Proceedings of a roundtable event 'Is communicating the concept of nutrient density important?'

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Abstract

The British Nutrition Foundation held a one-day roundtable event to gather views from a wide range of stakeholders on the relevance and importance of the concept of nutrient density in supporting and motivating people to make healthier dietary choices. The opportunities and barriers associated with the use of this concept were also explored. The roundtable involved experts from research, public health nutrition, dietetics, retail and nutrition science communication and this report describes the main themes emerging from the discussions. High obesity prevalence rates indicate that, on average, we are consuming too many calories relative to energy requirements, yet the quality of our diets, with respect to certain vitamins and minerals and fibre, seems to be falling somewhat short of recommendations. Addressing this issue may require a more holistic approach than the current focus on restricting single nutrients prevalent in public health messaging internationally. Most members of the roundtable felt that communicating the concept of nutrient density may help in encouraging healthier food choices and dietary patterns that are higher in nutritional quality. However, whilst nutrient profiling has been used to guide front-of-pack labelling and in restricting the advertising of less healthy foods to children, there is a lack of consensus on the precise definition of a 'nutrient dense' food or which nutrients should be used as markers of the 'healthiness' of foods/drinks, and the term seems to be poorly understood by consumers and health professionals alike. Therefore, further work is required if tools around this concept are to be developed to try and successfully promote behaviour change.

Introduction

The need to identify ways to help people meet nutritional requirements while simultaneously reducing caloric intake, a challenge presented by current obesity trends, has sparked increased interest in the concept of nutrient density. A roundtable event entitled ‘Is communicating the concept of nutrient density important?’ was held by the British Nutrition Foundation (BNF) in London on 29 May 2019 and was chaired by Professor Judy Buttriss, Director General at the BNF. Participants represented a range of UK and European stakeholders including those from academia, public health nutrition, dietetics, manufacturing, retail and nutrition science communication. The aim of the roundtable was to consider:

- the relevance and importance of the concept of nutrient density in supporting and motivating healthier dietary choices; and
- how to most effectively communicate or use the concept of nutrient density with health professionals and the general public.

This paper provides a summary of the proceedings of the roundtable presentations and discussions, as well as outlining some background information to facilitate an understanding of the context underpinning the meeting.

The public health perspective – making every calorie count

The need to tackle the high prevalence of obesity is well recognised and the UK government has set the challenge of halving childhood obesity in England by 2030. Policy initiatives designed to achieve this goal have largely been focussed around reducing intake of energy (calories) and individual energy-providing nutrients, most notably sugars. But if efforts to tackle obesity were to be solely centred on energy reduction (and potentially overall food intake), might this exacerbate the challenge of meeting the full set of dietary recommendations recognised as important for health; in other words, the overall nutrient density of diets? To mitigate this risk, calories should routinely be derived from foods and beverages that also deliver a range of essential nutrients – every calorie needs to count from a broader nutritional perspective.

In the context of improving population health, the importance of the overall nutritional quality of individual foods and of diets, depicted in the UK government's Eatwell Guide, has perhaps not always received the attention it deserves, particularly in light of findings from the *National Diet and Nutrition Survey (NDNS)* of worsening micronutrient intakes (Bates *et al.* 2019). The Eatwell Guide outlines the relative proportions of the different food groups that best enables nutritional adequacy and reduced chronic disease risk. Yet, the *NDNS* demonstrates that, on average, diets in the UK are falling short of this guidance (see Buttriss 2019 for a discussion).

Professor Judy Buttriss began the roundtable event by exploring these issues and setting the scene on nutrition-related public health concerns and challenges being faced in the UK and beyond. Europe is experiencing an ageing of its populations, alongside increasing prevalence of obesity, both of which are affecting healthcare costs. So the role of diet in disease prevention is a significant consideration. On average, people are living longer in the UK and across the EU but healthy life expectancy is not keeping pace (PHE 2018b). Yet it is recognised that good nutrition throughout life has a role to play in maintaining health into old age.

More than half of the European population is currently overweight or obese (WHO Regional Office for Europe 2014). In England, 64% percent of adults, 22% of children in Reception (age 4-5 years) and 34% of children in year 6 (age 10-11 years) are overweight or obese (NHS Digital 2019) and the health consequences of obesity are well-recognised. For example, obesity accounts for 80-85% of the overall risk of developing type 2 diabetes (Diabetes UK 2019).

Increasing health inequalities, both within and between countries, continues to remain a challenge for the EU (WHO Regional Office for Europe 2014). For example, the prevalence of childhood obesity doubles among the most deprived decile in England versus the least deprived (NHS Digital 2019), and the prevalence of severe obesity quadruples in the same fashion (PHE 2019a), so ensuring a healthy diet is accessible and affordable for all is very important.

Government initiatives to reduce obesity

Whilst obesity is influenced by a wide range of complex factors, the fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, there has been an increased intake of energy-dense foods and an increase in physical inactivity and sedentary behaviour (WHO 2019). In the UK, a focus of the Childhood Obesity Plan has been to reduce free sugars consumption in the population (DHSC 2018), with Public Health England (PHE) giving industry the target of reducing the sugars content of eight food categories by 20% by 2020 through a combination of reformulation, portion size reduction and shifting consumer purchasing towards lower or no added sugar alternative products. This initiative resulted in modest reductions in sugar levels between 2015 and 2018 (PHE 2019b). A soft drinks industry levy was introduced in 2018 and has resulted in an 11% reduction in the sugars content of the drinks covered by the levy; a reduction in the average number of calories per portion of 6% and a shift in volume sales towards lower sugar drinks (below 5 g per 100 ml), which are not subject to the levy (PHE 2018c). Furthermore, the levy raised £153.8 million between April and the end of November 2018 (HM Revenue and Customs 2018); funds which are earmarked for supporting physical activity in schools and breakfast clubs for children living in deprived circumstances (DHSC 2018). However, intake of free sugars remains well above the recommendation (a maximum of 5% of dietary energy) in all age groups (Roberts *et al.* 2018a), though intakes have decreased somewhat in children in recent years (*e.g.* from 16.1% to 14.2% of food energy between 2008/2009 and 2015/2016 in 11-18 year-olds) (Bates *et al.* 2019).

PHE has estimated that overweight and obese children are on average consuming 140-500 excess kilocalories per day (depending on age) and overweight and obese adults are consuming 200-300 excess kilocalories per day on average, indicating a pressing need to reduce calorie intake (PHE 2018a). PHE is therefore liaising with the food industry, to develop calorie reduction targets for 15 food categories (excluding those covered under the sugar reduction programme), in order to achieve 20% reductions by 2024 through a combination of reformulation, reductions in portion sizes and shifting consumer purchasing towards lower calorie options. Specific guidelines will be set for different product categories and it is envisaged that targets will relate to sales-weighted averages in terms of calories per 100 g of product, as well as calorie or portion size guidelines for products likely to be consumed in a single occasion.

Altogether, foods captured by the soft drinks industry levy and sugar reduction and calorie reduction programmes combined have been targeted to account for around 50% of children's caloric intake (PHE 2018a). In addition, PHE launched its *One You* campaign or '400-600-600', giving 'a rule of thumb' for adults on the calories to consume at main meals (NHS 2018) (*i.e.* 400 kcal at breakfast and 600 kcal at lunch and the evening meal, leaving scope for some snacks and drinks during the day).

Good nutrition is more than reduced calories and sugars

Given the high prevalence of obesity and associated focus of government policy, it can perhaps be easy to forget that dietary quality encompasses far more than the removal of ingredients such as sugars from the food supply. Good health is reliant on regular consumption of a number of essential nutrients (vitamins, minerals, essential amino acids and fatty acids, and fibre) and so the need to reduce the amount of energy provided by the diet, in an effort to reverse obesity trends, must not compromise overall nutrient intake. Therefore, healthy eating is not simply about eating less and cutting things out, it can also be the result of eating more overall but of particular types of foods (*e.g.* fruit and vegetables). The research of Professor Barbara Rolls demonstrates that, by choosing foods with a lower energy density (that is, the calories provided per gram), which is typically the result of the fibre and/or water content of the food, it is possible to consume larger overall quantities of foods (on a volume or gram basis), making it far easier to achieve nutrient requirements within calorie requirements, provided the foods chosen are rich in essential nutrients. Furthermore, there is some evidence that the larger volume of food may help to reduce hunger between meals which could aid weight loss (Rolls 2017). BNF's Quality Calorie concept illustrates that the nutritional quality of food choices, even when calorie content remains the same, can vary considerably (British Nutrition Foundation 2019). This serves to emphasise that both nutrient quality or density and energy density are important considerations when making dietary choices.

Although public health policy and media coverage often focus on nutrients present in excess in diets, we also need to consider those that appear to be present in inadequate amounts in many people's diets (Buttriss 2019). The 2015 report from the government's Scientific Advisory Committee on Nutrition (SACN), *Carbohydrates and Health*, contains recommendations to increase fibre and reduce free sugars, yet the message relating to fibre was largely lost among headlines focussing on sugar. High intakes of dietary fibre can reduce the risk of heart disease, type 2 diabetes and some cancers, and support digestive health (SACN 2015), but average fibre intakes in the UK are well below recommendations in all age groups (Roberts *et al.* 2018a) and change to typical UK diets to achieve the recommendation is proving to be another significant challenge for many. In addition, intakes of several essential micronutrients are below the lower reference nutrient intake (LRNI; the amount of a nutrient that is calculated to be sufficient for only 2.5% of the population sub-group to which it relates) in some population groups. As a rule of thumb, when more than 5% of a population are found to have intakes below the LRNI set for that population group, it is considered likely that, if maintained at this level, intakes will be insufficient to meet needs for at least some of the group. The situation appears most severe in adolescents, especially girls (see Table 1). For example, *NDNS* data show that one in four girls aged 11-18 years has an intake of vitamin A, riboflavin, zinc and iodine below the LRNI, and over half have a low intake of iron.

Furthermore, *NDNS* data indicate a worsening of micronutrient intakes between 2008/2009 and 2015/2016 in most age groups, including vitamin A, folate, iron and calcium [*e.g.* the proportion with intakes (from food sources only) of these nutrients below the LRNI increased from 13% to 21%; 4% to 9%; 24% to 32% and 11% to 16%, respectively, among adolescents] (Bates *et al.* 2019). There have also been increases in the prevalence of low serum folate (indicating increased risk of anaemia) and low vitamin D status in adolescents, and 90% of women of child-bearing age have a red blood cell folate status indicative of increased risk of neural tube defects developing in a fetus (Roberts *et al.* 2018a). In addition to the situation with micronutrients, there is evidence of other shortfalls in the British diet (as well as in other countries across Europe).

Table 1: Micronutrient intakes among UK adolescents

	Percentage with intakes below the LRNI	
	Girls aged 11-18 years	**Boys aged 11-18 years**

Vitamin A	24	19
Riboflavin	26	13
Folate	15	3
Iron	54	12
Calcium	22	11
Magnesium	50	27
Potassium	38	18
Iodine	27	14
Selenium	45	26
Zinc	27	18

LRNI, lower reference nutrient intake.

Source: National Diet and Nutrition Survey years 7&8 (Roberts *et al.* 2018a)

The Eatwell Guide encourages a healthy, varied and largely plant-based diet, yet market research suggests that consumers are somewhat confused about what they should be eating (New Nutrition Business 2018) and the *NDNS* shows that, on average, the current UK diet is not in line with the Eatwell Guide; with substantial changes needed if the two are to be aligned (see Buttriss 2019 for a discussion). For example, at a population level, to align with the Eatwell Guide we need to increase intake of fruits, vegetables and pulses and reduce meat consumption (Scarborough *et al.* 2016). Therefore, despite having food-based dietary guidelines in the UK, consumers may need further guidance on selecting nutrient dense foods and support in gaining the skills needed to incorporate nutrient-dense foods in their daily diet because there is a need to improve dietary quality widely within the population.

Roundtable discussion – current public health nutrition messaging

Following on from Professor Buttriss' presentation there was a wide-ranging discussion covering a variety of topics around the concept of nutrient density including current nutritional issues and public health messaging in the UK and Europe, front-of-pack nutrition labelling and benchmarking used by food manufacturers.

Roundtable participants reflected on some of the pitfalls of dietary guidance approaches that focus on cutting back or avoiding food sources of particular nutrients (*e.g.* free sugars, saturated fatty acids), given that it is believed that people are often more motivated by dietary advice that is framed in positive or permissive terms and linked to positive actions that can be adopted to prevent health problems, rather than negative and fear-based messaging (Wansink & Pope 2014; Fetter *et al.* 2019; Gallagher & Updegraff 2012). Examples discussed included the success of some popular weight loss programmes that promote diets based on low energy dense foods (Coe *et al.* 2019). Discussions also acknowledged that research and recommendations around the role of diet in health are increasingly adopting a dietary pattern approach, recognising that we do not eat single nutrients on their own. These healthier dietary patterns (*e.g.* Mediterranean diet, DASH diet or plant-based diets) are typically rich in micronutrients and fibre (Briggs *et al.* 2016).

Consideration was given to some of the problems that may arise from concentrating messages on individual nutrients that need to be limited, particularly when some foods that contain fat, salt or sugars make useful contributions to micronutrient and/or fibre intakes. It was agreed that there is a need to consider the context in which nutrients are delivered, including the food matrix. For example, some foods containing free (or added) sugars, such as a yogurt, high-fibre breakfast cereals, fruit juice or smoothies and some foods containing saturates, such as cheese, contribute a range of essential nutrients alongside the sugars or fat. Conversely, other foods, for example sugar confectionery or pastries, often do not offer the same breadth of nutrients and so should be consumed less often and in smaller amounts. Similarly, wholemeal bread is widely promoted as a ‘healthy choice’ (for example, as a source of fibre) although breads do make a contribution to salt intake [on average 16% among UK adults (Roberts *et al.* 2018b)]. On that basis, the majority of the roundtable participants agreed that there is a need to communicate that the balance of nutrients overall defines its value from a nutritional perspective. Despite this, the most visible nutritional classification of foods in the UK – namely front-of-pack traffic light labelling – only provides information on nutrients to limit in the diet: total sugars [which does not distinguish between free sugars on which government recommendations are based and the sugars naturally present in intact fruit and vegetables or those in milk and dairy products (*i.e.* lactose)], total fat, saturates and salt. Due to this, as an example, the use of nuts and seeds will typically increase the total fat content of a product, whereas use of dried fruit will often increase the total sugar content, yet the simultaneous increase in fibre and micronutrient content may not be apparent to shoppers using on-pack nutrition labelling information due to the absence of these ’positive’ nutrients on traffic light labels. Therefore, although a useful guide, the approach does not fully evaluate the holistic nutritional attributes of products. Moreover, consumers are also faced with having to make complex judgements on the healthiness of products when labels present a combination of greens (low), ambers (medium) and reds (high) for the different nutrients to limit. However, it is important to note that the traffic light labelling system currently used in the UK is being evaluated in consideration of the evidence underpinning different forms of front-of-pack labelling, and may be subject to change (DHSC 2019).

Many manufacturers and retailers have now introduced benchmarking in the form of nutrient profiling and guardrails (predominately constraints around the content of nutrients of concern) for internal use to define healthier products within their portfolio, providing guidelines for new product development and promote reformulation. Some are also used in consumer communications (*e.g.* via incorporation of healthy eating logos). Navigating the array of different, and often changing, mandatory (*e.g.* regulation around the format of front-of-pack labelling, if used) or voluntary (*e.g.* reformulation and portion size reduction) targets to consider, nationally and globally[1] can also be challenging, particularly as these are not always consistent. Therefore, some roundtable participants were in agreement that a recognised and accepted single standard measure of the nutrient quality of foods might be of value to industry and consumers alike, particularly if such as measure could be used in place of the myriad of different targets considered currently. However, there is currently no consistent approach to nutrient profiling, or consensus as to what that approach should be and the roundtable participants moved on to discussing what the definition of a nutrient dense food could be, which approaches had been established in the UK and elsewhere to qualify this, and whether this could encourage the consumption of better quality or more nutrient dense diets.

Nutrient density - concepts, definitions, current uses and evidence base

It was suggested that the term ‘nutrient dense’ may not be widely understood and its interpretation may also vary both within and between groups such as consumers, health professionals, academics and the food industry. Indeed, researchers have proposed several quantitative formats for nutrient density (as outlined below) and, perhaps unsurprisingly, given the absence of an agreed, internationally accepted definition of nutrient density, differences in opinion about the meaning were evident among the roundtable participants. For some participants, nutrient density refers to the concentration of ‘positive’ nutrients within foods (either just micronutrients, or also including fibre), whereas for others so-called ‘negative’ nutrients (*e.g.* saturates) were weighed against the contribution of positive nutrients in the definition. With regards to terminology, it was suggested that different phrasing to mean

[1] e.g. UK traffic light labelling, Change4Life Good Choice logo, NutriScore, WHO EU model, CQUIN targets for foods sold in hospital, PHE’s sugar and calorie reduction targets (PHE 2018d)

‘nutrient density’ could be used for different purposes, depending on the audience. For example, the term ‘diet quality’ may be more appropriate for consumers than ‘nutrient density’, and this could be user-tested for appropriateness. Furthermore, nutritional requirements vary by population group with different needs (*e.g.* young children versus frail older adults versus healthy adults). These factors are worthy of consideration in the definition of ‘nutrient dense’ or the thresholds used within models to quantify this, which are typically based on the reference values for adults (or specifically women).

Nutrient dense diets versus nutrient dense foods

The term nutrient density is more typically applied as an indicator assessment for the nutrient quality of individual foods rather than to diets as a whole. From a nutritional perspective, good quality foods and good quality diets are not necessarily synonymous; while higher quality dietary patterns that meet nutrient requirements will largely be made up of good quality (or healthier) foods, they can also contain some foods that are less healthy (high in saturates, free sugars and/or salt), provided they are eaten infrequently and/or in smaller portions and therefore make up a smaller proportion of the diet overall (Maillot *et al.* 2011).

Defining the overall quality of a diet or meals using a scoring system has been used for some time for research purposes, most notably in nutritional epidemiology. Diets with a high Healthy Eating Index (HEI) score (used as a measure of adherence to US dietary guidelines and calculated by assigning points for inclusion of particular foods such as wholegrains and vegetables, seafood and sources of plant protein), for example, have been associated with lower risk of chronic diseases (Krebs-Smith *et al.* 2018).

While reference has been made to ‘nutrient dense foods’ in the Dietary Guidelines for Americans since 2005 (see Box 1), the concept of ‘nutrient density’ is not referred to directly within UK food-based dietary guidelines.

Box 1

The definition of ‘nutrient dense foods’ in the latest Dietary Guidelines for Americans (2015-2020) (USDA 2015) is as follows:

“foods and beverages that provide vitamins, minerals, and other substances that contribute to adequate nutrient intakes or may have positive health effects, with little or no solid fats[2] and added sugars, refined starches, and sodium. Ideally, these foods and beverages also are in forms that retain naturally occurring components, such as dietary fiber”.

The Guidelines further report that:

- The term ‘nutrient dense’ indicates the nutrients and other beneficial substances in a food have not been ‘diluted’ by the addition of calories from added solid fats, sugars, or refined starches, or by the solid fats naturally present in the food.
- All vegetables, fruits, whole grains, seafood, eggs, beans and peas, unsalted nuts and seeds, fat-free and low-fat dairy products, and lean meats and poultry - when prepared with little or no added solid fats, sugars, refined starches, and sodium - are nutrient-dense foods.

[2]solid fats are defined in the US Dietary Guidelines for Americans 2015-2020 as coconut oil, palm oil, butter, beef tallow, lard, chicken fat, shortening (USDA 2015).

Methods used to quantitatively assess the nutrient quality of individual foods, of which nutrient density is part, have collectively become known as nutrient profiling. The World Health Organization (WHO) definition of nutrient profiling is ‘the science of classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health’ (WHO 2014a). Nutrient profiling methods are based on algorithms applied to foods and drinks that often take into account the presence or quantities of nutrients (*e.g.* saturates, protein) and ingredients (*e.g.* fruit and vegetables) that are considered as being positive/beneficial to health and/or negative/detrimental to health (based on current understanding of nutrients and their potential association with health outcomes). The output of the algorithms is a numerical score or ‘healthier/less healthy’ type classification (van der Bend & Lissner 2019). A summary of characteristics of nutrient profiling models can be seen in Figure 1. The figure illustrates the various choices that can be made when developing a nutrient profiling model, including a choice between a system based on food categories and/or 'across the board'; considering qualifying and/or disqualifying nutrients/ingredients and which specific ones; which reference base to use (*i.e.* per 100 g/100 ml, 100 kcal/100 kJ, and/or per reference quantity/serving) and a choice between a scoring system or a threshold system (Verhagen & van den Berg 2008). Nutrient profiling has various applications, including:

- restricting the marketing of less healthy foods to children {*e.g.* the Food Standards Agency [FSA]/Ofcom Nutrient Profile Model used in the UK (DH 2011) [proposals for a revised version that reflects UK dietary reference values for fibre and free sugars which were updated in 2015 (SACN 2015) was published in 2018 (PHE 2018e)]},
- regulating health and nutrition claims (Australian Government 2019),
- front-of-pack labelling schemes (Santé publique France 2018; DH 2016),
- setting food standards (*e.g.* for schools) and
- to direct fiscal policies aiming to influence food consumption patterns (*e.g.* the tax imposed on 'non-essential' snack foods in Mexico based on energy density) (Labonte *et al.* 2018; Drewnowski 2017).

As nutrient profiling models can be designed to perform different tasks, there is sometimes a lack of alignment between different approaches. In addition, as nutrient profiling is not routinely part of the process used to determine healthy eating guidelines, there can also be a lack of alignment when compared to food-based dietary guidelines. For example, 150 ml unsweetened fruit juice, which currently counts as one portion towards the UK 5 A DAY dietary recommendation as juices provide vitamins and minerals, will not pass the revised draft 2018 Nutrient Profile Model criteria (PHE 2018e) due to the free sugars content.

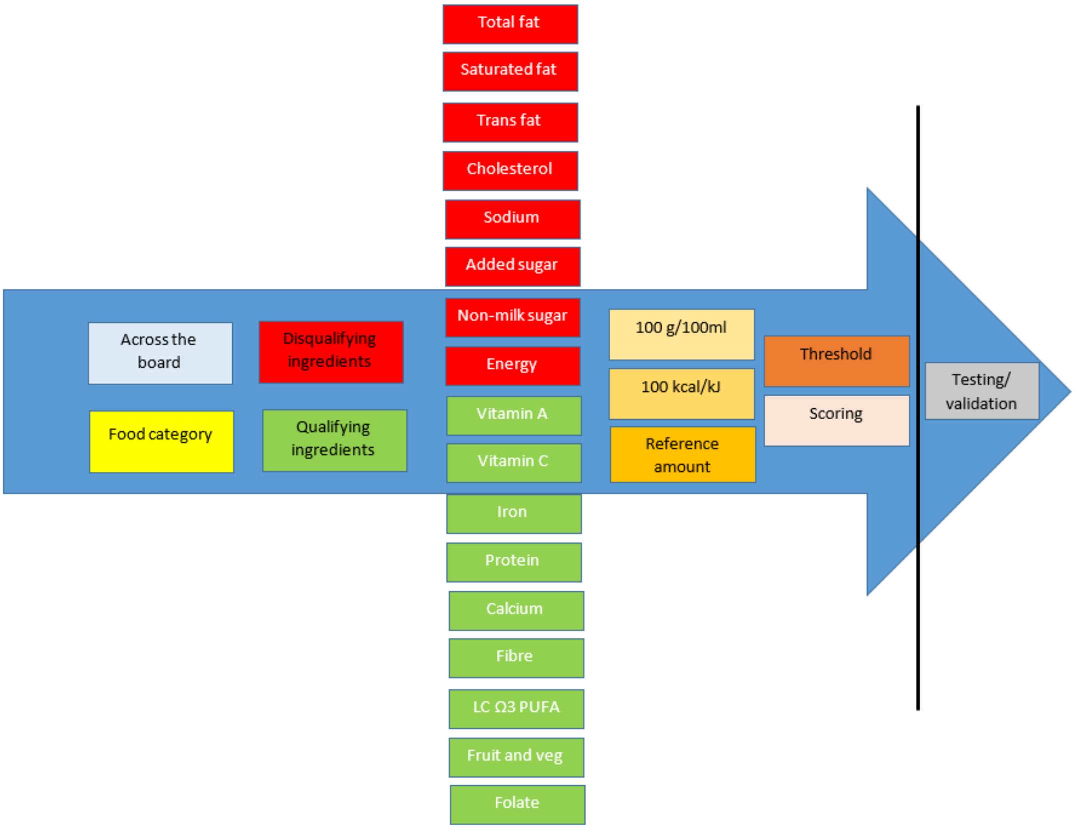

Figure 1: Summary of characteristics of nutrient profiling models.

Adapted from Verhagen & van den Berg H (2008)

LC Ω3 PUFA, long-chain omega-3 polyunsaturated fatty acids

Examples of scoring systems that assess the nutritional quality of foods

Nutrient density scores

Approaches using a scoring mechanism to assess the nutrient density of foods have been devised by researchers over many years (Guthrie 1977; Lackey & Kolasa 2004; Darmon *et al.* 2005; Sorenson & Hansen 1975; Lachance & Fisher 1986). A nutrient density score is commonly defined as the amount of selected nutrients per reference amount of food, the latter being expressed as 100 kcal, or 100 g, or as a portion. Indeed, ‘nutrient density’ is a ubiquitous term found in the scientific literature, policy documents, marketing strategies and consumer messaging. For example, the Naturally Nutrient Rich score (NNR) (Drewnowski 2005) and the Nutrient Density Score (NDS) (Darmon *et al.* 2005) both define the mean proportion of recommended daily values for a variable number of ‘nutrients to encourage’, expressed for 100 kcal of food. The same researchers subsequently developed the LIM (Maillot *et al.* 2007), a score including only nutrients to limit (namely, saturates, added sugars and sodium). These formed the basis of the Nutrient Rich Food (NRF) index (Drewnowski & Fulgoni III 2008), a composite score calculated by subtracting the LIM score from the score of nutrients to encourage, which is one of the most cited models for scoring food items according to their nutrient density. The index can also be applied to total diets. Various iterations of the NRF that vary in the number of ‘positive’ nutrients incorporated have been published, ranging from six (protein, fibre, vitamins A and C, calcium and iron, within NRF 6.3) to 15 (protein, fibre, monounsaturates, vitamins C, D and E, thiamin, riboflavin, folate, vitamin B12, calcium, iron, potassium and zinc, within NRF 15.3) (Drewnowski & Fulgoni 2014). Most recently a hybrid nutrient density score was proposed that builds upon NRF 6.3 to additionally incorporate food groups that are encouraged in the 2015-2020 Dietary Guidelines for Americans (*i.e.* wholegrains, vegetables, fruit, dairy foods, nuts and seeds) (Drewnowski *et al.* 2019), reflecting the growing shift in the focus of food-based dietary guidelines from nutrients to dietary patterns. Furthermore, the Elderly-Nutrient rich food (E-NRF 7.3) score has been developed to assess nutrient density of diets using dietary reference values for older adults for research purposes (Kramer *et al.* 2019).

The SAIN,LIM system was developed by Darmon and colleagues in response to the European regulations on nutrition and health claims (EC1924/2006) to determine foods that may be eligible for bearing claims (Darmon *et al.* 2009). Unlike the NRF index, SAIN,LIM classifies foods into four classes based on two scores (see Box 2). 'SAIN' (Score of Nutritional Adequacy of Individual Foods) is based on five positive nutrients expressed per 100 kcal (protein, fibre, vitamin C, calcium, iron), identified by the authors as the smallest number and combination of nutrients that could best reflect nutrient quality. 'LIM' is a score calculated on the basis of three negative nutrients, or nutrients to limit (sodium, free sugars and saturates), expressed per 100 g.

Box 2. The four SAIN,LIM classes*

- Class 1: High SAIN, low LIM (*e.g.* fruit and vegetables, fish, wholemeal cereals; recommended for health).
- Class 2: Low SAIN, low LIM (*e.g.* refined grains; should be eaten with high SAIN foods).
- Class 3: High SAIN, high LIM (*e.g.* fatty meats, cheese, oils, some mixed dishes; recommended in small amounts or infrequently).
- Class 4: Low SAIN, high LIM (*e.g.* pastries, cakes, biscuits, butter, cream; intakes should be limited).

* On the basis of SAIN and LIM values and on the threshold defined for each score, foods are classified into 1 of 4 possible SAIN,LIM classes with class 1 indicating the most and class 4 the least favourable profile: class 1, SAIN score ≥5 and LIM score <7.5; class 2, SAIN score <5 and LIM score <7.5; class 3, SAIN score ≥5 and LIM score ≥7.5; and class 4, SAIN score <5 and LIM score ≥7.5. Details of the scoring system are described in detail in Darmon *et al.* 2009.

The SAIN,LIM has subsequently been adapted to a hybrid system incorporating food groups (the SENS algorithm) to make it more operational for nutrition labelling in Europe (Darmon *et al.* 2018), although it is not currently being used for that purpose.

Nutrient profiling approaches

The FSA/Ofcom nutrient profiling model is the current nutrient profiling model used in the UK to restrict the advertising of less healthy foods to children

(DH 2011). In the development of this model, testing was carried out to identify the nutrients and food components that would be fundamental to include, those that could act as markers for important nutrients or foods and those which were not considered necessary to include (Rayner 2017). For example, total fat was not included in the algorithm as this was found to align well with energy (Rayner *et al.* 2004), and protein was found to correlate well with calcium, iron and long-chain *n*-3 fatty acid intakes and thus could be used as a marker for these (Rayner et al. 2009). Using protein as a proxy eases utility because calcium, iron and long-chain *n*-3 fatty acid values are not normally included as part of on-pack nutrition labelling for products.

The FSA/Ofcom nutrient profiling model has since been used to determine whether health claims can be used on foods in Australia and New Zealand and as the basis for front-of-pack labelling systems such as the Health Star Rating system in Australia (Commonwealth of Australia 20190 and Nutri-Score (first used in France) (Santé publique France 2018). Nutri-Score is a summary indicator system that categorises foods by assigning a score calculated using data from the nutritional declaration for 100 g of the product as sold but the exact calculation varies by product category. In general (though various caveats exist), the nutritional score (from minimum -15 to maximum +40 points) is equal to:

- the total number of points (out of 40) for the negative (N) nutrients, with 0-10 points allocated according to amounts of calories, sugars, saturated fatty acids and sodium minus
- the total number of points (out of 15) for the positive (P) nutrients, with 0-5 points allocated based on amount of protein; fibre; and fruit, vegetables, legumes and nuts

Full instructions for calculating nutritional scores is detailed elsewhere (Santé publique France 2018).

The final step is to grade products into five categories from A ('best') to E ('least good'), using the approach shown in the Table 2.

Table 2: The classification of the five Nutri-Score categories

Total number of points (N-P)		
Foods	**Drinks**	**Nutri-Score category**
-15 to -1	0	A
0-2	≤1	B
3-10	2-5	C
11-18	6-9	D
≥19	≥10	E

Whilst the EC supports the use of a nutrient profile model for regulating nutrition and health claims (EC 2006), it is yet to reach an agreement on the model to be used (EC 2015). Therefore, within Europe, a variety of front-of-pack labelling schemes, based on different nutrient profiling approaches and visual translations, are currently used to communicate the 'healthiness' of products to consumers to facilitate making healthier choices easier. These include the Keyhole symbol used in Norway, Sweden, Denmark and Iceland (EFTA Surveillance Authority 2014); the Heart symbol used in Finland (Finnish Food Authority 2019) (both of which are summary indicator systems that classify foods into being either eligible or ineligible to bear the symbol) and Nutri-Score, a system which was initiated in France, and has recently also been approved for use in Belgium, Spain, The Netherlands and Switzerland, as well as by the Federal Minister of Food and Agriculture in Germany (see Table 3). In the UK, a different front-of-pack approach is used – the traffic light labelling system – which applies thresholds for total fat, saturates, total sugars and salt [which result in a colour (red, amber, green) assigned to each nutrient based on quantity, as described earlier], rather than using an algorithm to reach an overall 'score' for the food or drink (DH 2016). Interestingly, a paper modelled the theoretical impact of different front-of-pack nutrition labels (specifically Nutri-Score, Health Star Rating system, traffic light labelling, Reference Intakes and SENS) on dietary intake and subsequent risk of mortality. The paper reported that these labelling schemes could result in a chronic disease risk reduction of around 1.1–3.4%, dependent on label type (Egnell *et al.* 2019). However, data on the influence of currently used labelling schemes on actual purchasing behaviour is relatively scant (Kelly & Jewell 2019) (see 'Barriers and facilitators' section later).

Strengths and weakness of existing nutrient profiling models were further discussed to better ascertain whether these systems can discriminate healthy and less healthy food characteristics, both between and within food categories. One of the issues raised was whether a single score based on the combination of both positive and negative nutrients (perhaps by subtraction) was appropriate, implying the existence of compensation phenomena between these nutrients at the physiological level (*e.g.* that a high fibre content could negate the effects of a high saturates content). Conversely, when nutrient profiling systems using non-compensating scores (*i.e.* systems which consider 'positive' and 'negative' nutrients side by side, for example SAIN,LIM) are used, a low concentration of 'negative' nutrients (*i.e.* low LIM) within a food is not sufficient for that food to be awarded the most favourable ranking, as a high concentration of 'positive' nutrients (*i.e.* high SAIN) is also required.

Table 2: Examples of front-of-pack nutrition labelling schemes used in Europe and the nutrients and components included in the underlying nutrient profiling algorithms

<table>
<tr><th rowspan="2">Labelling scheme</th><th colspan="2">Nutrients and food components* included within the underlying nutrient profiling algorithm</th></tr>
<tr><th>‘Negative’/disqualifying</th><th>‘Positive’/qualifying</th></tr>
<tr><td>Healthy choice logo (Czech republic and other (non-European) countries)</td><td>Energy
Saturated fatty acids
Trans fatty acids
Added sugars
Total sugars
Sodium</td><td>Fibre</td></tr>
<tr><td>Nutri-Score (France, Belgium, Spain, Switzerland)</td><td>Energy
Saturated fatty acids
Total sugars
Total sodium</td><td>Protein
Fibre
Fruit/vegetables/legumes/nuts</td></tr>
<tr><td>Keyhole (Norway, Sweden, Denmark, Iceland) **</td><td>Energy
Total fat
Saturated fatty acids
Trans fatty acids
Fat other than fish fat
Added fat
Total sugars
Added sugars
Salt
Sweeteners
Plant sterols/stanols
Added flavourings</td><td>Fibre
Wholegrain
Fruit/vegetables/legumes</td></tr>
<tr><td>Heart symbol (Finland)</td><td>Total fat
‘Hard fat’ (saturated fatty acids and trans fatty acids)
Sugars
Salt or sodium</td><td>Fibre
Vegetables
Fish/seafood</td></tr>
<tr><td>Traffic light labelling (UK)</td><td colspan="2">Fat
Saturated fatty acids
Total sugars
Total salt
Nutrients and nutrient thresholds are the same across food categories</td></tr>
</table>

*Criteria used may vary by food category **minimum meat content required for some categories

Possible improvements to existing approaches

Choice of nutrients for inclusion in the model

The nutrients selected for nutrient profiling models are typically based on expert consensus, policy driven considerations and/or scientific analysis in the form of modelling work (Tharrey, *et al.* 2017; Rayner 2017). Roundtable participants discussed further ways in which various foods/nutrients could be prioritised or justified for inclusion in a nutrient profiling model.

a) Based on country-specific burden of disease

A suggested novel approach is the consideration of dietary risk factors associated with disease outcomes relevant to different countries using, for example, data from the Global Burden of Disease study (Afshin *et al.* 2019). This dataset is not fully inclusive of all nutrients (*e.g.* saturates are absent) and has other limitations, such as statistical uncertainty, and may use nutrient intake data of questionable quality in relation to some countries. Nonetheless, it can still provide some insight into how dietary factors could be rated in terms of importance in different countries. For example, Global Burden of Disease study data presented at the roundtable event would suggest that low intakes of fibre and high intakes of sodium contribute significantly to the disease burden in high socio-demographic index countries, whereas vitamin A, iron and zinc deficiencies have a more marked impact in relation to child and maternal disease burden in low socio-demographic index countries. A further approach might be to consider inclusion of micronutrients for which there is not only evidence of poor intake, but also evidence of poor biochemical nutritional status, and/or nutrients for which there is evidence of intakes that are in excess of recommendations and where evidence that poor nutrient intake (too little or too much) is directly related to a specific health concern. Thus, nutrient density models could potentially be more closely related to population health outcomes in individual countries than is currently the case.

The rationale to determine which nutrients should be included in any model that aims to define foods as 'healthier' was also discussed. In the US, the Food and Drug Administration has sought to provide such a specification in their regulations to manufacturers. The current conditions for bearing a 'healthy' claim (or similar, for example 'healthier', 'healthiest') include specific criteria for nutrients to limit in the diet, such as total fat, saturates, cholesterol and sodium, as well as requirements for nutrients to encourage in the diet, including vitamin A, vitamin C, calcium, iron, protein and fibre (U.S. Food and Drug Administration 2018). The FDA has made some changes to the conditions over time to reflect the evolution of its thinking (U.S. Food and Drug Administration 2016). For example, as research has emphasised the importance of replacement of saturates with polyunsaturates and monounsaturates in relation to cardiovascular disease prevention, the term 'healthy' can now encompass foods/products with a high proportion of unsaturates rather than just those that are low in total fat. With regards to micronutrients, intakes in the US have shifted over time and so vitamins A and C are no longer nutrients of public health focus, but concern has risen in relation to potassium and vitamin D inadequacies and therefore these nutrients can now be considered as part of the 'healthy' criteria (U.S. Food and Drug Administration 2019).

Some differences in opinions were noted around which nutrients should be included within nutrient profiling models. It was argued by one participant, for example, that zinc is not of importance for nutrient profiling approaches used in high socio-demographic index countries due to its low contribution to disease burden. However, as around a third of zinc in the current UK diet is contributed by meat and meat products (Bates *et al.* 2014), it was suggested that if high meat consumption is moderated (as is widely promoted for environmental reasons), intakes of zinc are likely to decline unless mitigated by compensating changes in diet. Interestingly, the diet modelling work considering the impact of following the advice depicted in the Eatwell Guide (which is based on a lower meat intake than average consumption at that time) predicted that intakes of most micronutrients (including iron and folate) would increase, but that zinc intakes would decline (Scarborough *et al.* 2016). Vitamin B12 may also become more important to consider in future in light of the increased popularity of veganism, if this leads to a rise in the adoption of more restrictive vegan diets.

b) Based on outcomes of interest to consumers

Another question raised was whether the effects of nutrients on outcomes of current interest to consumers (*e.g.* immunity, fatigue, wellbeing) should also be considered alongside the role of these nutrients in determining risk of chronic diseases. Whilst much of the discussion centred around how models that focus on micronutrient intake could encourage intakes, a view was expressed by one roundtable participant that Safe Upper Limits also need to be considered when constructing algorithms. For example, products high in vitamin A may be of benefit in countries in which vitamin A deficiency is prevalent, but consideration should be given to Safe Upper Limits in countries in which intakes are already adequate.

c) Based on the use of proxy nutrients

There was also considerable discussion around which nutrients could be used as a proxy for other nutrients within nutrient profiling models. Use of proxies is particularly useful as micronutrient data is not always readily available and missing data will hinder the implementation of any nutrient profile model that requires it. Not all nutrients are subject to mandatory nutrient declaration, such as free sugars, and micronutrients may only be listed on labels when a 'source of' claim can be used. The identification of marker nutrients could therefore allow simplification and ease of use of models. However, it may be unclear which nutrients can reliably be used as a proxy in some food groups. For example, it was questioned whether protein is a valid proxy for calcium in all cases or whether calcium itself should always be included in profile models. Some participants suggested that looking at fibre as a potential marker of some micronutrients may be an interesting and useful exercise. It was also pointed out that the use of particular micronutrients within models might favour some food categories over others. Finally, it was noted that there are always likely to be trade-offs between an ideal scoring system from a nutritional perspective and one that can easily be applied consistently by manufacturers (*e.g.* the need for the full micronutrient composition of commercially available foods versus use of proxies) and therefore it may be more practical for a system to be based on nutrients that are included on the back-of-pack nutrition panel because determining these values for all products is already a legal requirement under EU law (European Parliament 2011).

A further discussion point at the roundtable was whether nutrients added as fortificants should be included within profiling algorithms. The importance of fortified foods to micronutrient intakes in some population groups, such as children, was recognised, although attitudes to fortification vary considerably across Europe. One participant expressed the view that including fortificants within nutrient profiling algorithms may lead to misclassifications since nutrients that are naturally present are sometimes used as proxies.

Developing food category-specific nutrient profile models

Nutrient profiling algorithms used as the basis of front-of-pack labelling schemes can either be applied across a broad range of different foods, or to specific food categories or eating occasions. These may be helpful in guiding consumers to healthier choices. Interestingly, an observational study (Scarborough *et al.* 2010) reported that those eating a diet of higher overall quality consumed healthier products (as measured through the FSA/Ofcom model) from within certain food categories. Accordingly, it may seem useful to base a core nutrient profiling system on a small number of defined food categories (Sacks *et al.* 2011). It has been suggested that nutrient profile algorithms may further benefit from increased specificity; for example, nutrients that are more relevant as signals of the relative healthiness of savoury snacks may include saturates, salt (sodium) and fibre rather than free sugars, vitamin C and iron (which are less likely to be present in savoury snacks).

Consideration of broader food attributes

There was a discussion around whether any nutrient profiling systems used for front-of-pack labelling could be tied to aspects of sustainable food provision/supply such as environmental impact, land and water use, animal welfare and also cost (the concept of 'food profiling'). This sort of additional information may appeal to younger generations where concern for the environment may be high and there may be motivation to make a difference through lifestyle changes that can benefit the environment. However, there may well be a need for some 'trade-offs' between consuming a healthy, balanced diet and other dimensions of sustainability such as the environmental impact, leading to potentially confusing and conflicting messages. For example, foods with lower greenhouse gas emissions can have relatively low nutritional values (*e.g*. sugar and sweets). By contrast, we are being encouraged to reduce intake of meat and milk products, due to concerns over environmental impact (Willett *et al.* 2019), although these foods contain a relatively high concentration of micronutrients and protein.

Communication and behaviour change

It was agreed by many of the roundtable participants that the concept of nutrient density could be applicable to population health throughout the life course in several different ways. For example, promoting the concept of nutrient density could be considered in strategies to help counter the low intakes of essential micronutrients, such as calcium and iron, particularly in adolescent girls and young women, as reflected in *NDNS* data for the UK (Roberts *et al.* 2018b) and as illustrated by Professor Buttriss in her scene-setting presentation (see 'Good nutrition is more than reduced calories and sugars'). It was also noted that poor nutrient intake is of particular significance in maternal nutrition, as the impact of maternal bodyweight and nutrient adequacy on the health of future offspring is now well-recognised. In the context of obesity prevention and weight loss, the concept of nutrient density could be key in helping consumers to obtain sufficient nutrients while reducing calories for weight loss or healthy weight management. Whether there is a direct relationship between obesity and the nutrient density of diets is unclear but the coexistence of overweight and obesity alongside micronutrient deficiencies does occur (Lefebvre *et al.* 2014; Sánchez *et al.* 2016; Kaidar-Person *et al.* 2008; Cano-Ibanez *et al.* 2019), though this may not be widely recognised. In addition, energy density has been positively correlated to obesity (Bes-Rastrollo *et al.* 2008; Vergnaud *et al.* 2009; Pérez-Escamilla *et al.* 2012), and, in general, there is an inverse association between the energy density and nutrient density of foods with respect to 'positive' nutrients (Darmon *et al.* 2005) (*i.e.* in general the higher the energy density of a food, the lower the density of 'positive' nutrients, although there are some exceptions, for example nuts) (Drewnowski 2018).

What do we know about consumer awareness/understanding of the concept of 'nutrient density'?

To be effective in facilitating consumer behaviour change and encouraging healthier food choices, any application of the concept of nutrient density will need to be feasible, affordable and culturally relevant. However, as outlined previously, the meaning of the term currently remains unclear and different definitions are used, therefore ascertaining consumer and health professional awareness and understanding of nutrient density is difficult. In this context it is interesting that a recent study reported very different terminology used to define the 'nutritiousness' of foods by experts (who used terms such as nutrient density, macronutrients, micronutrients, kilojoules and calories) compared to consumers (who used terms such as fuel, fresh, natural, body needs and functioning) (Bucher *et al.* 2017). More recently, a survey of 1,000 adults in the US revealed that nearly two thirds of respondents had at least heard of nutrient density, however only 24% felt confident that they knew what the term meant and that they would be able to explain it to someone else (International Food Information Council Foundation 2019). Interestingly, after being provided with a definition of ‘nutrient dense’ and examples of nutrient dense foods, respondents indicated that they were more likely to use ‘positive’ nutrients (such as micronutrients, protein and fibre), as indicated within the Nutrition Facts panel on food labels, to identify nutrient dense foods than ‘negative’ nutrients such as saturates and sodium. It is important to note that awareness of the term nutrient density may be higher in the US than the UK due to its inclusion within the Dietary Guidelines for America (see Box 1) and in addition, the US Nutrition Facts panel provides information about a wider range of nutrients (including micronutrients), than the back-of-pack nutrition panel on foods sold within the EU (which does not typically provide information regarding micronutrients unless a product bears a related claim) (FDA 2019; EC 2006).

Food choice is a highly complex, personal process in which health may be more or less of a priority to each individual depending on factors such as life stage, lifestyle and socio-economic status. A greater understanding of consumer barriers to healthy eating and the tools that can facilitate change is of great importance and this is recognised within the ongoing studies in the EU Horizon 2020 Food and Healthy Diet work programme looking at promoting informed consumer choices. Social listening in the digital sphere (*i.e.* the process of monitoring, segmenting and analysing conversations across social media) can be used to understand more clearly consumer thoughts around, and attitudes towards, healthy eating and could also provide a way to link communication of the concept of nutrient density with trends that may resonate with consumer interest, such as gut health or plant-based eating, to enhance engagement.

Should we be doing more to improve awareness of the concept of nutrient density?

There was strong agreement among the participants that there should be more focus on healthier dietary patterns and that advice should move from calories or single nutrients alone to encouraging foods of higher overall nutritional quality (nutrient dense foods) combined with advice about minimising intake of foods with a lower concentration of nutrients (*i.e.* those with limited nutritional quality). As such, the majority of the roundtable participants felt that communication around the concept of nutrient density (or diet quality) has the potential to improve consumers' nutrition knowledge and understanding, and enable them to make healthier choices. However one participant felt very strongly that providing another concept to the general public would be unhelpful as current advice about healthy eating through food-based dietary guidelines (as depicted in the Eatwell Guide), alongside labelling and advertising restrictions, already communicate the need for selection of more nutrient dense foods. Furthermore, it was unclear how messaging around nutrient density would be positioned and whether it would be accurately disseminated when there is already an abundance of competing nutritional messages being communicated both by nutrition professionals as well as individuals without academic training in nutrition science. Developing simple and consistent messages prior to any dissemination to consumers would be important, and establishing a strong research base with regards to the association between the promotion of nutrient density, change in dietary intakes and health outcomes would be helpful. Key stakeholders to involve in reaching consensus on messaging would include health professionals (such as GPs, nurses, registered nutritionists and dietitians), social workers, public health authorities and government. However, some of the current difficulties in reaching a consensus on the topic of nutrient density (as outlined previously) were raised. A structured strategy consisting of, for example, multidisciplinary roundtables and/or facilitated digital discussions, including influencers and health journalists (for tabloids and broadsheets), could be of benefit, particularly if these discussions were positioned alongside generating an increased awareness of low intakes of some micronutrients in some population subgroups – and were considered newsworthy to participating journalists.

In-store and community interventions

Vulnerable populations (such as those on low income) were highlighted as an important audience for nutrition interventions in order to tackle health inequalities. This is supported by recent *NDNS* data illustrating an association between higher income and small but significantly higher intakes of some micronutrients and fibre, and lower intakes of free sugars (Bates *et al.* 2019). Evidence of inequalities in dietary intakes such as this suggests that it is more difficult to consume a healthy diet on a budget (PHE 2019; WHO 2014b), although not impossible providing an individual's food budget exceeds the bare minimum required for fulfilling nutritional recommendations (Maillot *et al.* 2017), and that low cost foods with good nutritional quality are selected (Dubois *et al.* 2017). Other conditions such as access to cooking facilities and sufficient income for utilities (*e.g.* gas, electricity) are also likely to be important.

In a presentation given at the roundtable, Dr Nicole Darmon from the French National Institute for Agricultural Research (INRA) outlined an interesting initiative undertaken as part of a French study aiming to improve the nutritional quality of food purchases of low income households. Resources were developed to help subjects identify inexpensive foods with a high nutrient density[2] (Dubois *et al.* 2017). These were delivered as part of two interventions:

- a social marketing strategy called *Manger Top* (Eat Great) to increase the visibility and attractiveness of inexpensive foods with good nutritional quality in discount supermarkets and
- a nutrition education program called *Opticourses*, empowering subjects on shopping on a low budget, which was developed using feedback from study subjects.

[2] Foods with a high nutrient density were defined as foods with a SAIN:LIM ratio (see Box 2) that was higher than the median ratio from a food composition table [see Dubois *et al.* (2017) for full methodology]. Inexpensive foods were defined as being lower than the average national price or 'limit price' (defined as value of lowest price tertile).

For 6 months, two discount supermarkets in deprived areas used the *Manger Top* logo on shelf labels, leaflets and large banners in store (Gamburzew *et al.* 2016). Four stores in total were selected for the intervention as these were identified by the retail chain as being comparable in terms of size, number of employees, type of supply, whole store sales and number of visits per day, with the other two stores serving as controls. Some positive results were reported in relation to purchases in intervention stores compared to the control stores, including increased awareness of foods bearing the *Manger Top* logo and increased purchasing of foods bearing the logo from the starchy food group (from 26% to 30% of total spend; $p = 0.011$) and the fruit and vegetables food group (from 48% to 53% of total spend; $p = 0.001$), although improvements were not seen in all promoted food categories. Perhaps surprisingly, when questioned 3-4 months after the start of the intervention, it was clear that some shoppers had still not noticed the campaign.

During *Opticourses* workshops, a visual tool consisting of a simplified version of SAIN,LIM was used to inform subjects on food quality, why certain foods are healthier than others and why some should only be consumed in small quantities. The sessions also included discussions on ‘tips and tricks’ and beliefs about food and recipes. Subjects collected their food shopping receipts for one month and received feedback on their purchases from a health and cost perspective (Perignon *et al.* 2017; Tharrey *et al.* 2019). Subjects were also supplied with the Fair Price Booklet, a list of inexpensive foods with good nutritional quality. One month after the final workshop, results suggested that compared to baseline, food spend remained similar but there was a decrease in energy (by 38%) and a decrease in free sugars as a percentage of energy (from 8.5 to 5.8%) in foods purchased, and in addition, about a 50% decrease in the percentage of energy purchased from foods identified as high in fat, sugars and salt. There were no significant changes in the control group (Perignon *et al.* 2017). Therefore, this booklet may have contributed to improved purchasing behaviour in the intervention group.

The results of the *Opticourses* study suggest that empowering consumers with very practical ways of making healthier food choices, without an increase in cost (*e.g.* by providing lists of high quality, low cost foods), could promote some positive behaviour change. Therefore, several of the roundtable participants expressed the opinion that interventions similar to the *Manger Top* marketing strategy and the *Opticourses* workshops implemented in real life settings have the potential to make an impact in improving dietary intakes at a national level. However, it was noted that participants who are more likely to change their behaviour are more likely to volunteer to take part in interventions such as the *Opticourses* workshops (*i.e*. selection bias). Therefore, the results may not be representative of the level of change that could be achieved within the general population. Furthermore, the practicalities of keeping product lists up-to-date (for the provision of a resource such as the Fair Price Booklet), considering ongoing reformulation and pricing changes, was highlighted. Furthermore, agreement would be needed from manufacturers to make product nutrient composition data continuously available. Nonetheless, it was agreed that the large retailers could assist in measuring the impact and effectiveness of such schemes by making purchasing data available, for example loyalty card data, to enable feedback on the nutritional quality of purchases and to monitor the effect of interventions on purchasing.

Whilst acknowledging the potential of such schemes, it was also recognised that improving inequalities in dietary intakes will likely necessitate a system-wide approach to improve dietary intakes and support behaviour change. Furthermore, food provision, the food environment and food culture in establishments such as schools, care settings and workplaces, will need to be modified in many cases.

Front-of-pack labelling

There is some evidence that front-of-pack labelling encourages reformulation (Vyth *et al.* 2010; Heart Foundation 2012) and, in controlled conditions, front-of-pack labels have been shown to help individuals in discerning the relative nutritional quality of food products (Egnell *et al.* 2018b; Egnell *et al*. 2018a; Ducrot *et al.* 2015). However, findings have been inconsistent (Hersey *et al.* 2013) and several roundtable participants felt that there is some consumer confusion in the interpretation of the information presented on food labels and that more education may be needed, starting in schools, to support healthier food choices. A 2018 systematic review and meta-analysis found that educational interventions do improve consumer understanding and increase use of nutrition labels (Moore *et al.* 2018).

It was further suggested that interpretive schemes, such as traffic light labelling, may be more effective in encouraging healthier choices than labelling formats that simply present numerical values (*e.g.* Guideline Daily Amounts) (Cecchini & Warin 2016), potentially due to relatively low numeracy-specific literacy of consumers. A study comparing scores assigned to foods according to the FSA/Ofcom model with evaluations of their healthiness by members of the public (n = 85) found that these were highly correlated, indicating that, in general, the nutrition knowledge among this particular group was adequate for making decisions in this context (Bucher *et al.* 2015). However, although subjects were able to evaluate single food products, they had difficulties in evaluating the healthiness of entire meals.

Single logos or category ratings, such as Nutri-Score can help to categorise foods as 'more healthy' or 'less healthy'. Roundtable participants noted that the place in the diet for foods that either don't qualify to bear a logo (*e.g.* in the context of schemes such as Keyhole or Healthy Heart), have a 'mid-category' rating within a ranking system (*e.g.* a product labelled 'C' in the context of Nutri-Score) or foods that display a mix of green and red traffic lights may be less clear to consumers. Products classified in this way also present a challenge for industry and may result in reduced incentive for reformulating products if doing so would not result in a food changing its classification. From the perspective of driving reformulation to improve nutritional profiles, category-specific classification systems may be able to more appropriately rank foods within food categories (rather than across all foods) and could be a more useful stimulus for consumers and indeed industry.

As front-of-pack nutrition labelling schemes do not currently take into account all dimensions of foods, encompassing food practices or the food environment, the point was raised that these cannot be a complete stand-alone tool for improving a population's nutrient intakes. Consumers select foods predominantly on the basis of taste, price, convenience, mood and social norms, with their nutritional value often being a lower priority (Vyth *et al.* 2010; Smedman *et al.* 2010). Front-of-pack nutrition labelling may simply be ignored by some because, for example, the healthier option is more expensive and cost is their main priority, or because ethical concerns are the priority.

Other tools

Further tools were suggested that could be used to communicate the concept of nutrient density/diet quality. These included in-store nutritionists/dietitians giving advice on healthier products; Twitter chats for health professionals to share messages and the use of social media to share infographics, videos, podcasts, recipes, swaps and tips. Social media has the potential for wide reach and could also incorporate additional messages such as the importance of environmental sustainability, food wastage, cost, time and convenience. An example of a campaign that has combined some of these elements, including training of in-store dietitians, webinars, online resources and the recruitment of online influencers, is the *Fruits and Veggies for Better Health Initiative* (fruitsandveggies.org) from the Produce for Better Health Foundation (Hilliard *et al.* 2018), which promotes fruit and vegetable consumption in the US. Initiatives in the UK include the *Veg Power* and *Peas Please* campaigns.

What are the considerations around communication methods?

Many pertinent aspects of how best to communicate healthy eating, including the concept of nutrient density, were captured in a presentation shared at the event by Dr Milka Sokolović, Head of Food & Health Science at the European Food Information Council (EUFIC).

Dr Sokolović emphasised that bridging the gap between what nutrition experts may want to communicate and what consumers want to know is important in facilitating healthier dietary change. This requires starting with the consumer; thinking about their perspective, experience, and needs; and finding solutions that they can understand, make meaning of and appreciate. Research suggests that terminology such as 'nutrient density' is used only by limited audiences and so there is a need for translation into language understood and preferred by consumers in order to engage them in discussions about diet quality (Bucher *et al.* 2017). Effective communication of nutrient density may perhaps best be undertaken with the support of behaviour change and communications experts, with a focus on the actionability and memorability of messages, activating people's behaviour using recognised techniques (such as ease of visualisation, chunking and sequencing information into manageable units, specifying when to act and embedding triggers) (Ratner & Riis 2014). For example, communication to consumers should consider the fact that information retention is greater after seeing audio/visual materials (*e.g*. infographics, videos, gifs, podcasts) compared to reading text, and that visuals are also more likely to be shared on social media, reaching out further to their networks. A number of other participants agreed that there is a need for communication training for health professionals, as well as bringing together collaborations between health professionals, nutrition and social scientists, and consideration of budgets for designing end products for consumers. There also needs to be a structured strategy directing consumers towards appropriately qualified influencers on social media with the aim of reducing the impact of propagation of nutrition misinformation by non-qualified bloggers.

A number of recommendations were provided in order to improve the communication of nutrition science, improve knowledge and shape opinions, including:

- being where the discussion happens (*e.g*. social media);
- defining values, messages and tones and consistent use of these across different stakeholders;
- bridging the trust gap - for example by talking with consumers, not at them, by focusing on positive messaging, by including emotions and showing human faces - and hence becoming ‘one of us’ rather than positioning the scientific community against consumers;
- using a range of communication channels, for example printed/television/radio/social media, as these reach different demographics; and
- teaming up with other experts, for example educators, behavioural scientists, journalists and social media influencers.

However, communication is only one of the elements required for behaviour change and the broader food environment needs to be considered to facilitate healthier food choices.

What are the barriers/facilitators to the use of the concept of nutrient density (including regulation) from health professional, food industry and consumer perspectives?

The following list of barriers to the use of the concept of nutrient density were identified by the roundtable participants, drawing on points raised during earlier discussions.

1. ***No mandatory criteria for nutrient profiling in the EU***

Despite the implementation of nutrient profiling being planned as part of the EU health claims framework, consensus from stakeholders and policymakers across Europe has not been reached (EFSA 2008; EC 2015). The application of nutrient profiles as a criterion in determining which products can carry claims would aim to avoid a situation where nutrition or health claims could mask the overall relatively poor nutritional composition of a food product, which could mislead consumers trying to make healthy choices. One result of the lack of mandatory nutrient profiling criteria is that approved nutrition claims and health claims can potentially be put on any product, provided the specific conditions of use associated with the claim are met. The application of a standardised cross-European nutrient profile as a criterion would aim to counter this situation.

2. *Validity of models used*

Having one agreed global nutrient profiling system for front-of-pack labelling (whether used on a mandatory or voluntary basis) could potentially be useful among countries with similar nutritional issues within their populations. However, due to the continued improvement in our understanding of nutrition science, this would need to be updated over time. It is important to acknowledge, for example, how our understanding of the implications of the quality of fat (unsaturates to saturates ratio) and of carbohydrate (*e.g.* wholegrain/higher fibre versus refined) has increased. Therefore, it is important that any criterion used is kept up-to-date with policy and scientific research so that its relevance is not undermined. It is also important to allow sufficient time for industry to implement any changes that arise.

Although food-based dietary guidelines adopt an approach based on food groups, by contrast, most nutrient profiling models continue to assess the nutrient density of individual foods based on a small number of specific nutrients to be encouraged or to limit. Because current nutrient profiling models may not fully capture the relative healthiness of foods, there may be a case for advancing a hybrid nutrient profiling approach that takes both nutrients and all desirable food groups and food ingredients into account as mentioned above (Drewnowski *et al.* 2019; Maillot *et al.* 2018), whilst other existing models do include fruit and vegetables (Santé publique France 2018). Such synergy may lead ultimately to improved dietary guidance, linked to sound nutrition policy and better public health.

3. Practical issues - compositional data

As well as the challenge of reaching a consensus on which nutrients should be included in nutrient profiling models and the other characteristics of the approach adopted (*e.g.* whether or not 'positive' and 'negative' nutrients are considered to compensate for each other), the group further discussed the challenges in collating the product composition data required for assessing nutrient density. As referred to previously, the range of micronutrients is not routinely measured and furthermore some national food composition data can be out of date. Therefore, up-to-date complete analysis of products would be required before the implementation of any standardised nutrient profiling system requiring extensive micronutrient data could be established. Any additional analysis that was required would need to be justified (*i.e.* proof that including a greater number of nutrients within an algorithm would provide more accurate categorisation of the relative healthiness of foods). If they are to be widely adopted on a voluntary basis, approaches used for calculating the nutrient density of products must be easy to implement and furthermore, to drive reformulation to healthier products, there must be evidence that any nutrient density approaches can be understood and will be used by consumers when making food choices.

4. Evidence of efficacy or unintended consequences

While there is some (limited) evidence that health claims listed on pack may influence consumer purchasing behaviour (Kaur *et al.* 2017), findings from studies measuring the impact of front-of-pack nutrition labelling schemes on food choice (*i.e.* purchasing behaviour) have been inconsistent (Chantal *et al.* 2017; Hersey *et al.* 2013), with some reporting little or no effect; therefore, the potential impact on consumer behaviour and ultimately dietary intake of a standardised front-of-pack labelling scheme to categorise products by their relative nutrient density is difficult to predict.

It is important that any initiatives designed to induce behaviour change are tracked over time in order to measure their impact on consumer purchasing and dietary intake. In addition, the impact of a nutrient profiling system coming into widespread use would need to be monitored to ensure there are no inadvertent adverse effects. Manufacturers might, for example, consider adding fortificants to products that would not, in the absence of fortificants, be considered healthier choices in order to achieve a particular classification. Conversely, manufacturers may consider removing ingredients (such as seeds which have a relatively high fat and calorie content but also provide beneficial nutrients such as unsaturates, protein, fibre and micronutrients) in order to then qualify to carry a logo or change the classification of a product. Changes made to products to achieve a better outcome in a nutrient density model could result in decreased purchases as a result of unacceptable taste or texture changes or if ingredients/fortificants are used that are unacceptable to consumers. Consequently, if consumers will not buy newly developed nutrient dense foods, manufacturers may not be incentivised to produce them in the first place.

As highlighted previously, evidence of improved nutrient intakes following promotion of the concept of nutrient density/diet quality could be captured through purchase data. However, purchase data have several limitations including not capturing portion sizes consumed by individuals (*i.e.* who in the family consumes what and how much) or waste generated and there may be governance issues (*e.g.* permission needed from customers). Analysing purchase data may also be unhelpful in identifying the main reasons underlying any changes in behaviour, as a multitude of factors affect purchases including promotions, nutrition knowledge, past experiences and even the weather.

A lack of research was highlighted into the substitutions that may be made by consumers (*i.e.* food choice) in response to changes made by the retailer or manufacturer (*e.g.* a new front-of-pack labelling scheme). Such studies are difficult to conduct in practice, as often it is only possible to examine changes in relation to one food choice in isolation, which does not reflect most scenarios in the real world in which trade-offs or swaps could occur resulting in the selection of a different product that is nutritionally more or less desirable, or indeed no behaviour change may occur at all.

5. Responsible communication

Consumers receive nutrition messages from many different sources, including social and popular media, which may be inconsistent with that provided by governments and 'experts', undermining trust in these sources. Consumer trends do not necessarily follow nutrition science, as illustrated by the popularity of coconut oil or the perception that all low-fat products are less healthy, that has been propelled by strong proponents of low-carbohydrate/high-fat diets. Some of the roundtable participants expressed the view that evidence-based nutrition science communication is the joint responsibility of scientists, health professionals, science communicators, journalists, industry, policy makers and that messaging would need to be strong and consistent to stand out in the current landscape.

6. Consumer understanding

There is a concern that food and cooking skills are not being passed on to the younger generations, yet research suggests that enablers to the selection of healthier diets and nutrient dense foods include cooking skills (McGowan *et al.* 2017). While cooking and nutrition has been back on the curriculum for children aged 5-14 years in England since 2014, in a survey conducted by BNF, two-thirds of teachers reported no change or a decrease in lesson length, funding and teaching resource provision for its delivery (Ballam 2018). Some of the roundtable participants expressed the view that there is a need to build food and nutrition literacy so that consumers can prepare and select healthier, more nutrient dense foods that are more affordable. Interestingly, in a survey of US adults, the two most selected factors that would help them to eat more nutrient dense foods (both reported by around a third of subjects) were if such foods were more budget friendly and also easier to identify (International Food Information Council Foundation 2019). However, communication may need to go beyond basic education and information provision, for example workshops may be of benefit including practical advice and feedback on existing food choices, such as those provided in the *Opticourses* programme. In addition, the terminology used for information directed at consumers needs to be carefully considered (*e.g.* 'nutritional quality' may be more appropriate than 'nutrient density').

A number of key questions were identified during the roundtable discussions that warrant further consideration if the concept of nutrient density is to be used more widely with the public in the future. These include:

- Which combination of nutrients best reflects nutritional quality?
- Should the nutrients included in nutrient density scores/nutrient profiling algorithms all have the same weighting?
- How should fortified foods be scored within these approaches?
- Can nutrient density models be constructed to reflect varying health needs or goals at different life stages?
- Should nutrient bioavailability be taken into consideration?
- Is refinement of existing models necessary, for example should free or added sugars replace total sugars; should unsaturates routinely be included as well as saturates;

should there be more differentiation of particular food categories such as fats and oils or dairy foods to take into account fatty acid profiles or the food matrix?

- How could other nutrients/compounds that may increase in relevance over time (*e.g.* polyphenols) be considered?

There are also a number of practical barriers to the use of approaches to assess nutrient density. The evolving nature of nutrition science requires any system to be re-evaluated and adapted over time. This creates a number of challenges for stakeholders including multinational food companies that need to fit any nutrient density model into a complex myriad of global criteria and regulations, and for small and medium enterprises (SMEs) that may struggle with the cost of implementing a potentially evolving model. It is also likely that, for widespread use, any nutrient profiling system will need to be adaptable in order to be suitable in the context of specific public health concerns which may vary from country to country. Use of a simple approach to encourage widespread use may be at odds with the complexity required to classify 'healthier' foods in a transparent and consistent manner. Including micronutrients in profiling models is also challenging as this data is less readily available in comparison to nutrients [*i.e.* sodium (salt), saturates and sugars] that are part of mandatory nutrition labelling. While quantifying the micronutrient content of foods may be warranted in light of evidence of micronutrient inadequacies in some population groups in countries including the UK, modelling work carried out during the development of the FSA/Ofcom model concluded that protein is an adequate proxy for a range of micronutrients (Rayner *et al.* 2009), though this is debated.

Conclusion

The recognition of obesity as a major public health concern set the context for the discussions which took place during the roundtable event. Tackling obesity in the UK remains a priority, but there is also a need to consider the nutritional quality of diets in relation to wider health outcomes. There is a clear need to help consumers select foods that provide high nutritional quality in relation to their calorie contribution (the concept of ‘making every calorie count’). The need for action is also reflected in the growing number of nutrient profiling models around the world, and the support for their use by authorities such as the WHO (WHO Regional Office for Europe 2014). Yet, at present, dietary advice for the prevention of diet-related conditions, such as cardiovascular disease (CVD), type 2 diabetes and obesity, is more focussed on reducing intake of specific nutrients, such as saturates and free sugars, rather than on the broader nutritional qualities of foods. Furthermore, headlines oversimplifying such information can act to distort public perception. Consequently, there is a risk that any food containing sugars, including fruit and dairy products without added sugars, may be considered in a similar vein to discretionary foods or ‘treats’, such as confectionery and cakes. Moreover, messages that focus on restriction of single foods or drinks may not provide consumers with the wider information needed to make healthier food choices. Data illustrating the issue of overweight and obesity coupled with low micronutrient intakes suggest that more guidance is needed. Communication of the nutrient density concept to the public could provide more complete advice, as well as more positive and permissive messaging, with greater emphasis on nutrients to encourage, such as fibre and micronutrients, and there was support for this among some roundtable participants. However, a focus on nutrient density should not undermine the importance of energy density or imply that calorie intake is less significant. Instead, the two concepts of energy density and nutrient density should be dovetailed to encourage better choices and ultimately help consumers improve diet quality; for example wholegrains in place of refined grains and foods rich in unsaturates instead of those high in saturates, as depicted in BNF’s Quality Calorie resource (British Nutrition Foundation 2019). There remains a lack of agreement on a precise definition of the term nutrient density and the best way to assess the validity of different approaches.

Reformulation can have a significant impact on dietary intake at population level and it is therefore important to consider whether communicating the concept of nutrient density to consumers could drive further reformulation by the food industry by encouraging consumer demand for nutrient dense foods. Using nutrient density models to create logos or labels may be a useful centrepiece for a communication strategy, but to be effective these must allow manufacturers to demonstrate nutritional improvements, be widely used and easy to understand, and supported by appropriate consumer messaging and education.

The roundtable participants highlighted the fact that the nutrient density scores of individual foods alone cannot fully translate into advice on healthy dietary patterns as the latter requires guidance around the combination and balance of foods, as well as portion sizes and frequency. Dietary advice also includes the important component of variety. To illustrate this, a single variety of fruit may have a good nutrient density score but a better balance of nutrients will be obtained from consumption of different types of fruit (and vegetables). Messaging to include a variety of 'nutrient dense' foods from different food groups may therefore have merit. For example, consuming a wide variety of 'recommended' foods, as scored by the FSA/Ofcom model has been associated with reduced cancer mortality (Masset *et al.* 2015). However, the association between the consumption of nutrient dense foods and health outcomes is not always clear as the findings of cohort studies have been inconsistent. For example, consumption of less healthy foods, as defined by the FSA/Ofcom model, was not associated with risk of CVD in UK adults (Mytton *et al.* 2018), but an association was reported in French adults (Adriouch *et al.* 2017). Roundtable participants emphasised that in order to justify the communication of nutrient density to consumers, there must be evidence that this would improve nutrient intakes and subsequent health outcomes within populations and this is currently lacking.

Nutrient density is a concept that cannot be considered in a vacuum. It is clear that there is more to encouraging healthier food choices than nutrient density alone; food choice involves a multitude of factors including cost, taste, culture, food preferences and access and for some consumers the health attributes of foods may simply not be a priority. All dietary communications should be delivered with an understanding of social and health inequalities and the need to promote diets that are both healthy and sustainable. Consideration of who may use, and therefore benefit from, information on nutrient density is important to ensure that any interventions extend to vulnerable population groups, such as those living on low income and with poor health literacy.

The roundtable event allowed discussion between a range of stakeholders around the concept of nutrient density, and a chance to explore the limitations and opportunities for its use as a tool to improve dietary intakes. Whilst consensus was not reached on a number of issues, many valuable points were raised and the event promoted in-depth and lively debate. Tackling obesity in the UK remains a priority, but there is also a need to consider the nutritional quality of diets in relation to wider health outcomes. In comparison to messages focussed on single nutrients, communicating the concept of nutrient density to consumers may be a more effective tool to encourage behaviour change and this is worthy of further investigation. However, there are barriers to the use of the concept for different stakeholders and more work needs to be done to identify how best to frame the concept in a way that resonates with consumers.

Conflict of interest statement

BNF is grateful to General Mills for providing funding to support the running of the roundtable. BNF set the roundtable agenda, chaired the event, selected the participants and had full editorial control of this report. Some of the participants (Belinda Quick, Nilani Sritharan, Dr Sue Gatenby) were selected to provide an industry view. Janet Cade is a director of Dietary Assessment Ltd, a company supporting the nutritional analysis software myfood24.

All participants (Professor Janet Cade, Dr Nicole Darmon, Dr Mary Flynn, Dr Sue Gatenby, Azmina Govindji, Belinda Quick, Professor Monique Raats, Professor Mike Rayner, Dr Milka Soković, Nilani Sritharan) were given the opportunity to comment on various drafts of the manuscript. All listed authors approved the final version.

Disclaimer

Co-author S. Gatenby is employed by PepsiCo, Inc. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of PepsiCo, Inc.

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