10 – Fat Substitutes in Food Products

10-1 Introduction

Prospective studies have repeatedly shown overweight to be associated with an elevated risk for various diseases including cardiovascular disease and type II diabetes (non-insulin-dependent diabetes mellitus). Other complaints with an elevated prevalence among overweight people include hypertension, gall bladder disorders, back and joint pain and psycho-social problems. Intervention studies have shown that reduction of body weight immediately results in a lower cardiovascular disease risk and improved glucose tolerance.

In the 1980s, the prevalence of obesity (a body mass index, BMI, $\geq$ 30 kg/m^2) among European and American men and women aged 40–60 was 10–44%, with the highest value for Mediterranean and East European women. The prevalence in Belgium, Germany, the Netherlands and the UK averaged 13% for men and 16% for women. In many Western countries the prevalence of obesity is increasing [Blokstra *et al.*, 1993].

Overweight is by definition the result of a positive energy balance. The easiest way of reducing energy intake seems to be reduction of fat intake since the energy content of fat is twice that of protein or carbohydrate. Besides, it is generally accepted that the Western diet contains fat in excess. The guidelines for a healthy diet issued in various countries recommend to lower the diet fat content from the current 40% to 30–35% of total energy content.

A reduction of energy intake through a reduction of dietary fat intake is easier said than done because fat contributes strongly to the sensory characteristics of our food (taste and consistence). New developments in food technology now allow of the partial replacement of dietary fat with substitutes of much lower energetic value while retaining most of the product sensory qualities.

In this chapter the different fat substitutes, their applicability and possible drawbacks are discussed in some detail. A further focus is on these substitutes efficacy, *i.e.* on their actual capacity to help reduce energy intake. Relevant information for the preparation of this chapter was derived from a recent report by the Dutch Food and Nutrition Council [Voedingsraad, 1995].

10-2 Dietary Fat Substitutes

Fat-substituting ingredients can be defined as food constituents able to substitute, wholly or partially, dietary fat in such a manner that the sensory properties of the food product involved are left unaltered as far as possible. According to that definition, water, and even air, could act as fat substitutes. However, water and air as substitutes are left out of consideration in this chapter.

Fat substitutes can basically be grouped as follows:

- fat substitutes based on carbohydrates or proteins, also named ‘fat mimetics’,
- fat substitutes based on esters and ethers,
- structured fats.

Ester- and ether-based substitutes as well as structured fats are also referred to in the literature as ‘artificial fats’, ‘fat analogues’ or ‘fat substitutes’.

10-2-1 Fat Substitutes Based on Carbohydrates and Proteins

This category of fat substitutes can be classified on the basis of their physiological properties into substitutes based on protein or modified starch, and substitutes based on mucilages, vegetable and fruit fibre or polydextrose. A characteristic of the former group is that these fat substitutes are fully converted by digestive enzymes and hence fully utilized by the body; their energy content is 17 kJ/g. Substitutes of the latter group are characterized by incomplete conversion by digestive enzymes and consequently full or partial anaerobic fermentation in the large intestine. The fermentation process yields gaseous products such as carbon dioxide, hydrogen, methane, short-chain fatty acids and lactic acid. The energetic value of fat substitutes varies among the products but is also lower than 17 kJ/g. Microcrystalline cellulose is hardly fermented and hence contributes marginally to energy intake. In contrast, such products as inulin, fructo- and galacto-oligosaccharides are almost fully fermented and contribute to energy intake to an extent dependent on the fermentation pattern; their estimated energetic value is 6–10 kJ/g. Some (partially) indigestible fat substitutes are also used as prebiotics (inulin and various oligosaccharides).

Some examples of protein-based fat substitutes are Simplesse, Trailblazer (based on chicken and/or whey protein) and gelatin. Simplesse and Trailblazer are physically modified proteins whereas gelatin is a native protein. Protein-based fat substitutes find their major applications in ice cream and spreads.

Examples of carbohydrate-based fat substitutes (mucilages) are xanthane gum, guar gum, algic acid and algic salts, carragene and locust bean meal.

Mucilages are predominantly used in sauces, chocolate products, surrogate whipping cream, dressings and ice cream.

Examples of fat substitutes based on vegetable and fruit fibre are β-glucan, pectin, pectates, sugar-beet fibre, pea fibre, inulin and cellulose. Their area of application is similar to that for mucilages.

Polydextrose is a synthetic carbohydrate which, in contrast to modified starches, is not converted by digestive enzymes. Polydextrose is being applied in ice cream whereas modified carbohydrates are applied in frying products and meats.

Excessive intake of poorly digestible fermentable carbohydrates can have negative side-effects such as flatulence, rumbling in the stomach or an inflated stomach. Overdosing may give rise to osmotic diarrhoea.

10-2-2 Fat Substitutes Based on Esters and Ethers

Fat substitutes of this category, which are aso referred to as synthetic fats, are neither decomposed by digestive enzymes nor fermented in the large intestine. Hence, these fat substitutes do not contribute at all to energy intake. These fat substitutes have the same physical characteristics as fats. The best known examples are sucrose polyesters (SPEs) which are esters of sucrose and fatty acids. The US Food and Drug Administration has recently, after ample considerations (since 1987), granted Procter & Gamble permission to use these substitutes on a limited scale in such products as chips and snacks.

Excessive intake of SPEs, and possibly also of other indigestible synthetics fats, can give rise to anal leakage. Other examples of synthetic fats are esterified propoxylated glycerol (EPG) and dialkyldihexadecylmalonate (DDM). These compounds have not been admitted thus far.

Because dietary fats are the carriers of fat-soluble nutrients, such as vitamins A, D, E and K and carotenoids, it cannot be excluded that synthetic fats have adverse effects on the absorption of these nutrients. The final decision on this matter has certainly not been taken yet.

10-2-3 Structured Fats as Fat Substitutes

Structured fats are fats deliberately composed to let them have desirable properties. In the case of fat substitutes, such a property is a low energetic value. These fat substitutes contain fatty acids that either are of a low energetic value or are poorly absorbable. Examples of this category are Caprenine and Salatrim. Each Caprenine molecule is made up, in addition to glycerol, of two MCT fatty acids (C8 and C10) and one C22 saturated fatty acid (behenic acid). MCT fatty acids, by virtue of their shorter C chain, have a lower energetic value than longer-chain fatty acids, and behenic acid is not readily digested. Because of these properties, the energetic value of Caprenine is only half that of conventional fats. Salatrim contains short-chain fatty acids (C2, C3 and C4) alongside C18 fatty acids. Like Caprenine, the energetic value of this fat substitute is about half that of conventional fats.

Structured fats may substitute all fats in chocolate products, bakery products and dairy products. Although structured fats do not contain foreign components, their possible long-term effects on blood lipid level are still a matter of controversy. In other words, it is still questionable whether these products are nutritionally safe on the longer term.

10-3 Health Effects of Fat Substitutes

10-3-1 Effects on Serum Cholesterol

The use of fat substitutes can lead to a reduced fat content of the diet which may have favourable effects on blood cholesterol level. These effects on cholesterol will be most apparent if dietary saturated fat is replaced with fat substitutes based on proteins or carbohydrates or with synthetic substitutes. It should be taken into account, however, that substitution of carbohydrates for dietary fat can also result in a less desirable decrease in HDL-cholesterol level. Replacing dietary unsaturated fat with fat substitutes will not favourably affect cholesterol levels. The use of SPEs results, in addition to the decrease in blood cholesterol level caused by the replacement of dietary saturated fat, in a further decrease as a consequence of a decreased intestinal cholesterol absorption. Although information on the effects of Caprenine is scanty, this substitute probably can increase blood cholesterol levels. Salatrim seems to have hardly any effect on cholesterol level.

Guar gum, pectin and oat bran (with β-glucan as the active substance) can lower cholesterol levels in animals and man. Their action is presumably based on inhibition of re-absorption of bile acids in the distal part of the small intestine. A jelly-like action appears to be required for this effect.

10-3-2 Effects on Body Weight

The Dutch Food and Nutrition Council could conclude from the results of various short-term studies that the use of dietary fat substitutes can result indeed in a lower energy intake and hence to a better control of body weight [Voedingsraad, 1995]. After a meal with dishes containing fat substitutes there is 'energetic compensation' to some extent, but the lower energy intake is not fully compensated so that the net effect is a reduced energy intake. It should be noted, however, that few studies have addressed the effects of fat substitutes on long-term body weight control. (**Figure 35**)

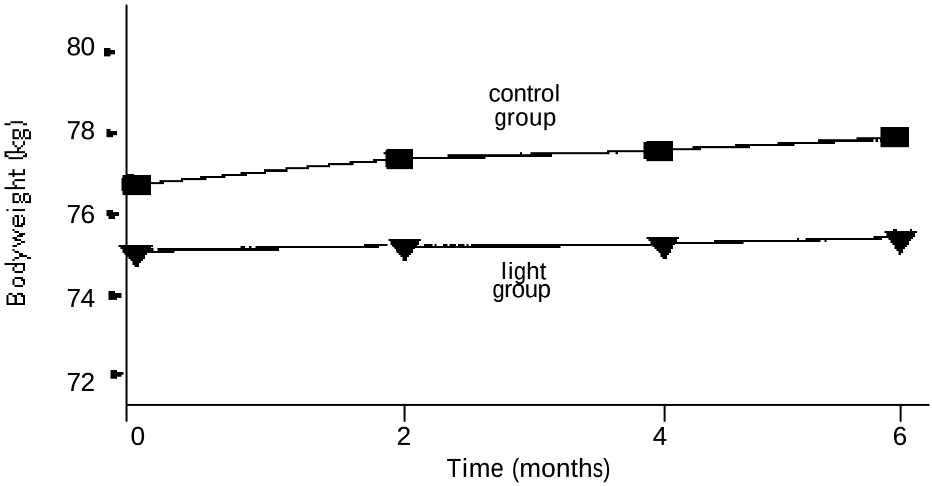

Figure 35 — Average body weight (kg) of all participants in the 'light' group (subjects who consumed commercially available 'light' products over a period of 6 months) and in the control group (subjects who used commercially available traditional food products) at baseline and after 2, 4 and 6 months. Body weight increased slightly, but significantly, in the control group, but remained stable in the 'light' group (results of the SMFAT study, Unilever Research Laboratories, Vlaardingen, The Netherlands).

References

Blokstra A., Hoffmans M.D.A.F., Seidell J.C. [1993]. Endogene determinanten. In: *Volksgezondheid Toekomstverkenning*, pp. 533–537. Rijksinstituut voor Volksgezondheid en Milieuhygiëne (RIVM), Bilthoven, Nederland.

Voedingsraad [1995]. *Vervangende ingrediënten in voedingsmiddelen: vetvervangers*. Voedingsraad, Den Haag.