the conclusion remains that in general one cannot maintain the statement that IOCCC products are conducive to obesity.

7.2 *Coronary Heart Disease (CHD)*

CHD is one of the major causes of death in industrialised nations. The disease has many contributing factors, some of which are uncontrollable by the individual such as age, sex and heredity. Others are controllable such as physical activity, smoking and diet (and to a lesser degree blood pressure). There is a growing interest in the role of diet in many chronic diseases such as CHD. One of the greatest areas of interest is the relationship between fats and CHD.

Fats are transported around the body by lipoproteins: large particles containing triacylglycerols, cholesterol and protein. There are three main lipoproteins, distinguishable by differences in their density which depends on triacylglycerol content. The highest amounts of triacylglycerol are found in very low density lipoproteins (VLDL) secreted by the liver. VLDL can lose triacyglycerol to adipose tissue and to muscle, thereby becoming low density lipoprotein (LDL). Another lipoprotein, high density lipoprotein (HDL) appears to have a cholesterol-scavenging function, removing excess to the liver for disposal.

Much attention has been focused on LDL because high blood levels have frequently been found to correlate increased risk of CHD, and likewise with levels of fat in the diet, especially saturated fat. High levels of HDL have been associated with reduced risk of CHD. HDL may, therefore, be protective. Ideally then, LDL cholesterol should be lowered and HDL cholesterol increased.

Levels of LDL and HDL in the blood are affected differently by the intake of individual fatty acids. Dietary cholesterol has little or no effect on blood cholesterol in healthy individuals.

The effects of the different types of fatty acids on LDL and HDL are summarised in Table 1.

Table 1

The effect of different fatty acids on blood lipoproteins

FATTY ACID	Effect on LDL	Effect on HDL
Saturated	↑↑↑	– –
Monounsaturated	↓↓	↑↑
Polyunsaturated	↓↓	↑↑
Trans	↑↑↑	↓

Not all individual fatty acids have the same effects. The saturated fatty acids which have the most detrimental effect upon blood LDL are C12:0 (lauric), C14:0 (myristic) and to some extent C16:0 (palmitic). Stearic acid (C18:0), the major saturated fatty acid in cocoa butter, has been shown to have no effect upon blood cholesterol levels. The same applies to the so-called CBE's (vegetable fats partly substituting cocoa butter): their major component is also Stearic acid.

Trans-fatty acids, especially the ones caused by processing (hydrogenating or hardening of vegetable oil), seem to have the worst effects on the risk for CHD.

Evidence for this has only recently been confirmed in various intervention studies, prospective cohort studies and patient-control studies. All of these studies indicate that if oleic acid (C18:1, cis configuration) is substituted for Elaidic acid (C18:1 trans) levels of LDL increase while levels of HDL decrease. Furthermore substitution of cis fatty acids for trans fatty acids also leads to an increase in the levels of VLDL particles and the levels of free triglycerides, other risk factors for CHD.

As stated earlier, IOCCC products do not contribute greatly to total fat intake although their contribution cannot be discarded altogether. The type of fatty acids included in IOCCC products is variable : all types (PUFA, MUFA, saturated and trans) can be found in the products. As stated earlier, chocolate contains relatively high levels of stearic acid (a saturated fat) that does not contribute to high LDL or VLDL cholesterol levels.

7.3 *Dietary recommendations for fat in the prevention of obesity and CHD*

Advice about the recommended level of fat in the diet has been given repeatedly by many agencies since the 1950s. Contemporary dietary guidelines recommend that total dietary fat should not exceed 30-35 % of energy intake and that SFA should not exceed 10% of energy (the latter is the more difficult target to achieve in a western diet. Achieving it usually requires reduction of total fat intake to below 30% of energy). It is also recommended that PUFA not contribute more than 10% of energy and that the remaining fat energy be provided by MUFA (10-15%). In many industrialised countries, actual intakes of total fat are much higher, nearer to 40% and SFA intake nearer to 18%. As yet there are no official recommendations for the levels of trans fatty acids, except that one should probably count them as SFA, and therefore include them in the maximum level of 10% of energy intake recommended for saturated fatty acids.

It is worth noting that infants do not thrive on low fat diets and these guidelines only apply to adults and older children.

World-wide, dietary recommendations have been made by numerous countries. A World Health Organisation (WHO) study group recommended a reduction in fat intake to 30% of energy as an intermediate goal; their ultimate goal is to reduce fat consumption to 15-25% of energy. Their position on SFA intakes is that it ultimately be reduced to 1-10% of energy. These recommendations have been updated by the most recent WHO/FAO Joint Consultation on Fats, 1995 as well as the Consultation on food Based Dietary Guidelines, 1996.

In general, many European countries recommend a reduction in total fat and SFA intake. For example, the recommended fat intake in both France and The Netherlands is 30-35 % of energy while in Japan, the recommended fat intake is 20-25% of energy; in the United Kingdom it is 35%.

Many countries have recommended a reduction in SFA intake and an increase in PUFA/MUFA consumption; however, the target goals have not been specified in many instances.

Care has to be taken with such recommendations. It may be difficult for some countries to meet them for cultural, environmental or economic reasons. In such cases, concentration should be on optimising health and not on absolute dietary values. Furthermore there is always the risk that infants are also put on low fat diets, as parents tend to apply healthy eating rules especially to their offspring.

7.4 *Cancer*

The growth of cancerous tumours requires the rapid proliferation of cells and hence, cell membranes, surrounding them. Fats form the structure of cell membranes, so in this way, they are intimately involved in the development of cancer. However, there is less evidence to suggest an involvement of fat at any of the crucial developmental stages of cancers.

Epidemiological studies have shown correlations between average fat intakes in populations and incidence of breast cancer. The real relationship, however, does not seem particularly strong or consistent. Prospective cohort studies (the silver standard in epidemiology apart from the golden standard intervention study) have not shown clear relationships between fat intake and the incidence of breast cancer at all. Recent research results actually point in a totally different direction: it seems that regular intake of alcohol shows a positive relationship with the incidence of breast cancer. Again, this association is not conclusive.

Population studies have also linked a high fat diet high in SFA with an increased risk of colon and prostate cancer. Laboratory studies with rodents have suggested a relationship between diets very high in n-6 PUFA and high incidence of certain forms of cancer. However epidemiological data are not supportive of this position. In addition, animal studies suggest that n-3 PUFA may inhibit carcinogenesis.

Although a lot of attention has been directed at fat and cancer, there is yet no conclusive evidence that a number of other nutrients and dietary constituents have been linked both to increasing (alcohol) or decreasing (dietary fibre) certain forms of cancer. The strongest evidence between diet and cancer is for certain food groups. For example, the protective effect of fruit and vegetable consumption is well-established.

As stated earlier, IOCCC products do not contribute greatly to total fat intake. So, even if the evidence relating the incidence of cancer to fat intake were conclusive, there would be no reason for pointing a finger at these products.

7.5 *Conclusions*

Dietary fats are an essential part of every person's diet and serve to insure good health as well as providing some of the unique characteristics of foods.

Both the associations between dietary fat, obesity and CHD are well documented and the public is becoming more informed about this subject. What is not so widely known is the difference in effects of individual fatty acids, making it very difficult to make broad classifications based on saturation, for example.

Many dietary recommendations around the world take account of the alleged relationship between fat and diseases such as obesity, CHD and cancer.

In the case of obesity it seems clear that high fat diets are detrimental to their continuing weight problems. Voluminous diets containing a lot of carbohydrates would make it easier to prevent weight gain while also helping weight loss.

There is still some disagreement among experts about whether the reduction of CHD is more likely to be achieved by changing the diet of whole populations or of high-risk individuals. In general, it is recommended that fat intake should not exceed 30-35% dietary energy, while saturated fats should not exceed 10% of dietary energy.

Relationships between fat intake and the incidence of cancer are less conclusive.

Regarding the role of IOCCC products and the incidence of obesity, CHD and cancer conclusions are relatively simple. First of all, the contribution to total fat intake is relatively low in normal real life consumption patterns. Therefore, only in cases where these products are consumed in abnormal quantities can anything be said anything about extra risk factors in relation to these diseases. However, the same applies to any type of foodstuff, so this does not make IOCCC products in any way unique among the range of foods we daily consume. Secondly, the types of fat included within IOCCC products are variable. So, as long as one consumes these foods moderately and varies them, no extra risk of CHD may be noted.

8. IOCCC POSITION

The IOCCC agrees that fat intake should not be excessive, and that reductions of fat intake to 30-35% of energy may be helpful in reducing obesity and also in contributing to a reduction in CHD. Furthermore that it would be worthwhile for obese persons to reduce their fat intake even further, as high fat intake leads to overconsumption and is detrimental to their health.

IOCCC products in themselves do not have a unique position within the daily diet, in relation to health and disease, as long as they are consumed in amounts currently normal within the developed world.

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