Invited commentary

Spicing fat for combustion

The 'cornerstone' method for managing body weight (by conscious control over what we eat) has proven to be largely unsuccessful, primarily because it is difficult for most individuals to stick to the hardship of dietary regimens. To quote Garrow (1992): 'The difficult thing is not to eat little, but to eat little when the option of eating more is available'. The key to improving the success of dietary control, it is believed, is therefore to make it easier (hence less painful) for the individual to control his/her energy intake. Such a 'softening' process is indeed reflected in the succession of mainstream methods for therapeutic slimming of the past 40 years. From the total starvation (zero-calorie) era of the 1960s, the trend switched to Very-Low-Calorie-Diets in the 1970s, followed by the Low-Calorie-Diets in the 1980s, before ending in this decade with a shift in emphasis from energy restriction *per se* to restricting the proportion of fat in the diet.

The idea to reduce fat consumption in weight control is of course not new, for it has long been known that high-fat foods, by virtue of their high energy density and low bulk, produce less gastric distension, delay gastric emptying, thereby retarding the feeling of fullness and the cessation of meals. The novelty today lies in the proposal for a metabolic basis linking dietary fat to appetite (Flatt, 1995). According to this nutrient balance theory, the fat balance (unlike carbohydrate and protein balances) is not precisely regulated, and the failure to adjust fat oxidation in response to excess fat intake will result in increased appetite. The mechanistic feature of this theory, which centres upon the need to maintain specific carbohydrate (glycogen) stores as a determinant of appetite, has however been challenged (Stubbs, 1995), and the increased appetite associated with high-fat diets is now primarily attributed (or re-attributed) to their high energy density rather than to fat *per se*. Since, in practice, reduction in high-fat foods automatically leads to reduction in energy density, fat restriction remains high on the list of recommendations for both the treatment and prevention of obesity.

But fat adds palatability to foods: all the flavour-enhancing, tongue-pleasing texture and palate-soothing smoothness of fats and oils contribute to the hedonic qualities of food through vision, smell and taste. From a sensory standpoint, foods that are rich in fat are pure taste and pleasure. It is therefore not surprising that fat restriction has proven to be as difficult to sustain over long periods of time as total energy restriction. The low-fat (high-carbohydrate) diet is bland, and the novel light 'fatty' foods based upon fat substitutes which are poorly absorbed or simply not absorbed (e.g. olestra) are still no match for the 'pure taste and pleasure' of foods cooked with conventional fats and oils. Unless food technology can resolve the issue of palatability of low-fat diets, the only realistic improvement in the control of body weight in a public unwilling to compromise on 'palate and plate' is to burn the excess fat, i.e. to increase fat oxidation and metabolic rate. In theory an increase in physical activity should provide the solution but, in practice, the compliance in sustaining regular exercise is poor, and there is increased recognition of the need for alternative or complementary strategies to enhance fat combustion.

In the search for dietary components that would promote fat oxidation and thermogenesis, the pungent spices in foods have attracted interest, triggered initially, perhaps, by their apparent ability to warm the body 'subjectively'. More objective evidence for spice-induced thermogenesis was first provided by Henry & Emery (1986) who showed that chilli and mustard sauces augmented the thermogenic response to a meal, and the most recent, by Yoshioka *et al.* (1998) in this issue, reporting that red pepper enhanced thermogenesis and lipid oxidation in women. It is now established from animal studies that it is the principle ingredients that confer pungency to these spicy ingredients and to others such as Tabasco sauce and ginger, namely the capsaicinoids (capsaicin and dihydrocapsaicin) and capsaicinoid-homologues (the gingerols and shogoals), that also confer the thermogenic and lipolytic properties (Kawada *et al.* 1986, 1991; Cameron-Smith *et al.* 1990; Eldershaw *et al.* 1992). Of particular interest in the study reported by Yoshioka *et al.* (1998) is that these metabolic effects of the capsaicin-rich foods were demonstrated in women showing diminished meal-induced thermogenesis and the failure to increase fat oxidation when shifted from a high-carbohydrate to a high-fat meal. The addition of the capsaicin-rich red pepper to the high-fat meal was found to stimulate fat oxidation, and to normalize the thermogenic response to the high-fat meal to levels found with the high-carbohydrate meal. In other words, spices rich in capsaicinoids have the potential for adjusting fat oxidation to fat intake.

These metabolic effects of pungent principles of spices are perhaps not unexpected in view of evidence suggesting that their main modes of action are intricately linked to interference with the sympathoadrenal system, which via circulating adrenaline and/or sympathetically-released noradrenaline plays an important role in the control of thermogenesis and fat oxidation. Indeed, pharmaceutical interests in the development of anti-obesity thermogenic drugs centre upon the development of novel adrenoceptor agonists with greater selectivity for an atypical (β_3) adrenoceptor believed to be the pivotal adrenoceptor by which catecholamines activate thermogenesis. By exerting their metabolic effects either centrally to induce adrenal medullary secretion

(Kawada *et al*. 1988) or peripherally by interference with sympathetic control in tissues such as the skeletal muscle and brown adipose tissue (Kawada *et al*. 1986, 1991; Cameron-Smith *et al*. 1990; Eldershaw *et al*. 1992), spices rich in capsaicinoids could therefore constitute a new class of dietary ingredients with sympathomimetic thermogenic effects. In this context, they join other dietary ingredients which also possess thermogenic properties by virtue of interference with the sympathoadrenal system, namely: caffeine (in coffee/tea/cola drinks consumed worldwide), catechin-polyphenols (in green tea consumed widely in China and Japan), and medium-chain triacylglycerols, MCT (in coconut oil, the main cooking oil in parts of SE Asia and Africa). In amounts compatible with their daily intake in the specific communities, they have all been shown to be effective in stimulating thermogenesis and 24 h energy expenditure in human subjects fed on high-fat diets under room calorimeter conditions (Dulloo *et al*. 1989, 1996; AG Dulloo, C Duret, D Rohrer, M Fathi, N Mensi and L Girardier, unpublished results). Among the spice-capsaicinoids, the beverage- containing methylxanthines (caffeine, theobromine), the green tea catechin-polyphenols and the oils rich in MCT, there is likely to be at least one (and generally two or more) of these dietary ingredients that form an integral part of the diet in most cultures of the world today. It makes one wonder about the extent to which they could already be helping many of us to put our excess dietary fat into the fire.

Abdul G. Dulloo
Department of Physiology
Faculty of Medicine
University of Geneva
1211 Geneva 4
Switzerland

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