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Food reformulation: the challenges to the food industry

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The role of the food industry (retailers, manufacturers and food service) in helping consumers eat healthily and sustainably has been receiving considerable attention in recent years. This paper focuses on the challenges facing the food industry and the role of food reformulation in meeting these challenges, through the lens of a public health nutritionist. Attention has been heightened by the Government's Responsibility Deal, launched in early 2011 by the Department of Health (England), by the UK's engagement with the global food security and food supply sustainability agendas and by the Government Office of Science's Foresight report. The Responsibility Deal's food network has to date focused on reduction of *trans* fatty acids, salt and calories and out-of-home calorie labelling (in food service settings). New pledges are expected soon on increasing fruit and vegetable intakes. Reformulation is a major feature of the Responsibility Deal's approach, and along with other approaches such as portion control, choice editing and information provision, there is potential to increase the breadth of healthier choices available to the public. With the exception of fruit and vegetables, the emphasis has been almost exclusively on aspects of the diet that are in excess for many of the population (e.g. energy and salt). Evidence of low consumption of some key micronutrients by some groups of the population, particularly adolescents and young adults, often alongside excess energy intake compared with expenditure, is all too often overlooked. This paper summarises the progress made to date, the challenges faced and the opportunities that exist, with particular focus on reformulation. One of the biggest challenges is the relatively poor understanding of how to effect positive and long-term dietary behaviour change. The paper concludes that, in isolation, reformulation is unlikely to provide a complete solution to the challenge of improving eating patterns and nutrient provision, although it is a contributor.

Food reformulation: Responsibility deal: Sustainability: Public health

Even in the twenty-first century, a billion people around the world go to bed hungry and a further billion suffer from a shortfall of micronutrients[1]. Alongside this picture of under-nutrition, more than a billion are overweight or obese, putting them at increased risk of diet-related diseases[1]. In rich and poor countries, overweight, obesity and diet-related diseases, such as CVD and type 2 diabetes, are found alongside under-nutrition. Even when energy intake is sufficient or in excess, the foods consumed may be poor sources of essential nutrients. Governments around the world are grappling with the challenges of food security, which has traditionally focused on producing more food, not necessarily more nutritious food. An emerging realisation over the past decade or so has been the need to take into account the sustainability of current food production methods in the face of climate change and the need to feed an increasing global population that is typically also living longer[1]. Towards the end of 2011, the world's population reached seven billion and is projected to increase by a further billion by 2025, adding 500 million people to African and to Asian populations. Population growth is far slower in Europe, North America

Abbreviation: GHG, greenhouse gas.

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Table 1. Progress with achieving current UK dietary recommendations. Information extracted from Bates *et al.*[9]

	Recommendation	Are adults (19–64 years) meeting the recommendation? (NDNS 2008–11 combined)	
Fruit and vegetables	At least 5 × 80 g/d	4·1 × 80 g/d 31% achieved five servings a day	✗
Oily fish	At least 1 × 140 g/week	77 g/week	✗
NMES	<11% E (~60 g/d)	Average 12·3% E (intakes are higher in children: 14·6% ages 4–10 years, 15·3% ages 11–18 years)	✗
Fat	Average 35% E	Average 34·7% E	✓
Saturates	Average 11% E	Average 12·7% E	✗
NSP	Average 18 g/d	Average about 14 g/d	✗
Salt	Average 6 g/d	Average 8·1 g/d	✗
Vitamins/minerals	DRV	Not all sub-groups are meeting the recommendation (see Table 2 for further information)	✓ ✗

NDNS, National Diet and Nutrition Survey; NMES, non-milk extrinsic sugars; DRV, dietary response values.

and other westernised societies, and in some cases is declining. Nevertheless, for the first time, the world's urban population has exceeded the numbers living in rural situations, owing to the transition taking place in many parts of the world. Despite the extreme poverty that continues to exist, many people in emerging economies are becoming more prosperous and this is triggering demand for different types of food, as well as fresh water and energy, and this in turn is influencing emissions of greenhouse gases (GHG; CO_2, CH_4 and N_2O). The pattern of climate change over the next 15–20 years will be determined by GHG already in the atmosphere. Agriculture contributes 12–14% of global GHG emissions (including those associated with fertiliser production), and it contributes disproportionately to CH_4 and N_2O production that have a higher impact on global warming.

Total global impact of the food system on GHG emissions, including in particular those beyond the farm gate and derived from land conversion, is estimated to be about 30%. Low- and middle-income countries contribute three-quarters of this and their proportional share is increasing. Keeping emissions in check is yet another challenge as we strive to produce significantly more food of appropriate nutritional quality to feed the growing number of mouths and progress is already being made. In contrast with the global picture, in the UK the food supply chain contributes 18% of emissions, with 7% from agriculture and the remainder in the food chain beyond the farm gate. Ongoing work is reducing emissions from livestock production[2], CH_4 production in the UK fell by 19% in the period 1990–2009 and N_2O by 23%[3].

It has been estimated that the global population will exceed nine billion by 2050; in the mid twentieth century it was just over 2·5 billion and has already reached seven billion, with the fastest rates being recorded in the 1960s (http://www.census.gov/population/international/data/idb/worldpoptotal.php). In the second half of the twentieth century, as population began to rise, solutions focused on generating more arable land by ploughing up grassland and cutting down forests. It is now realised that this contributed significantly to GHG emissions and also reduced the opportunity to sequester carbon in the trees and grassland. Foresight refers to sustainable intensification as the way forward, as a means to producing more food using the same amount of land and fewer inputs (water, energy and fertilisers), but whatever approaches are taken, we need to understand the impact they will have and to avoid unintended consequences. For a discussion of this see Riley and Buttriss[4].

All too often, nutrition has not featured high on the list of priorities in such discussions, which to a nutritionist seems strange, given that foods and drinks are primarily a key vehicle through which life is sustained and health maintained.

As urbanisation expands and our reliance on processed foods increases, the food industry has an even greater role to play in providing a choice of nutritious foods that are procured sustainably. This paper focuses on the challenges facing the food industry and the role of food reformulation in meeting these challenges, through the lens of a public health nutritionist.

Public health challenges in the UK

In Europe, obesity and associated conditions are widespread and one of the highest rates is in the UK[5], where prevalence has increased threefold since the 1980s. In 2010, 26% of adults in England were obese and a further 40% of men and 30% of women had a BMI in the overweight range (BMI 25–30)[6]; obesity prevalence is forecast to rise to 47% in men and 36% of women by 2015 if trends continue[7]. Three in ten children aged 2–15 years in England are overweight or obese[6] and the National Child Measurement Programme has revealed that almost 10% of children are already obese when they start school and almost 20% of 10–11-year-old are now obese[8]. There are also substantial social gradients in the prevalence of obesity among children, with rates being approximately doubled in children from less privileged backgrounds, at all ages[8]. However, obesity is not the only public health challenge in the UK. As shown in Table 1, most of the dietary recommendations have yet to be met. Since 1991 when the dietary reference values were published[10] some progress has been made, in particular in relation to total

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Table 2. Vitamin and mineral intakes, % below the lower reference nutrient intake. National Diet and Nutrition Survey, Rolling Programme Years 1 and 2, 2008–2011 combined; information extracted from[11]

	Male				Female			
Age, years	4–10	11–18	19–64	65+	4–10	11–18	19–64	65+
Vitamin A	6	**12**	10	4	5	**14**	6	1
Riboflavin	1	8	4	5	1	**21**	**12**	2
Folate	0	2	2	1	0	7	3	3
Fe	1	6	1	2	1	**46**	**23**	1
Ca	0	7	4	2	2	**18**	8	3
Mn	0	**28**	**16**	**18**	3	**51**	11	9
K	0	**17**	**11**	**14**	0	**31**	**23**	**18**
Zn	5	**11**	9	**9**	**8**	**19**	4	1
Se	0	**22**	**25**	**31**	1	**45**	**52**	**54**
Iodine	2	8	5	0	3	**21**	10	1

▢, Percentage of the sub-population below the lower reference nutrient intake was >15%.

fat intake, which is now below the 35%E target according to the National Diet and Nutrition Survey[11] but improvement in nutrient intakes remains a requirement. As shown in Table 2, the challenges are not restricted to macronutrients, there being widespread evidence of low intakes of a number of nutrients especially in teenage girls and young women. It should be noted that, publications from the latest National Diet and Nutrition Survey do not as yet provide data for age-specific subgroups of women, despite differences in requirements for Fe in particular. In the absence of such data, it is worth reflecting on the findings of the previous National Diet and Nutrition Survey[12] which found that the prevalence of intakes of Fe below the lower reference nutrient intake in girls/women of various ages was 44% at 11–14 years, 48% at 15–18 years, 40% at 19–34 years and 23% at 35–64 years[13].

Opportunities for the food and beverage industry

Opportunities to improve both the nutritional profile and the sustainability of diets exist all along the food chain, from the farm through manufacture and retail, to the home. Crop diversification, bio- and food fortification, nutrition-sensitive transportation, minimisation of waste throughout the food chain, reformulation and the promotion of healthier options are among the many factors that have a part to play. Some of the multinational companies have already responded publicly to the challenges faced. For example, Unilever launched a Sustainable Living Plan[14] in 2010 with three objectives: to help improve the health of more than a billion people, to halve the environmental impact of its products, and to source all its agricultural materials sustainably. Pepsico's Performance with Purpose strategy (2009) covers four areas including environmental sustainability[15] and back in 2007 Marks and Spencer launched its Plan A with 100 commitments to be achieved by 2012 (now extended to 180 by 2015) with the ultimate goal of being the world's most sustainable retailer, the five pillars being climate change, waste, sustainable raw materials, health, and being a fair partner[16]. Sainsbury's 20 by 20 Sustainability Plan (2011) sets out twenty goals to help customers make nutritional, sustainable and ethical decisions[17]. McDonald's sustainability goals for 2011–2012 include reducing environmental impact of direct suppliers, working on the next actions from the Global Conference on Sustainable Beef, making progress on products as identified in McDonald's Sustainable Land Management Commitment, adopting energy-efficient equipment and technology in restaurants, and increasing energy awareness and education across the system[18]. Nestlé's Creating Shared Value report focuses on three areas, one of which is water and environmental sustainability[19]. In addition, many companies have signed up to the Responsibility Deal, as discussed later.

Diet and health

There are a number of ways in which manufacturers, retailers and the food service sector can work with others to improve diet and health. These can be categorised as shown in Table 3, which provides some examples of the types of approach already being adopted. However, improving the nutrient profile of a food is often not simply a matter of excluding a particular nutrient, as is discussed in the section on Technical Challenges.

The Responsibility Deal

The Responsibility Deal, an initiative from the Department of Health (England) that focuses on partnership working with the food industry and other stakeholders, was established in early 2011 to accelerate delivery of public health goals through greater use of businesses' influence in the market and ability to engage consumers. Five networks have been established: food, alcohol, physical activity, health at work and behaviour change, and organisations engage with the process by signing up to pledges. In the food network, pledges have been established on the following, to which companies are invited to sign-up: Salt (2011), three additional pledges for catering sector (2012); *trans* fatty acids (2011); calorie labelling out of home (2011); calorie reduction in the food supply (2012); fruit and vegetables (expected Autumn 2012).

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Table 3. Examples of approaches that can be taken

Changing the composition of food (reformulation)	Reducing energy density (kJ/g food)
	Reducing the amount of fat, saturates, sugar or salt
	Changing the fat or carbohydrate profile, e.g. by choice of oil/fat, changing the diet of ruminants, use of structured lipids and blending of oils
	Removal of *trans* fatty acids
	Improving the nutrient profile through choice of ingredient or fortification
Providing more/less choice	Introducing healthier options
	Introducing smaller portion sizes
	Choice editing – limiting choice at point of sale
	Changing the default, so that the easy option/most readily available standard option is the healthier choice
Information provision and education	Information provision on packaging e.g. nutrient composition, guideline daily amounts, front-of-pack information e.g. traffic light schemes and guideline daily amount schemes, allergen and ingredient labelling
	Information provision point of sale and on websites
	Provision of cooking skills, preparation tips and recipes
	Food and health as a core component of schools' curricula
Others	Regulation, e.g. Ofcom rules for advertising to children
	Taxation, e.g. differential value added tax levels for different food categories; fat and or sugar taxes (as being applied in Denmark, for example Smed 2012[20])

Additional topics currently under discussion are revised targets for salt, activity around saturated fat reduction and promotions (e.g. in store). Product reformulation is a feature of a number of these pledges. For example, the wording of the calorie reduction pledge is: 'We will support and enable our customers to eat and drink fewer calories through actions such as product/menu reformulation, reviewing portion sizes, education and information, and actions to shift the marketing mix towards lower calorie options. We will monitor and report on our actions on an annual basis.' Publication of the calorie reduction pledge was preceded by a Call to Action in England[21], which set out the importance of action on obesity, and issued a challenge to the population to reduce its total calorie consumption by 5 billion calories (kJ) daily. Associated with this pledge is a menu of options suggesting how the pledge might be achieved (Table 4). At the end of May 2012, the delivery plans for the first twenty signatories to the calorie reduction pledge were published on the Responsibility Deal website[22].

Related to the calorie reduction pledge, the out-of-home calorie labelling pledge is in recognition of the fact that one in six meals is eaten outside the home. The pledge requires signatories to display calorie information (per portion/item/meal) prominently at point of choice in high street food outlets, restaurants and staff canteens. Provision of reference information (guideline daily amounts) is also required. By July 2012, forty-five businesses had signed up to this pledge, representing around 9000 outlets and estimated to cover 23% of all meals sold and a third of meals served on the high street[23].

A key theme in reformulation is the reduction of the energy density of foods (energy provided per g). In theory this can be done in a number of ways: Fat or sugar reduction; addition of low energy ingredients such as fruits and vegetables to composite foods; addition of dietary fibre (a low energy component that provides bulk) and use of wholegrain ingredients; addition of water; addition of air (aeration).

However, as will be evident from the text that follows this procedure is not always as simple as it may at first seem. For dry products, such as breakfast cereals, the removal of sugar often does not affect energy density to the extent that might be expected, unless fibre is increased substantially, because the sugar is replaced by starch (on a weight for weight basis) which has the same energy value. Another factor is that manufacturers are limited in the health claims they can make on foods/drinks to those permitted claims listed in the nutrition and health claims register that was published in 2012 by the European Commission[24]. Currently there are few permitted claims of relevance to fibre or whole grains and so this may be a disincentive for manufactures considering embarking on expensive reformulation work. Furthermore, claims that a reduction in fat or sugar has been achieved can only be made if the reduction is 30% or more, which is a substantial step to achieve without fundamental change to the product. There are also restrictions in the use of high intensity sweeteners and consumer concerns about the use in general of additives that may be required in increased amounts in reformulated foods given the functional roles of fat and sugar in some formulations, as discussed further in the next section.

Technical challenges

Some nutrients have a technical or functional role in foods, examples being Na and fat. Their removal can require the utilisation of alternative strategies to substitute for the function and these strategies can run counter to consumer desire for 'clean labels' (foods with minimal ingredient lists) and consumer views on the use of high intensity sweeteners and other food additives.

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Table 4. Menu of options for calorie reduction. Information extracted from Department of Health[22]

Action	Example
Reformulation	Decrease energy density Reduce or substitute fat and sugar
Portion size	Reduce – products/menu items
Development of lower calorie options	Baked instead of fried e.g. savoury snacks Energy restricted e.g. 99 kcal choc bars
Encouraging consumers to choose healthier options	Promotion of smaller portion sizes – down sizing Other 'substitution' promotions to favour lower calorie options
Satiety enhancers	Potential to increase the content of satiety ingredients to decrease overall energy intake e.g. fibre
Balance of portfolio/menu/etc.	Greater proportion of healthier options Default option is the healthy option e.g. coffee shops use of lower fat milks
Activity intended to inform and educate consumers towards making healthier choice	Funding healthier eating sessions in local schools alongside other actions
Other	Innovative use of loyalty cards

Salt

From a physiological perspective, many systems in the body rely on the balance of electrolytes such as Na, K and Cl. Na is a dietary essential but requirements are far lower than current intakes. Concerns about the association between salt intake and blood pressure triggered the Food Standards Agency's salt campaign (see Wyness *et al.*[25]) and the drive, in partnership with manufacturers and retailers in particular, to reduce the amount of salt present in foods. A recent analysis has found that the campaign achieved a reduction in salt intake of approximately 10% across the population; the impact was stronger in women than men. Over the past 10 years, salt intake in England has fallen by almost 1·5 g (15%) towards the target for adults of less than 6 g/d. In 2000–2001, salt intake (assessed by urinary Na measurement) was 9·5 g/d. It has fallen progressively since that time: 9 g in 2005/6, 8·6 g in 2008 and 8·1 g in 2011 (men 9·3 g, women 6·8 g)[26]. The Responsibility Deal salt reduction pledge is linked to the Food Standards Agency's salt targets for 2012, which if achieved will deliver the removal of 1 g salt from the food supply. The figures for 2011[26] suggest that half of this reduction has now been achieved. However, it is interesting to note that while average intakes in women are now relatively close to 6 g/d (at 6·8 g/d) average intakes in men are still far in excess of the target, suggesting the value of exploring more targeted approaches to salt reduction. The High Level Steering Group for the Responsibility Deal's Food Network is currently considering next steps and has established a forum for detailed technical discussions on salt and reformulation.

Salt (NaCl), has long been used as a preservative in foods as it controls water activity and hence growth of food poisoning and spoilage organisms. It is also effective in flavour perception. In bread production, salt controls the growth of yeast and fermentation rates, makes gluten more stable and less extensible, and assists in preservation and reduction of spoilage. In cheese manufacture, salt regulates the activity of the starter culture, modifies enzyme activity and has a direct effect on water content during maturation of the cheese. In meat products, together with fat, salt contributes to sensory properties, textural properties (tenderness and juiciness) through the solubilisation of myofibrillar proteins, and also to safety (preservation and shelf life). In the manufacture of savoury snacks, salt creates the hard bite texture and expansion during cooking.

Leatherhead Food Research has reviewed progress in the area of salt reduction and concluded that while there are a number of options (see Tables 5 and 6), each food category has its own particular challenges as salt has multiple roles (influencing taste, texture, shelf life and food safety) and note that food wastage could be an unintended consequence if shelf life is diminished[27].

So, salt usage is not simply about flavour and, in achieving the reductions in salt content attained to date (almost 1·5 g on average across the population since 2000–2001), various technical approaches have already been adopted. In a number of cases, the gradual (stepwise) removal of salt has been taking place for several decades ever since concerns about salt intake were first raised. For example, the Federation of Bakers has recorded a reduction of 23% in the salt content of bread since 2004; however, reduction began in the 1980s–1990s and they estimate that a total reduction of about 40% has taken place during this period (personal communication). A major challenge is to ensure that reductions do not outpace consumer expectations from a flavour perspective as this would be counterproductive i.e. sales would fall and this would adversely affect the company's viability and/or salt would simply be added back by the consumer. It is to be hoped that the new salt pledges recently introduced will stimulate greater engagement of the wider food service industry. While some of the high street chains committed to salt reduction some time ago, alongside major retailers and manufacturers, others have been far slower to react. To ensure that progress in adjustment of salt preferences

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Table 5. Challenges for salt reduction. Information extracted from Wilson *et al.*[27]

Category	Role and challenges
Meat and meat products	Preservation and microbiological safety: by reducing water activity. Salt reduction may reduce shelf life. Any further reduction by the European Commission on permitted levels of nitrate/nitrite in these products (often used in combination with salt) will place greater reliance on the preservative effect of salt Other antimicrobials such as K lactate and Na diacetate can maintain microbial safety and shelf life in products with a 40% reduction in salt; but taste and consumer acceptability are issues Taste and aroma: Na binds to protein receptors and also enhances natural flavours present in meat Salt is effective in releasing volatile aroma compounds from the food matrix (via an influence on osmotic pressure) Texture: by binding to myofibrillar proteins
Bread, rolls and morning goods	Rheological properties of dough are dependent on salt; low usage weakens the gluten and makes the dough sticky adversely influencing the efficiency of processing lines and causing wastage Salt stabilises yeast fermentation and influences flavour, crust colour and product volume In some products (morning goods) Na is also contributed by Na bicarbonate and other leavening agents
Cheese	Salt influences various aspects of cheese quality: texture, water binding capacity of casein in the cheese matrix, apparent viscosity; prevents undesirable microbial growth, influences aroma release, supplies flavour. The composition of some cheeses e.g. Feta is covered by legislation and many cheeses are imported from countries with less aggressive salt reduction policies
Extruded and pelleted snacks	Main focus to date has been reducing surface salt. Further reduction may require reduction of salt in the snack matrix. Use of starch with a high amylopectin content can overcome the expansion issue when salt is reduced
Cakes, pastries and fruit pies	Na is derived from a combination of salt, Na bicarbonate and other leavening agents
Pesto and other thick sauces	Pesto contains hard cheeses such as Parmesan, the composition of which is protected under EU law, and this limits salt reduction Higher levels of salt are required in high viscosity products to optimise flavour taste compared with thinner products
Canned fish	The challenge here is that canned fish (salmon and tuna) is mainly canned overseas. Canned tuna is frozen in brine (for preservation purposes) before it is put in oil, water or more brine. Salt is commonly added to thermally processed fish as a flavour enhancer and it influences texture and cook yield

Table 6. Strategies for salt reduction. Information extracted from Wilson *et al.*[27]

Approaches	Current position
Small step reduction	Preference for salt can be adjusted over time and so small step reduction can go unnoticed. This approach has already been widely adopted and significant achievements have been made; to achieve government targets, other approaches will be needed as salt reduction limits from a consumer acceptance perspective are approached
Increased use of spices	Salt can be reduced by use of highly flavoured spices; particularly successful in sauces to date. Only suited to applications such as soups, sauces and ready meals; not well suited to bread and cheese
Use of mineral salts	KCl is the most feasible salt replacer currently as it has equivalent antimicrobial effect on typical pathogenic species and a similar effect on strengthening gluten in bread making. But acceptability is limited by its pronounced bitter, chemical and metallic taste and after taste, which are difficult to mask. Combination with monosodium glutamate (MSG) – another source of Na, yeast extracts or other flavourings are the most common approaches. KCl is not being used to any extent in the UK on advice from the Department of Health (implications in renal health) Other options are: ingredients naturally rich in mineral salts. Examples are: 'milk salt' derived from the fractionation of milk (five times less Na than NaCl but may be considered an allergen) – work has taken place with bread, sausages and cooked ham, and is ongoing in cheese; whey permeate (potential allergen issues) – significant reductions in Na have been achieved in cakes and muffins $MgSO_4$ provides both a salty and a bitter taste depending on concentration and may be an option for the future
Use of phosphates	These can reduce the amount of NaCl needed for protein functionality and control of water activity in meat products but there are maximum legal usage limits
Use of taste enhancers	These lack a salty taste themselves but enhance a salty taste when combined with NaCl by activating receptors in the mouth and throat. Examples include amino acids, MSG, lactates, yeast products. Umami ('a pleasant savoury taste') imparted by glutamate and ribonucleotides e.g. inosinate, has potential in salt reduction. Tomatoes and onions, especially when roasted, pickled or fermented, convey umami. Other sources are green teas, seaweed, mycoproteins and mushrooms Taste enhancers are most likely to work in savoury products and will also have to be included in ingredient lists, which may influence consumer acceptability (e.g. MSG)

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Table 7. Challenges faced in reformulating to reduce SFA content

Food type	Challenge
Chilled breaded fish range	The challenge was to provide a more favourable ratio of unsaturated to saturated fatty acids. A 16% reduction in SFA and improved nutritional profile across the range was achieved by using rapeseed oil. It necessitated developing a new breadcrumb coating, which also offered better texture and eating quality. This was a time-consuming process, but developing the improved breadcrumb was an important milestone in extending the technology to other categories
Margarines and spreads	Reducing SFA: SFA deliver the melting sensation in the mouth associated with butter. It provides a network of fat crystals that gives firmness to margarine and captures the liquid oil. Reducing SFA results in a softer product – may deform (if in a wrapper) during transport and storage (less of a problem for margarines packed in tubs but oil exudation can occur when the product is subjected to temperature cycling). SFA also influence flavour release
	Liquid margarines have been developed but require changes in consumer-cooking practices
Frying oils	Typically these are blends of sunflower, rape and palm oils; prices of individual oils can fluctuate and so blends (and associated fatty acid profile) often change. Change in blend can also change the properties of the oil e.g. amount absorbed by food. Cheaper blends (higher in palm oil) are higher in saturates
	Optimal characteristics: good nutritional profile, long frying time without degradation (i.e. reuse), minimal risk of oxidation and associated toxic compounds (i.e. low in PUFA), minimal risk of polymerisation (this increases oil viscosity, increases oil absorption into fried products, produces gums which stick to the fryer). One way of achieving these optimal characteristics is with a blend that is high in MUFA (>70%), low in SFA (<10%) and low in PUFA (<15%)

continues, widespread action is required; the new pledges focus on training in kitchen practice, reformulation and procurement in the catering sector and commit companies to a 15% reduction in salt usage in their kitchens[28].

Work conducted at Leatherhead Food Research has confirmed that saltiness perception is changed when the salt crystal size is altered; using smaller particle size salt leads to a larger initial perception of saltiness[27]. Using smaller particle sizes may also help with dispersion thus requiring a lower overall salt level. Adjusting crystal structure and size is the basis of new technologies; none of the products currently available are based on nanoparticle technology although this may offer solutions in the future, subject to EU approval. Yet another approach is odour-induced taste enhancement[27].

Fat

A number of approaches have been used to reduce the fat content of foods and to improve their overall fatty acid profile. These include changes in animal husbandry to produce leaner animals and hence leaner meat; manipulation of the diets of dairy cows to produce milk with less SFA; removal of fat during processing e.g. trimming meat during butchery, skimming of milk to remove the cream; choice of fat-containing ingredients to modify the fatty acid profile (e.g. selecting a vegetable oil rather than a ruminant fat), use of structured lipids (interesterification) and the blending of oils to avoid processes associated with the production of *trans* fatty acids during the manufacture of spreads and margarines, use of new baking technologies to change the fatty acid profile of pastry or to reduce the fat content of snacks. The overall contribution of fat to energy intake is now in line with recommendations (Table 1) but contribution of SFA remains above the recommended level (12·7% compared with 11% of energy) although in absolute terms, SFA intake has fallen considerably over the past couple of decades from 42 g in men and 31·1 g in women in the 1980s to 28·8 and 22·0 g/d, respectively, in the latest National Diet and Nutrition Survey[11,29].

Table 8. Functions of sugar and potential routes for sugar reduction

Function	Alternative approaches
Sweetness	High intensity sweeteners, polyols
Mouthfeel/texture (e.g. crumb texture in baked goods)	Hydrocolloids, polyols and other sugars
Bulk	Bulking agents, polyols and dietary fibre
Colour	Additives
Flavour	Additives
Stability/preservation	Additives
Fermentation substrate	??

An aspect that is sometimes overlooked is the constraints of legislation for some sectors, for example the Chocolate Directive specifies the fat content of chocolate and limits the changes in composition that can be made. Also, the Nutrition and Health Claims Regulation[24] places constraints on businesses that wish to publicise changes in the fat content of their products; unless the reduction is at least 30%, a fat reduction claim cannot be made and claims of 'low fat' are only permissible if a food contains <4 g fat/100 g (a low in saturated fat claim requires there to be <1·5 g per 100 g and the sum of SFA and *trans* fatty acids must not provide >10% of energy). Manufacturers will want to retain the characteristics of the product that are attractive to consumers, making reformulation to reduce fat a costly and time-consuming business for which a one size fits all approach is not appropriate, even within a particular food category. This is in part

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because of the structural and organoleptic characteristics provided by SFA. Table 7 summarises some case studies.

In some cases, really innovative technological developments have been achieved, an example being ice cream manufacture. With conventional techniques, if the fat content is reduced, the resultant product is less smooth, less creamy, more icy/cold and less stable. An ultra high pressure homogenisation technique has been developed whereby very small fat droplets stabilise small air bubbles, enabling the production of a lower fat/lower energy product that still tastes good (personal communication). Sugar also has a functional role in ice cream, not only does its removal reduce the sweetness but also makes the product harder.

Sugar – not just sweetness

Sugar, in particular non-milk extrinsic sugars, has been targeted for reduction. This poses challenges because sugar's role in foods is often more than simply providing sweetness. Functions are listed in Table 8 along with potential solutions. Some of the alternative approaches have limitations, such as regulatory constraints with high intensity sweeteners, the gastrointestinal consequences associated with high intakes of polyols, resistance of many consumers to foods that contain lots of additives (desire for 'clean' labels; minimal ingredients lists). Also, the alternatives are often more expensive than sugar and cannot replicate its unique flavour profile.

Changing eating patterns – is reformulation the answer?

Reformulation in isolation is unlikely to provide a complete solution but it can contribute. To date much of the emphasis of the Responsibility Deal's Food Network has been on reformulation but there are signs that the Network's steering group is looking to broaden its strategy. Other aspects that require urgent consideration and attention are: How best can we influence behaviour change?; what is the role of information provision and what are the key messages for consumers (to stimulate behaviour change)?; can the need for sustainability of the food supply, as discussed at the beginning of this paper, be used to drive change and benefit health?; is there a special role for particular sectors?; what is the role of choice editing (*v.* free choice with regard to portion or pack size, or the nutrient composition of standard products)?; is there a role for regulation?; where does education in schools fit in?

One of the challenges the food industry faces is balancing the provision of what consumers want to buy (the industry exists to make a profit) with what is important from a public health perspective, recognising that there is often a tension between consumers' desire for choice and choice editing by manufacturers, retailers and the food service sector. People generally do not like to feel they are being told what to do. Some of the successful reformulation efforts have been achieved by stealth, whereby gradual reductions in salt, for example, have been undertaken in a manner that does not alienate customers wedded to a particular flavour profile. Despite these worthy efforts, well-known brands that have used this approach in order to achieve the government's salt targets for their category are sometimes pilloried in the press by media stories that claim that the public has been hoodwinked; changes to their favourite brands have been made behind their backs. This emphasises the need for all sectors to work together in improving the national diet; lots more needs to be done, and more will be achieved, more quickly if the bickering and sniping can be put on the back burner.

One of the biggest challenges faced is the relatively poor understanding of how to change behaviour for the good and in the long term. This was the focus of a recent conference[30]. We know that simply giving people information or telling them what they should, or should not, do is not effective in changing behaviour. Delegates heard that the starting point is understanding the problem, the target behaviour(s) and the context in which it exists. These are the principles of the COM-B process, which is at the centre of a new framework for intervention that combines nine interactive functions, based on elements of capability, motivation and opportunity[31]. Delegates heard that adults make about 200 decisions about food daily but only a small proportion of these are under conscious control (fourteen on average). This means that interventions that encourage change on a conscious level will be limited by the fact that so many of these choices are made on an unconscious level; this brings into sharp focus the importance of insuring the default choice is a healthy choice.

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