Invited commentary

Regulation of energy and fat intakes and body weight: the role of fat substitutes

It is widely accepted that a reduction in the amount of fat in the Nation's diet would confer significant health benefits. These include a reduction in the prevalence of obesity, overweight, cardiovascular diseases and certain cancers. The role of fat substitutes (or fat replacers) in helping people to achieve the recommended level of fat consumption (i.e. no more than 35 % of total food energy) lies in their ability to reduce the fat content of foods, while maintaining their hedonic qualities.

Dietary fat substitutes have existed for over a decade and more than 100 fat substitutes have been formulated. A useful table illustrating the main categories of fat substitutes, examples within each category (trade names), their uses and regulatory status can be found in an article by Warshaw *et al*. (1996). The majority of the research conducted on fat substitutes has been conducted on the fat-based fat substitute, olestra. Olestra is a sucrose polyester (SPE) that has the physical properties of fat but is not absorbed by the gastrointestinal tract and, hence, provides no fat or energy to the diet. It has recently been approved by the US Food and Drug Administration (FDA) for use in savoury snack foods and is marketed under the brand name Olean by Procter and Gamble.

Although it can be assumed that replacement of high-fat foods with those containing SPE will lower dietary intake of both fat and energy, few data can be found on this issue. Short-term covert studies (where the subjects were unaware of the energy–fat manipulation) show variable results with either no compensation, partial compensation or full compensation for the energy reduction (see Lawton & Blundell, 1998). However, all such studies show minimal compensation for the substitution of fat. Hence, when energy compensation did occur it was largely in the form of energy from carbohydrate and protein, thereby significantly reducing the percentage of fat in the diet. Few studies have investigated the long-term effects of replacement of dietary fat by SPE on energy and fat intakes. Additionally, those longer-term studies that do exist show variable results with respect to energy compensation (see Lawton & Blundell, 1998, for more details) probably reflecting different methodologies. The study reported by Kelly *et al*. (1998) in this issue is, therefore, an important contribution to this field of research.

The subjects in the study conducted by Kelly and colleagues consumed between 20 and 40 g (mean 26·8 g) of SPE per day for 12 weeks. This dietary intervention caused them to reduce their daily intake of fat (from 38 % of total energy at baseline down to 36 % at 12 weeks) but had no effect on energy intake and consequently no effect on body weight. When the same subjects consumed control fat (triacylglycerol, TAG) foods their fat intake increased by 22·1 g/d ($P < 0{\cdot}001$) compared with when they were consuming the corresponding SPE-containing foods, whilst their energy intake was also increased by 0·83 MJ (NS). Although not statistically significant, the rise in energy intake on TAG foods (passive overconsumption) is likely to be of biological significance since it was accompanied by a small (+0·92 kg) but significant ($P < 0{\cdot}001$) increase in body weight.

The results of this study are in line with the results of recent longer-term studies (e.g. Westerterp *et al*. 1996) on the effects of conventional reduced-fat (i.e. non-fat-substituted) diets on daily fat and energy intakes and on body weight. Westerterp *et al.* (1996) studied 217 subjects who ate freely from either full-fat or corresponding reduced-fat foods for a period of 6 months. The main outcome was that individuals who consumed the reduced-fat foods reduced their intake of fat (from 35 to 33 % of energy) but not energy, and had no significant changes in body weight over the study period. In contrast, individuals who consumed the full-fat products increased their fat and energy intakes significantly and gained weight (body mass and fat mass).

On balance, research conducted to date indicates that fat replacers such as SPE are a useful tool to help people to control their fat and energy intakes. SPE-containing reduced-fat foods appear to have a similar impact on energy and fat intakes as conventional reduced-fat foods. Since SPE foods have the added bonus of retaining the hedonic qualities of full-fat foods they are likely to improve adherence to a low-fat diet. They may, therefore, be particularly useful for people who find themselves vulnerable to passive overconsumption on high-fat foods. The positive consequences of consuming SPE products such as the reduction in dietary fat intake and favourable effects on lipid profiles (reduction in plasma cholesterol and TAG) reported by Kelly *et al*. (1998) must, however, be weighed against the negative consequences reported in this and other studies.

Kelly *et al*. (1998) found that a daily intake of 20–40 g SPE was associated with significant reductions in plasma concentrations of vitamin E (but not vitamin A or D) and six carotenoids (lutein, β-cryptoxanthin, lycopene, α-carotene, β-carotene and *cis*-β-carotene). Furthermore, this level of consumption of SPE provoked unacceptable gastrointestinal problems such as urgent calls to stool (in 30 % of cases on SPE compared with only 10 % of controls) and anal leakage of SPE oil in 7·2 % of cases on SPE. It is, therefore, clear from the carefully controlled work of Kelly and colleagues that SPE (at doses of 20–40 g/d) significantly affects bowel function, although the authors do point out that it is possible that it might not do so in the amounts that would be expected to be consumed as a result of consuming savoury snacks (around 2–11 g/d).

Fat substitutes are regulated under two FDA-approved categories, substances generally regarded as safe (GRAS) and food additives. The majority of fat substitutes approved by the FDA have been GRAS substances, created from common food components (carbohydrate or protein), and have therefore required minimal safety testing. In contrast, since SPE is classed as a food additive, extensive safety testing has been required with the majority of studies being performed using olestra. These studies address the potential for toxicity, the potential for olestra to affect the structure and function of the gastrointestinal tract, and the effects that it might have on digestion and absorption of nutrients (e.g. the fat-soluble vitamins and carotenoids) and on the absorption of lipophilic drugs.

Studies carried out on the effects of olestra on both gastrointestinal functioning and absorption of fat-soluble vitamins have yielded mixed results. Certainly the findings of Kelly and colleagues are in contrast to those of early studies which suggested that ingestion of SPE had little effect on bowel function. With regard to the effects of olestra on absorption of fat-soluble vitamins, vitamins D and K appear to be less affected than vitamins A and E. What is clear, however, is that olestra can only affect the uptake of fat-soluble vitamins when other foods containing these vitamins are consumed at the same time. Nevertheless, in order to offset any undesirable effects on fat-soluble vitamin status, manufacturers of foods containing olestra are required to add fat-soluble vitamins (A, D, E and K) in amounts specified by the FDA. The health benefits of carotenoids are still poorly understood and so it is not yet clear whether the effects of SPE on these substances poses a health risk. Consequently the FDA has concluded that olestra does not need to be supplemented with carotenoids. The absorption and/or efficacy of lipophilic drugs (e.g. oral contraceptives) do not appear to be affected by consumption of olestra.

On the basis of current knowledge it can be concluded that fat-substituted foods have the potential to prevent people from accumulating positive fat balances. The effects of their consumption on energy and body weight, however, remains equivocal. Definitive answers regarding the usefulness and safety of fat substitutes will depend on more longer-term, overt and covert, controlled studies in normal, overweight and obese subjects. For the time being, however, I would agree with Kelly and colleagues that the deleterious side effects of SPE consumption, as observed in their study, warrant further investigation before this product is made available for widespread long-term consumption in a broad range of foods.

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