

Chapter 2

Cutting Through the Challenge of Improving the Consumer Experience of Foods by Enabling the Preparation of Sustainable Meals and the Reduction of Food Waste

Wayne Martindale

Abstract The communication of sustainability and Corporate Social Responsibility measurements by food industry campaigns has identified key areas of activity that dominate sustainable thinking in the food industry. The purpose of this chapter is to show that one of these areas of activity, the intensity of resource use and resulting food waste, can be used as a universal connector of sustainability practice across supply chains and between them. This requires an assessment of food waste production because it is an attribute consumers are familiar with and as such; these connectors are often overshadowed by high-level issues such as global food security, climate change and the loss of biodiversity. While these high-level issues rightly dominate the policy arena they will often take the attention away from issues that practically relate sustainability to us as consumers when we prepare, present, preserve and consume three or four meals a day. This situation presents a major challenge that is tackled here by providing sustainability and security metrics that relate to meals. The Six-Function-Model (*6fm*) is a model developed to assess the sustainability of food and it can be used to overcome the stifling of sustainability thinking by methods that do not enable practical application in retail, kitchen and restaurant situations. The use of the *6fm* by manufacturers, retailers and consumers will stimulate the ‘designing-in’ of sustainability attributes into meals. The model and a benchmarking analysis of the *6fm* are presented here to account for resource use and food waste associated with meals. The future goal of *6fm* is to stimulate the use of it in the food and beverage industry so that it ‘builds-in’ sustainable thinking to product design and consumer experience.

Keywords Sustainability · Consumption · Consumers · Responsibility · Consumer goods

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2.1 Introduction

The development of the Six-Function-Model (*6fm*) for the sustainability and security assessment of meals is derived from ground-breaking work that has combined expertise from academic and industrial sectors. This was initiated by the development of methodologies that have assessed how consumers purchase, prepare and utilise food for each meal (Martindale 2014a). This type of approach not only identified sustainability criteria associated with meals, it also provided specific insight into the ‘values attributes’ consumers associated with meals. This supply chain focussed methodology has been refined by using a model of household food waste production from different preserved food categories (Martindale 2014b). These studies have demonstrated that food waste can be reduced by half in households if resource use is optimised using freezing as a means of food preservation. In demonstrating this, the requirement to understand how we consumers make meals and associate values of convenience, taste and affordability with them was identified. A model of food waste production from household meals presented by Martindale (2014b), showed the impact of doing this was considerable because frozen preservation in households currently removes 5.5 million tonnes of household food waste across the European Union for seafood, meat, fruit and vegetable food product categories. This begins to establish the goal of achieving zero household food waste when we consider frozen food purchases are lower volume than fresh food purchases and consumer awareness of food preservation can be communicated with greater impact if sustainability outcomes are utilised.

The goal is for the *6fm* to enable manufacturers and retailers to communicate the sustainability credentials of meals and for us consumers to use the *6fm* to action sustainable meal choices. The *6fm* model combines ‘values attributes’ and ‘technical attributes’ associated with food choice in a model that is tested in this study with particular focus on manufacturing scenarios that will provide an improved consumer experience. This is because manufacturing is where the outcomes of understanding sustainability in product development are high-impact in the supply chain because they result in stronger manufacturer-retailer relationships and ultimately decide how a large proportion of consumers utilise food products for meals (Jones et al. 2014). Indeed, it is a control point and while the aim is for the *6fm* to be used in all parts of the food supply chain it is important to identify control points in the test of *6fm* presented here. The approach is also to use *6fm* to obtain feedback on the use of foods from consumers so that it can be used to re-design products for meals.

2.2 The Need for a New Approach in Creating Resource Efficient Food Supply Chains

The ‘technical attributes’ include in the *6fm* are those obtained by using carbon footprinting and Life Cycle Assessment (LCA) methods that are now well established in food industry sustainability practice (Hornibrook et al. 2013). Experience

of delivering these carbon footprinting investigations with respect to consumer trends has most notably been obtained in the non-meat protein product marketplace (Martindale et al. 2014). These meat-replacer products dominate the emergent flexitarian markets and provide an important case-study where consumer ‘values attributes’ and LCA ‘technical attributes’ must be integrated for application (Green et al. 2010). The need to assess the Greenhouse Gas Emission (GHG) credentials of meat and non-meat foods is an important aspect of meeting global sustainability and security goals. It has provided the opportunity to begin to understand how we as consumers interact with high-level sustainability measures such as eating less meat. While GHG reduction goals are important ‘technical attributes’ in the meat reduction debate, health issues dominate it and these are the ‘values attributes’ that consumers associate most favourably with (De Boer et al. 2013). This type of scenario results in a complex decision framework of technical and consumer values associated with choice of meat and non-meat products that has provided the industry with important dietary models (Macdiarmid 2013). The debate on meat free products has stimulated the growth in the flexitarian meal trend in Europe and it has shown how food sustainability criteria can often force us to consider extending scientific evidence to consumer values-driven goals (De Boer et al. 2014).

This work in the meat-free arena has enabled an understanding of trends in marketplaces and the impact of dietary transitions on sustainability outcomes. This has provided insight into more realistic applications of carbon footprinting because models show diets with lower GHG emissions that have lower meat with more fresh fruit and vegetable content can result in greater production of household food waste (Martindale 2014a). Extending such LCA data to populations using consumption models is important because they show us sustainability is not a single issue movement and it is dependent on several values with which scientific evidence must interact. This is precisely what the *6fm* is aiming to achieve by enabling sustainability practice for everyone rather than considering the challenge ‘too big’ to be solved.

The consumer issues associated with sustainability are often values-driven goals that are focussed on food choices that align with specific environmental issues. These often become a platform for policy development through channels such as the activist programmes of Non-Governmental Organisations (NGOs). This is an important aspect of policy development for the food industry to understand because it does not always result in efficient consumer communications because the industry and consumers are often removed from developing them. Indeed, if science evidence-based and consumer values-based criteria do not align it creates a situation where there is a clash and the policy makers have to take the approach that evidence must be adhered to at all costs, in which case consumer values can seem to be ignored. The retailer to consumer relationship in the food supply chain is another control point challenge that the *6fm* will tackle because it aims to create transparent measurement for sustainability criteria and communication. This is achieved, not by developing feelings of guilt in consumer activities or aligning them to the goals of NGO’s but to identify the benefit of using diverse food choices and preparation practices that are sustainable and can be measured.

The approach of *6fm* has evolved because if we do fail to integrate trend-led consumer data into LCA methodologies we will stifle the use of sustainable principles by both industry and consumers alike. It is well known that LCA and footprinting techniques do not integrate well with Fast Moving Consumer Good (FMCG) businesses because market trends and how consumers consume foods are rarely considered by them (O'Rourke 2014). Indeed, this is at the very core of the *6fm* approach, where we determine why consumers like a particular food and then ask, can that product be re-designed in a more sustainable or security conscious way so that preparation and consumption aligns with these values. This approach will communicate the measures of sustainability and security criteria back into the supply chain from consumers so that redesign can be applied. Standard or classical techniques of sustainability assessment such as carbon footprinting or LCA only identify where criticality occurs and act by communicating reduction of consumption alone and I believe that this approach will not work. The *6fm* offers an alternative that can be used by producers, manufacturers, retailers and consumers for an innovative and engaging redesign of practice.

An example of our challenge is provided with livestock products where LCA techniques have shown they embody more energy and result in greater GHG emissions than consuming plant products directly because livestock consume crop products as feeds (Martindale 2014a). In this instance, a weakness of classical LCA is apparent because of two key factors;

- the diversity of livestock production enterprise types means that a single type of LCA will never define the environmental impact of animal production;
- consumers will utilise varying amounts of protein and carbohydrate food groups in meals and these are determined by lifestyle and preference.

In its simplest form these two factors can be described in the fact that comparing feed-lot reared beef to grass-fed grazed beef is not possible; when the production system is normalised, studies might be used to compare meat products but this is rarely done (Ridoutt et al. 2011). Thus, the inflexibility of LCA creates confusion which is compounded by a complete misunderstanding of the functional unit used to communicate LCA results which is usually kilograms of product and this does not easily relate to ingredients of meals.

This inflexibility of LCA in food FMCG supply chains results in organisations reporting sustainability and security goals using biased data for specific causes. For example, when organisations have required the reporting of the more intensive GHG measures for beef production they can use the energy intensive rearing for premium markets such as Wagyu beef or production systems based in areas where grazing is limited by rainfall (Ogino et al. 2007). This does not represent an evidential view of all livestock production enterprises with respect to the diets we consume. While efforts are made to provide normalised perspectives on diets there is still much scope to improve (Garnett 2013). The changes in resource use intensity associated with climate and different production systems are the very basis of optimal grazing and husbandry that are overlooked here. Indeed, the words of

Norman Borlaug ring in our ears with ‘there are no miracles in agricultural production’, an understanding you can’t achieve optimal crop or livestock production in areas where varieties and breeds are not suited-to, seems forgotten by some applications of LCA. However, this happens time and time again for consumer communications creating a confusion and a distrust of data and evidence in the marketplace.

As such, this leads us to observe that attempts to standardising diets, meals and foods using LCA has potentially confused consumers by making comparisons of different food products when they should not be made. This has often only promoted values-driven communications that undermine sustainability and security targets globally. The *6fm* approach breaks through the high-level issues such as meat versus non-meat product use to consider how we as consumers make and consume meals while still maintaining a line of evidence to sustainability and security criteria. The *6fm* structure differs from LCA in that it is designed to firstly to benchmark and consider consumption in marketplaces. This approach will consider meal portion and an outcome will be improved sustainability and reduced food waste in meal preparation and consumption. Finally, the *6fm* develops a measure of sustainability and security that can be used as a dash-board measurement or index within businesses or homes that wish to respond to sustainability and security criteria by redesigning product or meal formats.

2.3 The Six Function Model Approach to Assessing Food Use

The six function model (*6fm*) method presented here tackles two key themes that have vexed food sustainability and security thinking for several years and these are:

- Measuring the potential to provide an adequate supply of nutrients in foods we enjoy as consumers that are accessible, affordable and assured (as the established ‘Triple A’ standard).
- Developing resource efficient ways of guiding us to consume sustainable meals (Martindale 2014a).

The identification of these themes has been made possible by mapping food supply chain sustainability attributes and identifying areas where there are likely to be the most effective resource utilisation gains. While many organisations consider this too complex a task we have obtained data on food supply chains from food manufacturers in semi-structured interviews regarding resource use and waste reduction that have a benchmark that is practical and usable in situ. The need for this has identified six functions in food supply chains that have resulted in developing the *6fm*. It is based on a food supply chain model which is shown in Fig. 2.1, which demonstrates how the *6fm* methodology interacts with supply chain operators.

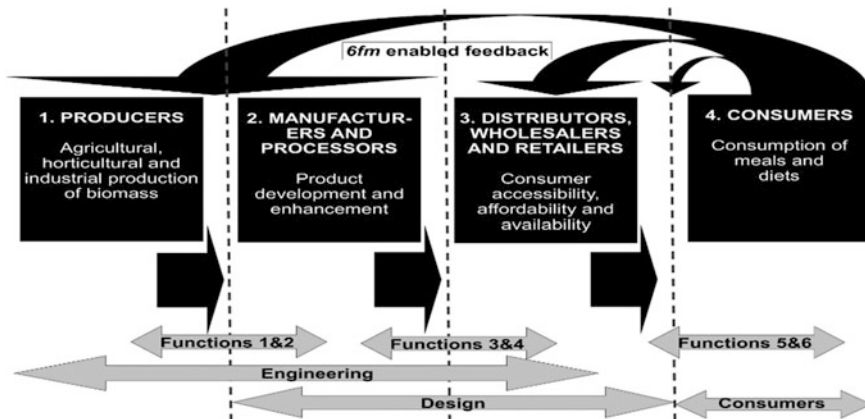


Fig. 2.1 The supply chain approach of the *6fm* is shown here. The supply chain operators of producer, processor and manufacturer, retailer, distributor, wholesaler; and, consumer are shown in a linear function. The *6fm* enables feedback across the whole supply chain as shown in the model developed by Martindale (2014a)

Figure 2.1, shows the four production, manufacture, retailer and consumer operators of the food supply chain and where the six functions of the *6fm* operate in it to provide a measure of sustainability and security. The *6fm* benchmarks meals in terms of energy and resources used in accessing foods, preparing meals and preparing what we eat. The *6fm* functions described here are shown in their typical role of influence in Fig. 2.1, for each supply chain operation (i.e. production, manufacture, retail or consumption) together with the principle skill-sets that dominate in these supply chain operations (i.e. engineering, design or consumers). The six functions have been in part selected through my experience of delivering sustainability research projects that have carbon footprinted individual food products, mapped food supply chains and assessed the impact of consumer use of foods in making meals (Martindale 2014a). They represent a practical set of functions that can be used to measure the sustainability of meals and they were selected using the feedback from semi-structured interviews with food industry professionals. The goal reflected in the supply chain model in Fig. 2.1, is that the *6fm* will be used by the whole food supply chain from producers through to consumers to create a much greater understanding of both security and sustainability associated with meal choices. The six functions of the *6fm* whose operation is shown in Fig. 2.1, are as follows.

- 1. Import and export volumes of ingredients (I + E).** These are based on traded volumes of food ingredients and commodities that are available from FAOSTAT. The volumes determine pressure points and these can be used to project trends when compared to the national crop or livestock yield per unit area data. Tailored ingredient folios would be used for specific manufacturers and they highlight mass-flow sensitivity in delivering food to consumers.

2. **Nitrogenous fertilisers utilised in production of ingredients (N_{production}).**

The assimilation of nitrogen into protein is dependent on the production of both organic and mineral fertilisers. The function is based on typical nitrogen requirements for crops and livestock that is quantified using the fertiliser recommendations for crop ingredients and feed conversion factors for livestock ingredients. Nitrogen requirements are well tested and reviewed by Smil (2002) and in this context plant proteins are given a value of 1.0, and livestock products are multiple of this with fish or seafood meat being 1.5, chicken meat being 2.3, pig meat being 5.9, beef meat being 12.7, eggs being 3.8 and milk being 0.7 using feed conversion ratios. Nitrogen use is a convenient function for food because it is converted into protein and accounts for up to a third of the energy balance of the production operator of the food supply chain, it is typically a third of the agricultural energy balance.

The first two functions are concerned with producers and the producer-to-manufacturer and processor relationship within the supply chain model presented in Fig. 2.1. The first and second functions assess the production of ingredients.

3. **Protein content of the food ingredient used in meals (P_{content}).** This is a key determinant of dietary security, it is based on the ability of meals to provide 800 mg of protein per kg of body weight per day and represents the point in the *6fm* where ingredients are constructed into meals (Martindale 2014a). A key quality determinant of meals are their protein content, this is emphasised in the *6fm* because protein supply is a critical component of maintaining food security. Protein values of foods are benchmarked with plant proteins are given a value of 10 and livestock products are multiple of this with fish or seafood meat being 18, chicken meat being 20, pig meat being 14, beef meat being 15, eggs being 13 and milk being 3.5 based on edible protein content (Smil 2002).
4. **The micronutrient content of the food ingredient (Micro_{content}).** The functional nutritional properties of foods are classically determined by protein, fat and carbohydrate content. Meta-analysis of micronutrient contents have been used to guide the benchmarking process for this function. However, the range of micronutrients is extensive and often misrepresented (Brandt et al. 2013). This means the micronutrient value of meals is not easily communicated to consumers and we require a robust indicator of micronutrient nutrition for this function. We have chosen to use the social or value-attributes in the selection criteria for measuring micronutrients. The use of the Google Trends tool has identified that ‘Vitamin C’, ‘Vitamin D’ and ‘essential fatty acid’ are the terms that have greatest social interest for a range of micronutrients. The *6fm* is reflective of consumer awareness and we have used these trends to measure the benchmark for this function. Thus, Vitamin C, Vitamin D and essential fatty acid content are the micronutrients used to benchmark this function and the micronutrients used can change in respect to trends identified. This function is the one within *6fm* that is subject to greatest change by users because of the

changes in trends and Google Trends manages syntax searches to standardise the approach of selecting the trends.

The third and fourth functions are concerned with manufacturers and retailers relationship within the supply chain model presented in Fig. 2.1. The third and fourth functions measure the use of ingredients in meals to provide quality attributes, in this case protein and micronutrient nutrition. Notably the quality qualifier terms are determined by Google Trends citation volumes.

5. **The energy utilised by the supply chain that delivers foods from farm to consumer (Esupply).** The embodied energy of supply provides an important indicator of food affordability and efficiency. The energy consumed in producing; processing and manufacturing; and, distributing and retailing foods is well characterised with peer review and open-access data-bases (Nielsen et al. 2003). The *6fm* uses this data to assess the amount of energy consumed in the supply chain to produce specific meals. This is reflected in LCA data where the products are produced in manufacturing arenas and the data reported considers energy used to the point of sale by a retailer (Wallén et al. 2004).
6. **The energy utilised in preparing and consuming foods for meals (Eprep).** This is the area of the supply chain that is often disregarded because of the complex decisions that take place during food preparation and consumption. Our approach has been to simplify this decision based system to assess specific ‘flagship’ meals and in this test of the *6fm* we select six meals shown in Table 2.1, that are selected to represent different culinary management the marketplace. Eprep is a critical point of the *6fm* model because the supply chain prior to preparation of meals is well understood through the application of LCA and carbon footprinting. The *6fm* extends this understanding to meal preparation using meal groups with an assessment of ingredients and food waste. Table 2.1, also considers food waste intensity from different meal types because waste is a critical part of the energy balance for the consumer experience.

The fifth and sixth functions are concerned with consumers and the retailer-to-consumer relationship within the supply chain model presented in Fig. 2.1. The functions measure the use of meals in diet and lifestyle, they are indicative of the food experience of the consumer.

2.4 Testing the Six Function Model

The testing of the *6fm* has been framed using the six specific meal groups that are shown in Table 2.1, they have been selected by reviewing recipe databases from chefs and retailers. The meal groups are constantly under consideration and are representative of the UK trends in meal popularity (Defra 2014). The selection of meal groups is strengthened by this study undertaking semi-structured interviews of nine practitioners in the food industry working with food trends and product

Table 2.1 The description of the meal groups used to test the *6fm* in this study considers the Esupply and Eprep functions together with the energy embodied in potential domestic food wastes

Meal group	Principle ingredients	Proportion of typical ingredient groups (% of meal weight in brackets) ^a	Energy consumed supply chain	Energy consumed domestic preparation	Energy embodied in domestic wastes	Notes
Fish and seafood	Fish		Intermediate	Low	Low	Fillet and high quality meat may be used, there is variability
Pasta	Cereals, Eggs	Cereal 70, egg 5, vegetables 20, meat 20	Low	Low	Intermediate	Optional processed meat can be used, potentially reduce protein if vegetables are used
Curries, mince and stews	Meat, Pulses, Spices	Vegetables 40–60, rice 20, meat 40–60	High	Intermediate	Low	Optional processed meat can be used, potentially reduce protein if vegetables are used
Salads and fruit	Leaf, Pulses, Fruit, Eggs	Vegetables 50–90, egg 20, oil 10	Low	Low	High	Optional processed meat can be used, potentially reduce protein if vegetables are used
Roasts	Meat, Veg	Meat 20–30, vegetables 60–70	High	High	Intermediate	Fillet and high quality meat may be used, there is variability
Breakfasts and bakery	Cereal, Dairy, Sugar, Eggs	Cereal 40–60, sugar 25, egg 5, fat 20, dairy 5–20, fruit 5–20	Intermediate	Low	High	Flexible preparation is built into this meal design

^aProportions have been derived from recipes reported in Martindale et al. (2008)

development. The practitioners included three development chefs, three food manufacturers and three retailers. The development chefs were independent specialists who regularly develop meals for restaurants and develop food solutions for food manufacturers that are from the Small Medium Enterprise (SME less than 250 employees) to large company (international and pan-European) scales. The food manufacturers were SME's with 50–100 employees and included a bakery, a ready meal provider; and, a confection and snack supplier. The retailers were regional or local retailers who had at least 20 employees in the specific retail-outlet identified and included two general retail grocery outlets and a farm shop specialising in local food. The focus of this sample was regional because the goal of the *6fm* is SME accessibility to sustainability assessment and it is well established that large multinational companies have robust sustainability reporting measures in place for internal and external affairs.

The Google Trends web-crawler tool has added rigor to the six functions used by the *6fm* because it has provided a search system that can rank specific consumer-used terms associated with each of the functions. The use of the web-crawler enables benchmarking and testing of the responses from the nine practitioners. The most popular terms selected are shown in Table 2.2, they are those terms that have greatest citation volume from Google searches and they are used to guide the selection of the six functions and guide the benchmarking for each meal identified in Table 2.1.

The benchmarking analysis of *6fm* is carried out by asking end-users of *6fm* to relate their understanding of the six functions to a scale ranging from 0 to 9 points (a rank of 1–10). In taking the test a participant is asked to mark on a scale of 0–9 the score for each function. This is guided by the 'technical' or LCA derived attributes and the 'values' or Google Trends attributes described in this methodology.

Using the meal groups identified in Table 2.1, and descriptors of each of the six functions in Table 2.2, we can begin to develop an index that effectively sums the functions by scoring them. The scoring is influenced by product type and the security and sustainability criteria associated with each function to infer ethical outcomes by users and the choice of meal. The testing of the *6fm* here used six meal groups obtained by interviewing nine practitioners involved with developing meal design strategies. The sample meal groups selected are as follows.

1. **Pasta dishes.** The pasta trend is still relevant in providing the basis for the Mediterranean diet (Kearney 2010).
2. **Salad dishes.** The salad meal has changed dramatically in the United Kingdom and it still provides an important health driven trends in diets (Leslie et al. 2014).
3. **Mince, stews and curry dishes.** These represent those that are convenient and flexible in that the meals can be both vegetable and meat focussed (Scarborough et al. 2014).

Table 2.2 The selection of keywords used to support the assessment of the functions in the *6fm*, these keywords are used for the micronutrient function in this study

Function	Key words identified by Google Trends
Import and export volumes	Food trade, coffee trade are used as keywords These were filtered from a group that also included the keywords imported fruit, imported vegetables, imported meat, exported fruit, exported vegetables, exported meat; fruit trade, vegetable trade, meat trade, soy trade, corn trade, cereal trade, sugar trade, banana trade
Nitrogen used in production	Intensive agriculture, organic food are used as keywords These were filtered from a group that also included the keywords nutritional quality, meat and environment, meat and greenhouse gas, low greenhouse gas food, sustainable agriculture, fertiliser and food, (low impact food) was changed to organic food. Greenhouse gas references with food provided no trend volume
Protein content of foods	Protein and disease, protein and muscle; protein for aging; protein and the elderly; meat alternatives, meat consumption are used as keywords These were filtered from a group that also included the keywords sustainable protein, synthesised protein, waste protein, protein and research, protein and capacity, protein and government decisions, protein and global warming/climate change, protein availability, protein and exercise, protein and deficiency, protein and child development, protein and carbon footprint, protein and eating demographics
Micronutrient content of foods	Vitamin C, Vitamin D, essential fatty acid are used as keywords These were filtered from a group that also included the keywords iron nutrition, essential amino acid, folic acid, carotene, biotin, phosphorus nutrition, calcium nutrition, copper nutrition, zinc nutrition
Energy used in food supply chain	Transport cost and manufacturing cost are used as keywords These were filtered from a group that also included the keywords fuel cost (too general), refrigeration cost, resource efficiency, frozen food, chilled food
Energy used in preparation of food	Cost of preparation and healthy food are used as keywords These were filtered from a group that also included the keywords environmental food, cost of recipes, convenient food (preparation), family food, food for ageing (no trend), food for young

4. **Roasts.** The roast meal is the celebration meal in the United Kingdom, the meal will typically have a meat ingredient as the centre-of-the-plate and the preparation and cooking processes provide an important test for the *6fm*.
5. **Fish and seafood.** These meal trends are also driven by health issues and are included here because they do present specific sustainability issues.
6. **Breakfast and bakery.** The breakfast and snacking trend is dominant in recent years and it is an important test group for the *6fm* because of this (Hoyland et al. 2012).

2.5 Benchmarking Meals with the Six Function Model

A summary of the results for the testing of *6fm* by the assessment of nine food industry specialists is shown in Fig. 2.2, and it can be seen that an index of sustainability can be developed using the sum of rank for the six functions. Figure 2.2, shows the highest *6fm* scores are for meat containing meal groups and variation between meal groups can be relatively small. This means that meal choices over longer periods of time are likely to only show large differences and the *6fm* will convey this to consumers using it. That is, *6fm* needs to be built into lifestyle and used constantly for the impacts of sustainable meals to be realised by consumers. The actual format and design of the *6fm* will be decided in future with a range of clients in manufacturing and retail arenas. Herein lies the challenge to us currently, it is well established that meat products have increased GHG emissions, it is likely that the differences between different meat and non-meat products will continue to be identified and discussed but there is a current opportunity to relate these analyses to meal making and diet planning with the *6fm*. Figure 2.2, shows the *6fm* can be used to inform meal planning within diets across supply chain operations using consumer experience as a focus of application.

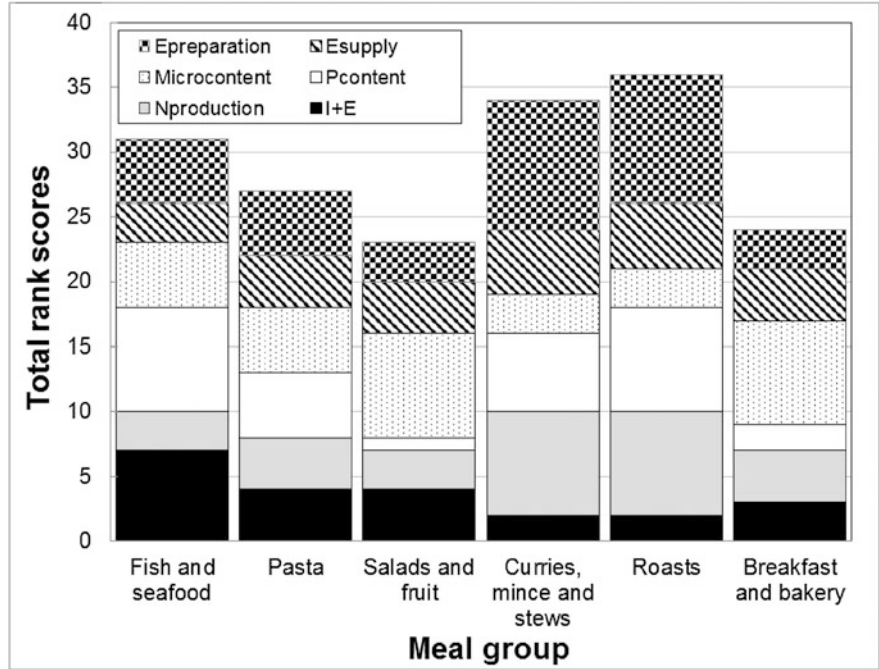


Fig. 2.2 The *6fm* test summary for the meal groups considered in Table 2.1. The scoring was obtained by analysing the responses of nine specialists that tested the *6fm* approach

A sustainable outcome for every meal is the ultimate goal of the *6fm*, with this being coupled to the ‘Triple A’ standard of affordability, assurance and assurance already being built-into the design of most food ingredients and products it is possible to achieve the most sustainable outcome. A sustainable meal will be defined as one that enables consumers to live within limits of available resources so that they are not destroyed. Assessing and defining this as a practice is what the *6fm* guides end-users to do by enabling access to good culinary preparation.

The *6fm* can help benchmark high-level sustainability and security issues with the consumption of meals. An important aim for *6fm* is to create change in diets where there is sufficient or over supply of protein so that the consumption is balanced. As such, we considering transitions in protein use or changing protein preference in order to reach a sustainable goal rather than limiting protein itself. Typical summaries of the functions include the following.

1. Meal groups containing fish and seafood had the greatest import and export rank with pasta, and, salad and fruit, meal groups having notably greater ranking than other meal groups.
2. Meal groups for mince, stews and roasts that typically include livestock ingredients have increased ranking for nitrogenous fertiliser use.
3. Meal groups for seafood, pasta and breakfasts show increased micronutrient content. The protein content rank of meal groups containing seafood and livestock products is greater than the other meal groups.
4. The meal groups show relatively constant energy of supply whereas the energy for preparing stews and roasts is increased compared to other meal groups.

2.6 The FMCG Supply Chain Challenge

While supply chain operations can be simplified, analysis of how supply chains interact with consumer choices are complex because of the scale of behaviours in populations where there are millions of consumers who exert choice editing, preference and demand pressures. The *6fm* approach provides an opportunity for end users to cut through this complexity with individual meal choices they make. This is achieved by identifying universal connectors to assess resource utilisation at all control points of the supply chain and packages these connectors into the six functions of the *6fm*. This enables the user of the *6fm* to ask structured questions about the ingredient and meal choices made for specific meals and relate this understanding to values of security, sustainability and ethics of diets. The six functions we identify to assess the meal groups are well characterised in literature and we use this evidence to support our reasoning for including them in the *6fm*.

Consumer use of the *6fm* will also enable feedback into the whole supply chain and Fig. 2.1, shows this feedback being most effective when transferred back to the producer operators so that it impacts across the whole supply chain. Currently, feedback is more advanced way for the consumer to retailer and manufacturer

operators and this is reflected in Fig. 2.1 (Hutchinson et al. 2015). There are notable successes of feedback where specialist science has complemented cultural interest in preparing food and communicated dietary changes effectively. Such an example is the Total Well Being (TWB) Diet from CSIRO in Australia that has used dietary trials and recipe listing to promote health and sustainability in domestic food preparation (Noakes and Clifton 2013).

The use of preservation and preparation practices methods will be critical to ensuring nutritional quality and this is a well-established practice for consumers (Hounscome et al. 2008). We must now integrate these understandings with the excellent body of GHG emission, water-use and energy use studies that have established data initiated by Nielsen et al. (2003), Wallén et al. (2004) and strengthened by the meta-analysis published by Tilman and Clark (2014). The energy used to supply meals in the test of the *6fm* here is relatively constant because it relates to supply chain resource efficiency where sites of processing and manufacture can optimise resource utilisation. The energy used in food preparation by consumers is highly variable because energy used in preparing meals is rarely measured and managed in the same way as in manufacturing or service environments. This emphasises the requirement to stimulate the use of sustainability assessment in situ, when meals are actually being prepared whether the users are producers, manufacturers, retailers or consumers.

While food waste is not one of the six functions in the *6fm*, it is universally connected to each of them through resource use and an important consideration here is the waste of food by consumers. Consumers' waste food because

- we have too much,
- we do not like,
- we have forgotten about it while it has been stored.

The *6fm* was developed to capture this information so that meals can be designed efficiently for preservation or portion control. A food waste model that utilises preparation data has been developed and the data supporting this model is reported by Martindale (2014b). It considers the use of frozen and fresh foods and shows the use of frozen foods results in less domestic food waste. This study highlights the importance of understanding how meals are prepared because much of the food waste debate has tended to overlook the importance of preparation and preservation in tackling food waste and focus on the problem of food waste rather than the solutions to it. Our future efforts on applying the *6fm* will be in the consumer use environment because ultimately this is where the *6fm* will change food preparation and storage practices that in turn will have positive impacts on security and sustainability.

An important consideration in applying the *6fm* is the relationship it has with other methods of assessing sustainability practice for preparing meals. The dominant methods in this arena are LCA's and these are not necessarily the most practical for informal use because they require in-depth analysis of data quality and processes. However, sustainability criteria associated with foods and meals often

requires us to consider attributes that are not measured by LCA methods, these include food waste, transportation, purchasing frequency, preservation method and so on. The *6fm* provides flexibility to include these attributes and provide a broad measure of sustainability through the sum of the six functions as an index. The sustainability assess arena has established standards such as the Carbon Label and certifications for many different products that develop communication and transparency for the sustainability of the supply chain. The *6fm* is primarily concerned with the use of food by consumers even though the data obtained can be utilised by manufacturers and retailers; and this differentiates the *6fm* from LCA which is designed to be specific. It is important for us to consider how we might link successful brand communication techniques to sustainability communications and the household management of food groups that we consume. The development of such systems that utilise meal groups is already well established with nutritional profiling tools that have been successful at linking food product development with consumer driven nutritional outcomes and meal design (Vlassopoulos et al. 2016). The *6fm* aims to utilise these types of techniques used by nutrient profiling to group meals, but to extend this thinking to a sustainability theme. In maintaining the flexibility and reducing the requirement for detailed investigation in the *6fm* it also exposes the weakness of the *6fm*; that is, the data output will be variable and dependent of the intrinsic knowledge the end-user holds. This caveat in the use of *6fm* also provides a need to introduce learning and self-assessment feedback techniques which are the subject of future development of the model.

The *6fm* approach does relate more closely to the broader established certifications of the food industry in that it has to remain flexible and informal so that it can be used by many different end-users. This approach has been used in general FMCG arenas with the Lifestyle of Health and Sustainability (LOHAS) principles that are used internationally (Lifestyle of Health and Sustainability 2016). They provide a focus on the health of consumers and food consumption using attributes of freshness and dietary standards, as well as sustainability actions that include reaching lower or zero-waste goals. The LOHAS movement has been focussed on the USA marketplace where some 13% of citizens are considered LOHAS consumers, if we consider the European consumer, some 15% fit into the aiming for LOHAS. Indeed, the scorecard approaches used by LOHAS are incorporated into the *6fm* because the scorecard method provides flexibility of use and reduces the requirement for in-depth investigation (Crawford and Scaletta 2006). The LOHAS platform partners with trade organisations and Non-Governmental Organisations (NGOs) so that the actions delivered achieve purchasing awareness across supply chains. The *6fm* differentiates its approach here because it is focussed on how foods are utilised when they are delivered to consumers from the supply chain, this is a particularly important difference because it is consumer focussed and it is not associated with the goal of certification.

The *6fm* moves us towards an important point in the development of sustainability of food FMCG which is to enable consumers to demonstrate what a sustainable meal is using the *6fm* methodology. The *6fm* can be used universally across food and meal groups by all supply chain operators and there is a focus on

consumers when they are considering how to make meals. In conclusion, our goal is to stimulate a transition from ‘LCA-thinking’ to one of ‘consumer experience-thinking’ by 9 billion consumers if we are to develop successful dietary scenarios for meal design and food consumption. A critical future consideration for the *6fm* approach is to understand how it might be delivered and promoted across food supply chains. This requires future investigation into how consumers will utilise the *6fm* methodology and how the data obtained from consumers will be most effectively fed-back into the supply chain in order to stimulate the re-design of sustainable products.

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