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Nutrition – function or impact?

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Abstract

This work provides a conceptual framework to distinguish between two different roles of nutrition in Life Cycle Assessment of foods, namely on the one hand in the functional unit that forms the basis of comparisons of foods, and on the other hand in the calculations of health impacts from ingestion of food products. Satiety is proposed as a central attribute for comparisons of food products, while weighted measures nutrient content are suggested to be largely misplaced as part of the functional unit. In contrast, nutritional measures have a large role to play in assessing the human health impacts of the marginal ingestion of specific food products for the more than half of the global population that lives on an unbalanced diet.

Keywords: *Nutritional quality; functional unit; satiety; dietary risk; health impact.*

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1. Rationale and objective

The purpose of Life Cycle Assessment (LCA) is to compare the environmental impacts of products, in order to support decisions that can lead to a reduction in the overall impacts. The compared products must fulfill the same needs, i.e. have the same functional unit. Environmental impacts include impacts on resources, ecosystems, and human health. While nutrition is one of the obvious functions of food, a diet that is not nutritionally balanced can cause human health impacts. This dual role of nutrition has led to some confusion on how to include nutritional measures in LCA. The purpose of this work is to provide an unambiguous framework for inclusion of nutrition in LCAs of food, clearly distinguishing the role of nutrition in the functional unit and in the impact calculations.

2. Approach and methodology

We review how nutritional aspects have been considered in the functional unit of LCAs of food and compare this to the procedural requirements for ensuring comparability of the functional units. We likewise review the literature on food related health impacts to identify the nutritional measures of food intake that should be included in LCAs of food, in order to provide a systematic, comparative, and holistic assessment of the marginal impact of specific food products on human health.

3. Main results and discussion

3.1 Nutrition as a function

Nutrition can be seen as the "original" biological function of food. With this starting point, many researchers have suggested that nutrient content should be included when determining the functional unit of food. The most simple approaches rely on a single component of nutrition, such as metabolic energy or protein (e.g., Sonesson et al. 2017), while others have suggested more complex weighted measures of qualifying and/or disqualifying nutrients based on pre-existing

nutrition guidelines or recommendations, or dietary patterns that are considered healthy, e.g. the Weighted Nutrient Density Score (WNDS) of Arsenault et al. (2012). Drewnowski & Fulgoni (2008) reviewed a large number of such nutrient profiling models and van Dooren (2016) noted that they all have the same structure and that it was sufficient to include three nutrients, namely total protein, essential fatty acids, and dietary fibre, because these elements correlate significantly with all other essential nutrients. In van Dooren's resulting Nutrient Density Unit, the limiting macronutrients were left out because they can result in negative values, as also pointed out by Heller et al. (2013). A negative functional unit obviously creates a conceptual problem for LCA. This is a sign of the more fundamental problem of seeking to include nutritional health impacts into the functional unit. Bruun Werner et al. (2014) and van Dooren et al. (2017) even go a step further and include the greenhouse gas emissions into an overall "Sustainable Nutrient Rich Food index", thus reflecting a weighted index of global warming and nutritional impacts relative to the energy density of the food products. Since LCA results are normally expressed as impacts per functional unit, the inclusion of the most important impacts in the denominator leaves the question what is then left in the numerator?

For a product property - like nutrition - to be relevant from the perspective of the functional unit, it must be obligatory, i.e. it must be essential for the product to be considered as a relevant alternative by the customers (Weidema 2017). With the exception of "functional foods" and situations where food is insufficiently accessible, presence of specific nutrients does not enter into purchase decisions as properties that should be optimised, but rather as requirements of low content or complete absence of specific undesirable components, such as allergens or certain types of fat. Thus, in general, specific undesirable components may be obligatory properties relevant for the functional unit for specific customer segments, while in general the positive nutrient content is rather a positioning property in line with price, which may place a food product more or less favourable in a comparison, but is not generally relevant as an obligatory product property of food, the presence of which is essential for a specific food to be seen as acceptable alternative by the customers.

However, different food components deliver different degrees of satiety (feeling of fullness). When comparing foods with the same energy content, foods rich in protein and fiber deliver more satiety than carbohydrate rich foods, while sweet-tasting foods and foods rich in fat delivers less satiety (Chambers et al. 2015, Hopkins et al. 2016). Satiety is therefore a central nutritional measure for the functional unit of food products, because it determines how much time will pass before an additional meal or snack will be demanded and/or how much will subsequently be consumed.

Even in situations where food is insufficiently accessible, satiety is a relevant measure to include, considering that the purpose of LCA is to compare the products that are actually being substituted, rather than an idealized, abstract measure that is not possible to take directly into account in the purchase situation.

3.2 Nutrition as a risk factor for human health

A nutritionally balanced diet is a prerequisite for human health. There is a rather large span within which a diet can be regarded as balanced, and within which it will not be possible to discern any health effect of an addition or subtraction of a specific food item. However, for a diet that is already unbalanced, i.e. already providing an increased risk of dietary related diseases, the addition or subtraction of a specific food item will have a marginal influence on this risk, and thus on the potential human health impact – beneficial or detrimental – of the overall diet. Dietary risks from an unbalanced diet is the single most important risk factor for preventable human health impacts causing 9.6% of the 2016 Global Burden of Disease or 229 million Disability-Adjusted Life-Years

annually (Forouzanfar et al. 2016).

More than half of the global population lives on an unbalanced diet (Imamura et al. 2015), more specifically a diet low in fruits, vegetables, whole grains, nuts and seeds, milk, fiber, calcium, polyunsaturated fatty acids, and omega-3 fatty acids or precursors, or high in red meat, processed meat, sugar-sweetened beverages, trans fatty acids, and sodium. Specific thresholds and characterization factors for each of these components are provided in the form of the theoretical minimum risk exposure levels and age-specific risk ratios of the Global Burden of Disease study (Forouzanfar et al. 2016) that also provide data for the current gender-specific exposure levels for each of these risks. There is a general agreement on the thresholds for calcium, fibre, sodium and trans fatty acids, but while the Global Burden of Disease study focus on gross food categories such as fruits, vegetables, whole grains, nuts and seeds, milk, and red meat, the nutrient profiling models reviewed above are generally based on the recommended or maximum daily intake of specific vitamins, trace elements and fatty acids. This higher degree of detail in the nutrient profiling models may be used to give a more differentiated quality score to the individual components of the gross food categories.

For the assessment of the marginal contribution of the intake of individual foods to human health impacts, it is obviously necessary to take into account the large variation in diets between individuals and between specific population groups (Imamura et al. 2015). Most of the nutrient profiling models reviewed above are missing considerations of how individual foods interact with the remaining diet. The approach of Fern et al. (2015) seeks to overcome this by adding a nutrient balance indicator showing the extent to which a food, meal or diet can satisfy the daily requirements for all qualifying nutrients. In line with van Kernebeek et al. (2013), the nutrient balance indicator of Fern et al. (2015) excludes contributions of qualifying nutrients once the requirement for a specific qualifying nutrient is met, thus preventing against inflated values for a food containing abnormally high amounts of one or two individual qualifying nutrients.

For assessments at the level of population averages, it is furthermore necessary to take into account the intake distribution for the specific food over different population groups. Intake of food is part of the use stage of a food LCA, and takes place in the form of either snacking, home cooked meals, restaurant meals, or institutional meals.

4. Conclusion

The answer to the question raised in the title is not an either/or, but rather that nutritional measures enter into both the functional unit in the form of satiety measures and into the calculation of impacts in the form of the marginal influence of the specific food on the human health impact of the overall diet. The Global Burden of Disease study health risks ratios for each qualifying and disqualifying food category or nutrient can provide measures of health impact per food category in each specific dietary context, and may be combined with the nutrient balance indicator to enhance the differentiation at the level of individual foods.

Both satiety and marginal health impacts of food intake are complex mechanisms with a large variation between individuals and population groups. However, this should not be an argument for their exclusion from LCAs of food products, but rather for the inclusion of realistic uncertainty measures for each of the mechanisms involved.

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