A comparative evaluation of the use of a food composition database and nutrition declarations for nutrient profiling

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Summary

Nutrient profiling is used to classify foods according to their nutritional composition for various reasons, including the regulation of food labelling and advertising of foods to children. When applied to a representative sample of foods on the market, nutrient profiling has the potential to also be used to assess and monitor changes in the food market. In this study, we assessed whether data from a food composition database can be used to substitute or supplement data taken from food labels to conduct analyses using nutrient profile models. Study was performed using the Office of Communications (London, United Kingdom) nutrient profile model (Ofcom model), and Food Standards Australia New Zealand (Canberra, Australia) nutrient profile model (FSANZ model). When applying both nutrient profile models to a full sample of foods in various food categories using nutrition composition data from the nutrition declaration or from the food composition database, we observed a moderate to good level of agreement between both classifications. This can be further improved, for example, by excluding some food categories or by using the energy value as an indicator of a specific product's proper match with one in the food composition database.

Keywords

nutrient profile; food composition databases; food supply; food quality; health claims; Slovenia

Nutrient profiling is defined as the science of classifying foods according to their nutritional composition for reasons related to preventing disease and promoting health [1]. Nutrient profiles refer to the nutrient composition of food or diets [2] and are produced by different algorithms (nutrient profile models) that use food composition data [3]. Nutrient profile models can be used to adjust the supply of food, regulate the marketing of foods, and aid consumers in healthy dietary choices [4].

Nutrient profile models vary considerably from each other in their purpose and in the way they are constructed, for example, in the number of categories of food included, the nutrients involved, the reference quantities taken into account, whether they involve scoring or the extent to which they have been validated [5–9]. Over 100 models have been published, although only a few of them have been validated by known methods of validation [10].

Around the world, different public and private institutions employ the nutrient profiling of foods for a variety of purposes including regulating the advertising of food to children and the use of nutrition and health claims on foods [11–13]. To avoid the situation in which such a presentation of foods would mask their overall nutrition composition and confuse consumers when trying to make healthier food choices, the introduction of nutrient profiles was also provided in the European regulation on nutrition and health claims made on foods [14]. However, this part of the legislation has not yet been implemented [15, 16], most likely due to the difficulty of the design process and disagreement on these topics among stakeholders [17, 18].

Nutrition declarations are only compulsory in the European Union (EU) for foods labelled with nutrition or health claims, while for other foods they are voluntary until the end of 2016 [19, 20]. The proportion of foods with labelled nutrition information varies significantly between various

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food categories and even countries [21]. On a number of foods, the key product information needed to apply nutrient profile models is lacking in a significant proportion of foods in the Slovenian market.

When applied to a representative sample of foods available in the marketplace, nutrient profiling could also be very useful for monitoring changes in the food supply. This would not only be useful for public health reasons, but also to assess the impact of regulatory changes. In recent years, regulations have changed in the area of the addition of vitamins, minerals and other substances to foods [22], the use of nutrition and health claims on foods [14] and general food labelling [20]. All those regulations implemented reporting on the development of the food market to assess the need for further changes in food policy.

In line with this, the Slovenian Government funded a research project, which included collection of data on a sample of over 6000 food products available in different grocery stores in the country [23]. However, only about one-third of those foods included a "Group 2" nutrition declaration [24], providing the energy value and the amounts of proteins, carbohydrates, saccharides, fats, saturated fats, dietary fibre and sodium. In addition, many nutrient profile models require composition information that is more detailed than that can be found on a food label. Two possible scenarios emerge when we are considering a study of whether nutrient profile models are useful for analysing the food supply: The easier option would be to include only those foods for which a "Group 2" nutrition declaration is available. Yet, this could bias the results given the chance that only foods labelled with nutrition information are not a representative sample. Such bias is actually quite reasonable as producers of foods with a poor nutritional quality may have intentionally decided not to state the nutrition information on the label. The other option would be to also include those foods for which a nutrition declaration is not available, while estimation of their composition should be sufficient to ensure reliable results when applying nutrient profile models.

Having a sample of several thousand foods available, determining the nutritional composition by laboratory analyses would be a very expensive option. Another option would be to use a food composition database (FCD), but there is a risk of an improper matching of foods, which might result in an unreliable classification of foods when applying nutrient profile models. The main research question in this study was to assess whether data from FCD can be used to substitute or supplement data taken from food labels to conduct analyses using nutrient profile models. For this purpose, we compared the results of nutrient profiling using two sources of nutrition information for each product: one set of data was extracted from food labels, while the second one came from FCD. The Office of Communications (Ofcom, London, United Kingdom) nutrient profile model (Ofcom model) and Food Standards Australia New Zealand (Canberra, Australia) nutrient profile model (FSANZ model) were used.

MATERIALS AND METHODS

Database of food products on the market

The starting point was a database of food products in the Slovenian marketplace. Products were collected within a research project evaluating the use of nutrition and health claims on foods that was previously described [23]. In summary, the sample included all food products in selected food categories that were available in selected grocery stores at the time of sampling. Sampling was done in grocery stores of the three most important retailers with a share of sales exceeding 60% of the national market (one megamarket, two supermarkets and one discounter). The selection of the food categories was made according to Lalor et al. [25], with addition of processed seafood, ready products, vegetable oils, milk and yoghurt imitates, and chewing gums. Altogether, the following food categories were included: milk; yoghurts and fermented milk drinks; cheeses; butter and spreads; other dairy products; eggs; frozen fruits and vegetables; frozen ready products; breakfast cereals; breads and bakery products; biscuits; pasta and rice; fruit juices, nectars and smoothies; soft drinks and waters; teas; peas, beans and lentils; processed meat products; processed seafood; ready products – whole meal; ready products – other; vegetable oils; yoghurt imitates and milk imitates; chewing gums. The sample of foods therefore did not include some food categories, i.e. food supplements, alcoholic drinks, confectionery, unprocessed cereals, snack foods, honey and related products.

The whole sample included 6348 food products, of which 36% had a "Group 2" nutrition declaration [24]. Using a simple randomization across all food categories, we selected at least 5% of products labelled with a "Group 2" nutrition declaration in each food category. In categories where less than 5% of products were labelled with nutrition information, all available products were included. Altogether, 125 foods were selected, representing our final sample. Data extracted from the labels of these products were then used in further analysis (the ND data set – composition data extracted from the nutrition declarations).

Matching of foods available in the market with foods in food composition database

Information about nutrition composition from the nutrition declaration was deleted for all selected products (n = 125) before the product details were provided to a researcher, a food technologist, who had to find a comparable product in FCD. The protocol of this matching was to find comparable food in a Slovenian food composition database using the national OPEN Platform for Clinical Nutrition, which is also included in the EuroFIR database [26, 27]. The OPEN Platform is publicly available as a web application [28] designed for meal planning, and contains the Slovenian food composition database [26] with nutrient levels for major food products. In the data extraction process, the following parameters were extracted: energy value, proteins, carbohydrates, saccharides, fat, saturated fats, dietary fibre, sodium and calcium. The content of fruits, vegetables and nuts in each product was estimated using recommendations of the Nutrient Profiling Technical Guidance [29]; the same estimated content was used in both data sets (ND and FCD).

Nutrient profiling

Nutrient profiling was performed using the following two nutrient profiling schemes.

The first one was the Ofcom model, which is used for regulating the broadcast advertising of foods high in fat, salt and/or saccharides to children in the United Kingdom [29]. This model is a scoring system, which provides a single score for foods or food and drink, respectively, based on their content of both ‘negative’ (energy, saturated fats, saccharides and sodium) and ‘positive’ constituents (fruits, vegetables and nuts, dietary fibre and proteins). The score depends on the actual nutrient composition per 100 g of the evaluated food and allows ‘healthier’ and ‘less healthy’ foods to be differentiated [2, 29, 30].

The second model we used was the FSANZ model, which is a modified version of the Ofcom model and is employed in Australia and New Zealand to regulate the use of health claims on foods [31]. This model calculates a score for foods for three defined categories: (1) beverages; (2) all other food; (3) oils, oil spreads and cheeses with a high calcium value based on the actual nutritional composition per 100 g (100 ml) of food. The final score depends on the baseline points for energy, saturated fatty acid, saccharides and sodium content and modifying points for the percentage of fruits, vegetables and nuts, dietary fibre and protein. The derived score determines whether the evaluated food is eligible to carry a health claim (‘healthier’) or not (‘less healthy’) [2, 31]. These two schemes were selected because both were published and scientifically validated [32–35], defined per 100 g (100 ml) of food, and currently under consideration for possible regulatory use in Slovenia.

The randomized products were evaluated against both nutrient profile models using a set of nutrition composition data extracted from: (a) nutrition declarations on food labels (the ND data set), and (b) a food composition database as described above (the FCD data set). The overall agreement between the nutrient profiling results of both sets was calculated for the two profiling schemes as a percentage agreement, in conjunction with Cohen’s kappa statistic.

In addition, the level of agreement between the Ofcom and FSANZ models in their classification of foods was calculated. For this purpose, only the ND data set was employed. The overall agreement was calculated as the percentage agreement and by using Cohen’s kappa statistic.

Statistical analysis

Statistical analyses were performed using R software version 2.13.0: R Console and R Commander (The R Foundation for Statistical Computing, Vienna, Austria) and Microsoft Excel 2007 (Microsoft, Redmond, Washington, USA). The 95% confidence intervals (CI) were calculated using the modified Wald method [36]. The percentage agreement is a measure of agreement between observers [6, 37]; in our case, this was the percentage of foods for which the two different nutrient profiling systems gave the same classification result. Cohen’s kappa statistic (κ) accounts for the level of agreement that is expected between observers or models by chance [6, 38–40] and was used as a measure of the ‘true’ agreement between the two different nutrient profiling systems. These systems were in complete agreement when $\kappa = 1$, while lower κ values revealed less agreement. We considered $\kappa < 0.2$ as poor agreement, κ from 0.2 to 0.4 as fair agreement, κ from 0.4 to 0.6 as moderate agreement, κ from 0.6 to 0.8 as good agreement, and κ from 0.8 to 1 as very good agreement.

Tab. 1. Results of nutrient profiling using a set of nutrition composition data extracted from the nutrition declaration or food composition database.

Foods data set	Number of foods in set	Ofcom model								FSANZ model							
		'Healthier' using ND			'Healthier' using FCD			Agr [%]	κ	'Healthier' using ND			'Healthier' using FCD			Agr [%]	κ
		n	[%]	*CI* [%]	*n*	[%]	*CI* [%]			*n*	[%]	*CI* [%]	*n*	[%]	*CI* [%]		
Sample A Full sample of foods	125	71	57	48–65	72	58	49–66	82	0.62	81	65	56–73	82	66	57–73	82	0.59
Sample B Exclusion of some food categories	81	53	65	54–75	56	69	58–78	94	0.86	63	78	67–86	66	82	71–89	94	0.81
Sample C Exclusions based on energy value	95	55	58	48–67	56	59	49–68	91	0.81	61	64	54–73	63	66	56–75	89	0.77

'Healthier' using ND – foods classified as 'healthier' using a set of nutrition composition data extracted from their nutrition declaration; 'Healthier' using FCD – foods classified as 'healthier' using a set of nutrition composition data extracted from the food composition database; *n* – number of foods, *CI* – 95% confidence interval; Agr – percentage of agreement: the percentage share of foods in the data set for which the two different nutrient profiling systems (ND, FCD) gave the same classification result; κ – Cohen's kappa coefficient; Sample A – full sample of 125 food products; Sample B – the set of foods with the exclusion of the following categories: frozen ready products, processed meat products, processed seafood, ready meals and products, biscuits, soft drinks, breads and bakery products; Sample C – the set of foods with the exclusion of specific food products, where the difference in the energy value between the ND and FCD data sets exceeded 200 kJ/100 g.

RESULTS AND DISCUSSION

When we applied the Ofcom model to the full sample of 125 foods using nutrition composition data extracted from either the nutrition declaration (the ND data set) or the food composition database (the FCD data set), 71 (57%; 95% confidence interval *CI:* 48–65%) and 72 (58%; *CI*: 49–66%) foods were classified as 'healthier', respectively (Tab. 1). A different product classification was observed for 23 products, resulting in 82% agreement between both classifications. The observed Cohen kappa coefficient of 0.62 indicated good agreement.

When the FSANZ model was applied, 81 (65%; *CI*: 56–73%) and 82 (66%; *CI:* 57–73%) foods were classified as 'healthier' using the ND and FCD data sets, respectively (Tab. 1). For 82% of the products, both classification systems (using the ND and FCD data) gave the same classification result; Cohen's kappa coefficient of 0.59 showed moderate agreement.

These results show that while the use of FCD for the extraction of nutrition composition data enabled very reliable estimations of the percentage of 'healthier' products within the full set of foods, the classifications of specific foods were less reliable and resulted in 18% mis-classifications. The reason for the excellent agreement, when looking at the full sample of foods, was that about half of the mis-classifications were from 'healthier' to 'less healthy', while the other half were contrary, compensating the positive and negative errors.

Further, we checked the level of agreement of both classification systems (ND vs FCD data sets) within different food categories. Using the FSANZ model, we established that the percentage of agreement was below 80% in the following food categories: frozen ready products (40% agreement), processed meat products (50%), processed seafood (50%), ready meals and products (50%), biscuits (67%), soft drinks (75%), and breads and bakery products (71%). Although the limited number of samples per food category did not enable us to make significant comparisons between food categories, it should be noted that, in those food categories, we also experienced the greatest difficulties in matching specific products with FCD. We therefore constructed an experimental sample of foods with the exclusion of foods in the mentioned categories (sample B, $n = 81$; Tab. 1) and used it to calculate the agreement of both classification systems (ND vs FCD data sets). When the Ofcom model was applied, 65% and 69% of foods were classified as 'healthier' using the ND and FCD data sets, respectively; the

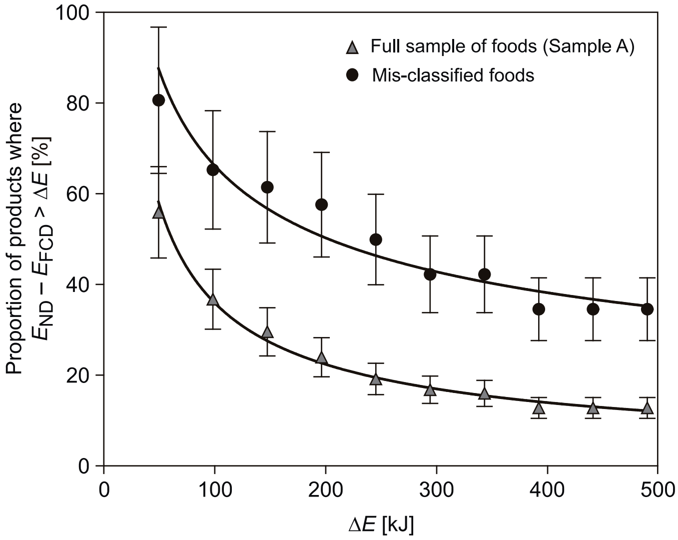

Fig. 1. The proportion of mis-classified products by the Ofcom and FSANZ models in relation to the difference in energy value between nutrition declaration and food composition database data sets.

ΔE – difference in energy value between nutrition declaration and food composition database data sets (expressed in kilojouls per 100 g of product), E_{ND} – energy value from nutrition declaration, E_{FCD} – energy value from food composition database.

level of agreement between both classifications improved from 82% (the full sample of foods) to 94% (the sample of selected foods). Similarly, Cohen's kappa coefficient increased from 0.62 to 0.86, showing very good agreement in the sample of selected foods. Very similar results were observed when the FSANZ model was employed (Tab. 1).

To better understand the reasons for the mis-classifications, we checked the differences in the energy value of products in both data sets (ND, FCD). In the whole sample of foods (n = 125), there were 30 products (24%, *CI*: 17–23%) where the difference in energy value between the ND and FCD data exceeded 200 kJ/100 g (Fig. 1). In the sample of foods mis-classified by the Ofcom and/or FSANZ model (n = 26), the proportion of such foods was significantly higher (58%; *CI*: 39–74%), showing that energy value could represent a valuable indicator of the proper matching of a specific product with one in the food composition database. This holds a very practical value in cases where the food label contains limited nutrition information. For example, while only 36% of investigated foods in Slovenia provide "Group 2" nutrition information on the label, the energy value is available for 66% of products [23].

In the next phase of the analyses, we tested whether the agreement of the nutrient profiling using the ND and FCD data sets could be improved in practice, if the difference in energy values between both data sets was used as an indicator of a poor match and as a possible exclusion criterion. By excluding products where the difference in the energy value between both data sets exceeded 200 kJ/100 g (n = 30) from the whole sample of foods, we constructed Sample C (n = 95), which was then used for further classifications (Tab. 1). When the Ofcom and FSANZ models were applied using the ND and FCD data sets, 91% (κ = 0.81) and 89% (κ = 0.77) agreement was observed, respectively. Interestingly, the introduction of the stricter exclusion criteria did not improve the level of agreement. When we excluded 46 foods where the difference in energy value between both data sets exceeded 100 kJ/100 g (n = 79), the observed agreement remained almost unchanged: 91% (κ = 0.82) for the Ofcom model and 89% (κ = 0.77) for the FSANZ model.

Having a representative set of foods available, we also calculated the agreement of the Ofcom and FSANZ models in the classification of the foods. Using the full sample of 125 foods and the ND data set, we found that 115 products (92%, *CI*: 86–95%) were classified in the same way ('healthier'/'less healthy') by the Ofcom and FSANZ models; Cohen's kappa coefficient of 0.83 showed very good agreement between the models. The percentage of 'healthy' foods was a bit higher with the FSANZ (65%; *CI*: 56–73%) than with the Ofcom (57%; *CI*: 48–65%) model; the difference can be attributed to differences in the classification of foods in the categories of cheeses, vegetable oils, butter and spreads. This was expected as the FSANZ model classifies oils, oil spreads and cheeses with a higher calcium value with less strict criteria than the Ofcom model.

A limitation of our study was that the comparison was made using the nutritional composition information labelled on food labels, and not by using laboratory analyses. In practice, the declared values of the nutritional composition of foods shall be based on: (a) manufacturer's analysis of the food; (b) calculation based on the known or actual average values of the ingredients used; or (c) calculation based on generally established and accepted data [20]. We considered those values as valid.

CONCLUSIONS

Using a sample of foods available in the Slovenian marketplace and employing the Ofcom or FSANZ models, we studied the agreement between the classification of products using nutrition composition data from the food label or from the food composition database. Use of the FCD data changed the Ofcom/FSANZ classification for 18% (*CI*: 13–26%) of the products, mostly in the categories of processed meat products, processed seafood, ready meals, biscuits, breads and bakery products, and soft drinks. In those food categories, the name of the product and the other labelling information did not provide enough information to match a food with FCD or to predict the nutrition composition if a specific product was not included in FCD.

The results of our study show that data from a food composition database can be used to substitute/supplement data taken from food labels to conduct analyses using the two tested nutrient profile models, at least for products in some food categories. We also showed that energy value may be a valuable indicator supporting the proper matching of specific food products with those in FCD. Since food composition databases include a limited selection of foods and, in some cases, proper matching is simply impossible, the use of different FCDs could importantly affect the accuracy when predicting the nutritional composition of foods. In cases where it is not possible to match specific food products with those in FCD, alternative sources of information on nutritional composition could provide more reliable information, for example the webpages of food producers.

These results importantly contribute to knowledge on the nutrient profiling of foods. Future studies should also focus on comparison between different food categories, and the applicability of different food composition databases and other possible sources of nutrition information. The applicability of nutrient profile models for analysing the food supply should be also investigated.

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