

Review Article

Assessment of nutritional profiles: a novel system based on a comprehensive approach

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The prevalence of non-communicable diseases (for example, cardiovascular disorders, type 2 diabetes and cancer) is rampant in Western societies, accounting for approximately 60% of all causes of death. A large proportion of non-communicable diseases can be prevented through appropriate diets and lifestyles. Accordingly, several health authorities and regulatory bodies are assessing the nutritional profiles of food items and whole diets, to implement guidelines aimed at improving the diet of the general population. While a global approach is desirable, the need of individuals to maintain their distinct dietary habits must also be taken into account. The portion sizes of food as well as pattern of food consumption, for example during or between the main meals, are very important in determining the nutritional profile of a diet. A novel method to assess the nutritional profile of foods is being proposed and made available on-line. Its main innovative aspects are (1) the comprehensive manner with which the system analyses and computes a great range of features of individual food items and (2) the distinction among eating occasions, namely during or in-between the main meals. Moreover, this approach allows for rapid modification and great flexibility to suit individual needs and gastronomic habits.

Nutritional profiles: Disease prevention: Dietary modification: Eating behaviour

The prevalence of non-communicable diseases (for example, cerebro- and cardiovascular disorders, type 2 diabetes and cancer) is rampant in Western societies, accounting for an estimated 60% of all causes of death. The WHO underlines the causal correlation between lifestyles, nutrition and incidence of non-communicable diseases⁽¹⁾. Diets and their individual components also play a major role in the development and/or prevention of other diseases such as dental caries and osteoporosis⁽²⁾, as well as complications associated with ageing^(3,4).

The current worldwide epidemic of obesity, termed 'globesity' by Deitel⁽⁵⁾, which is largely due to improper diet and lifestyles, is driving health authorities toward adoption of preventive measures that would slow or regress this trend. Even though malnutrition and obesity often now both occur within the same countries, the global incidence of the latter is currently higher than that of the former⁽⁶⁾.

The short-term results of government-driven campaigns for proper nutrition and adequate energy intake have been modest. Along these lines, the European Health and Consumer

Protection Directorate (DG-SANCO) has produced during the past 5 years some regulatory guidelines on health claims and nutritional profiles (for example, Scientific advice on the setting of nutrient profiles, regulation 1924/2006⁽⁷⁾). This regulation is to be placed within the wider framework 'Food for Life'⁽⁸⁾, which is being compiled on the basis of a wide body of research, including 'PASSCLAIM'⁽⁹⁾. The development of this framework is still in progress, but it represents the platform on which political and scientific discussion is being developed. All European Union members are obliged to use this platform to develop processes and intervention with mutual goals, even though the applications will be outsourced to individual countries.

The nutritional profile concept

According to the FAO/WHO *Framework for the Provision of Scientific Evidence on Food Safety and Nutrition*, any scientific advice is described as '... the conclusion of a skilled evaluation

Abbreviations: BMEE, between meals eating episodes; FSA, Food Standards Agency; GI, glycaemic index.

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taking account of scientific evidence, including uncertainties⁽¹⁰⁾. Hence, any definition of nutritional profile should be based on this proposition. Currently, there are no internationally approved models for deriving nutritional profiles and even the USA, where a long-standing regulation of nutritional and health claims is in place, adopts a very pragmatic model that is not transferable to other countries⁽¹¹⁾. Europe has chosen a novel and independent approach, with the European Food Safety Authority in the leading role of scientific watchdog. The official European Union definition of nutritional profiles is very detailed⁽⁷⁾, and different approaches to its implementation have been independently tested in individual countries. On one hand, this multitude of viewpoints has fostered debate on the application of the nutritional profile concept^(12–14). However, different implementation politics often conveyed a perception of non-homogeneity and of unsound scientific bases⁽¹⁵⁾. This untoward outcome is the natural consequence of the extremely varied culinary habits of European Union members. A simple, empirical comparison between the food cultures of, for example, Scandinavia, France, and the Mediterranean countries suggests that the adoption of a single, fit-all guideline is not feasible.

The Food Standards Agency model

To date, more than twenty approaches to a standard nutritional profile have been described; however, the ultimate goal is to come up with an integrated nutritional profile of all food items. Yet the current lack of consensus makes it difficult for health authorities to reach their aim of reducing the incidence of non-communicable diseases via proper diets.

The UK Food Standards Agency (FSA) is the regulatory body most active in the development of a reliable nutrition profile model. In 2005, the FSA conclusions were published⁽¹⁶⁾: a system based on scores has been developed where scores are assigned on the grounds of the nutritional content of a food item or a beverage (per 100 g).

The FSA system is based on two sequential scoring classifications, with the overall nutritional profile score calculated from the two scoring levels as follows: (1) 'A' points = points for energy (range < 335 to > 3015 kJ) + points for saturated fats (range < 1 to > 9 g) + points for sugars (range < 4.5 to > 40 g) + points for Na (range < 90 to > 810 mg). A maximum of 10 points can be attributed to each nutrient in the 'A' points category. A food or drink scoring 11 or more 'A' points cannot gain further points from proteins, unless it also scores five points for fruits, vegetables, and nuts; (2) 'C' points = points for fruits, vegetables and nuts + points for fibre⁽¹⁷⁾ + points for protein.

A maximum of five points can be attributed to each nutrient or food component in the 'C' points category: the higher the score, the higher the nutritional profile of the food under scrutiny.

If a food scores less than 11 'A' points, the overall score is calculated as follows: (total 'A' points) minus (total 'C' points). A food is classified 'less healthy' when it scores 4 points or more. A drink is classified 'less healthy' where it scores 1 point or more.

Beneficial as well as non-beneficial nutrients (i.e. those evaluated as public priorities by the authors) are included in order to ensure that advertising of food such as fruit and

low-fat dairy products is not affected. Nutrients are assessed on a per 100 g basis to define and limit the multifaceted issue of recommended portion size. It has been suggested that tighter broadcast advertising rules could be applied to products categorised as 'less healthy'.

In the system proposed by the FSA, each point attributed to individual nutrients corresponds to 3.75 % of the values published by the UK guideline 'Daily Amount or Dietary Reference', as defined by the Committee on Medical Aspects of Food Policy (COMA)⁽¹⁸⁾, UK Department of Health⁽¹⁹⁾ and the Scientific Advisory Committee on Nutrition (SACN)⁽²⁰⁾. The reason for the selection of a 3.75 % factor is not entirely clear, but the cut-off that builds the three categories was defined according to the best method to classify foods in use today⁽²¹⁾. Overall scores are restricted to a maximum of 37.5 % of guideline daily amounts or daily reference value for unhealthy nutrients (a maximum of 10 points for each criterion) and 18.7 % for healthful nutrients (maximum of 5 points for each criterion). The system was tested and validated by sending on-line questionnaires to numerous nutrition professionals.

A rapid comparison with four other systems currently being evaluated (the American Heart Association Diet and Lifestyle Recommendations⁽²²⁾; Canada's food guide⁽²³⁾; Tripartite⁽²⁴⁾; Center for Science in the Public Interest's Guidelines⁽²⁵⁾) reveals several inconsistencies between the systems. For example, currants (black, red) rank low in the FSA and Tripartite models, but are classified as healthful according to the other three classifications. Different results are obtained when the same group of food items is tested using the five schemes of nutritional profiles. Indeed, only 53 % of all products share the same categorisation. When considered individually, all of the systems proposed to date are far from being flawless and from representing a universal approach to nutritional profiling.

A novel method to assess nutritional profiles

A universal approach to nutritional profiling – one that takes into account the culinary habits of individual countries, but suits the global population – has to take into account data published by the FAO, in particular its food balance sheets⁽²⁶⁾, the FAO being an agency that represents all countries. An ideal food-profiling method should be (1) based on solid scientific data, (2) applicable to different socio-economic contexts, (3) inclusive of all food items, (4) easy to use, (5) flexible and adaptable to new scientific discoveries, and (6) able to provide guidelines that are easily understandable by consumers, at the same time leaving a large freedom of choice.

Accordingly, a novel approach to nutritional profiles is being proposed in the present report (www.foodprofile.org), based on the following conditions: (1) there are no 'good' or 'bad' foods when the overall energetic balance is computed; (2) the profiles should be universally applicable, but framed within the average European food culture; (3) both macro- and micronutrients are being taken into account; (4) portion size is an important contributor to the evaluation criteria; (5) innovation is rewarded; (6) an 'informatics'-based system to be used that is easily accessible, simplifies calculations and simulations, and can be easily updated.

The starting point of this novel approach lies on the basis provided by the FSA's nutritional profiling system. Nutrients

in block 'A' build the foundation. However, these items are placed within a context of either meals or 'between meals eating episodes' (BMEE), i.e. food consumption that occurs outside of the main meals. The latter, particularly in young people, plays an increasingly important role in providing energy (up to 30 % of the daily energy intake) and micronutrients (up to 50 % of the daily intake)⁽²⁷⁾.

The novel system being proposed integrates differences among many cultures and eating habits of various countries. The two main meals, because of their energy load (estimated at 30–40 % each of the overall energy intake) and to their complex structure, need to be based on a broad foundation. With this in mind, the FSA parameters appear to be adequate to reach this goal. Moreover, a system which analyses the major portion of the energy intake and which chiefly takes into account energy, saturated and *trans*-fatty acids, cholesterol and Na covers most of the nutritional topics from the public health perspective. However, the 'ideal' system should also take into account breakfast and, most of all, BMEE, which are increasingly becoming part of the European dietetic behaviour.

The novel system employs scores that range from 0 to 10. In particular, a score from 0 to 3.33 indicates a low nutritional value, a score from 3.34 to 6.66 indicates a medium nutritional value, and a score from 6.67 to 10 indicates a high nutritional value.

The main criteria on which the novel system is based are the following.

Energy

Energy density is paramount in the evaluation of a food item's nutritional profile. In agreement with the FSA, a score attributing the highest ranking to the least-energy-dense item has been implemented, via a regression curve.

Portion size

Portion size significantly determines whole energy intake. Though obvious, this concept is often neglected. Hence, the novel system attributes a relevant role to portion size in the overall assessment of a nutritional profile.

Breakfast

Scientific and regulatory bodies often underline the importance of consuming approximately 15–20 % of daily energy at breakfast. Indeed, subjects who skip breakfast, especially children, are at higher risk of obesity⁽²⁸⁾ and might be exposed to an imbalance of their macro- and micronutrient intake. The novel system presupposes an average intake of 1676 kJ among various age groups (> 6 years old). To allow for flexibility, the following approach is being proposed: portions and their energy load are the primary discriminants in the evaluation of breakfast food items. Two parameters can be taken into consideration to appraise the inclusion of a food item into breakfast and to integrate it into the simulation, namely 50 % and 33–66 % of breakfast energy (model 1 and model 2, respectively). This double proposal is linked to the heterogeneity of foods and habits. Both models allow for flexibility and dietetic combinations. Accordingly, the higher the flexibility of an individual food item, the higher its score

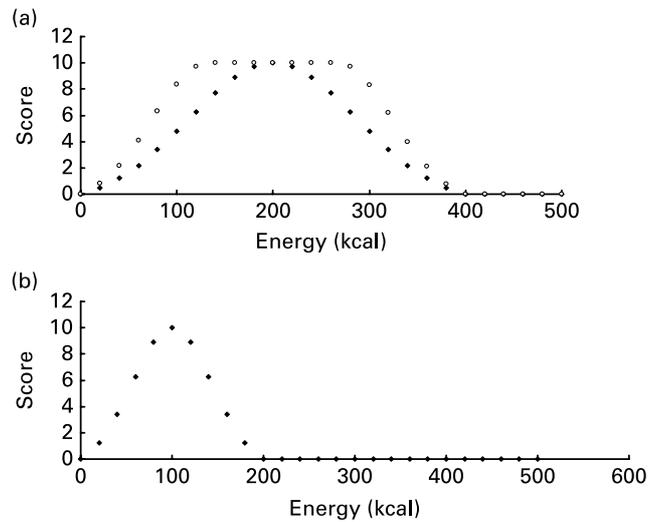


Fig. 1. (a) Scores attributed to breakfast and (b) between meals eating episodes, according to portion sizes. (◆), Model 1; (○), model 2.

(and vice versa). The calculations are based on a Gaussian distribution of the energy provided as shown in Fig. 1 (a).

Between meals eating episodes

Other eating opportunities such as mid-morning and mid-afternoon snacks are computed by following the same line of reasoning to that applied for breakfast, but their maximal energy load has been established as 838 kJ. Consequently, the zenith of the Gaussian curve is reached by portions of 419 kJ, in order to maximise flexibility in terms of both energy intake and dietary diversity.

Noticeably, the system favours portion sizes that by default do not constraint the main meals and is in line with the wider aim of favouring food items with low- to moderate-energy loads. Such recommendations regarding food size are in agreement with those of the DG-SANCO (see above) and with data from the literature that indicate energy loads as the main determinants of obesity⁽²⁹⁾. The calculations are based on a Gaussian distribution of the energy provided as shown in Fig. 1 (b).

Carbohydrates, sugars, total and saturated fat, proteins

Most of the nutritional scores that the new system attributes to macronutrients utilise the parameters published by FAO/WHO, which are elaborated by using a Gaussian approach that assigns the highest score to foodstuffs falling into these categories. The Gaussian approach is corroborated by the fact that food items gradually move away from the ideal, theoretical value. At the same time, this methodology maintains the uniqueness of each product and leaves industry and consumers free to produce and consume, respectively.

Trans fat

Consumption of *trans*-fatty acids (at least of those of non-animal origin) is associated with an increased incidence of degenerative diseases such as atherosclerosis⁽³⁰⁾. Accordingly, a maximal threshold of < 1 % has been chosen to allow their substitution with other lipids. Moreover, the < 1 % threshold

is in agreement with the Agence Française de Sécurité Sanitaire des Aliments (AFFSA) document published in April 2005⁽²³⁾.

Fibre

The need to increase fibre intake, at least in the Western world, is often emphasised⁽³¹⁾. However, in agreement with the European directives, nutritional claims can be made according to fibre content; hence, the fibre-related score increases proportionally to its content in foodstuffs up to a maximal value of 6 g, above which further increments do not result in higher scores.

Glycaemic index

One of the major contributors to nutritional imbalances is the introduction of refined foods, namely carbohydrates, in the Western diet. Indeed, most nutritionists and regulatory bodies, for example, the WHO/FAO suggest the use of complex carbohydrates instead of simple sugars⁽³²⁾. In addition, a wide body of recent research indicates that, in addition to quantity, the quality and the speed of digestion and absorption of carbohydrates is a primary determinant of the physiological response to their absorption. Accordingly, diets with a low glycaemic index (GI) help maintain glycaemia by reducing postprandial glucose and insulin responses and are associated with a reduced risk of CHD. For these reasons, the GI is a useful marker of the nutritional attribute of carbohydrates. The proposed system favours low-GI carbohydrates through an arithmetic function that integrates, in a curve, values from 1 to 100. The maximal score of 10 is attributed to food items with negligible glycaemic impact, whereas a score of 5 is accredited to foods with a medium, i.e. ≥ 50 , GI. Finally, foodstuffs with GI = 100 are given a score of 0.

Sodium

A goal shared by many dietary guidelines is that of reducing the daily intake of Na to 5–7 g, since Na significantly affects blood pressure above these consumption levels, with subsequent detrimental consequences on cardiovascular risk⁽³³⁾. Na is attributed a score that approximates to the FSA's nutritional profiles, by using a linear regression which attributes the highest grade to low Na concentrations and vice versa.

Fruits and vegetables

There is a worldwide agreement on the need to increase consumption of fruits and vegetables. In particular, the daily intake of vegetables should not be lower than 400 g and that of fruits should reach 200 g⁽³⁴⁾. Nuts and seeds, as a result of their high content of MUFA and PUFA and micronutrients, fall within the fruit and vegetable category. The score attributed by the novel method to fruit and vegetables approximates that of the FSA.

Vitamins and minerals

An often-neglected part of food items is their content of micronutrients, namely vitamins and minerals. Often, industrial processes reduce the content of vitamins and alter that of minerals. To foster the establishment of milder treatments that maintain most of the vitamin and mineral content of foodstuffs, the method described herein evaluates their concentrations. This inclusion is indeed important from a nutritional point of view, given the increasing inadequacy of Western diets in this regard^(3,35).

Micronutrients that contribute to the quality of food must be included in its nutritional analysis. Therefore, as a function of the amount of vitamins and minerals that exceed 15% of the RDA (thus declarable on the product label; directive 2002/46/EC of the European Parliament and of the Council⁽³⁶⁾), a positive, add-on score that increases with the number of vitamins and minerals accounted for has been assigned as a maximal of +0.5 each for vitamins and minerals at $> 15\%$ RDA.

Carbohydrates and fats combined

These derived parameters summarise, in single indices, both the quantities and the qualities of carbohydrates and fats, by computing, respectively, the average scores of total carbohydrates and simple sugars and their GI and the amount of total fat, simultaneously taking into consideration the proportion of saturates and *trans*-fatty acids.

Macronutrients combined

This parameter condenses, in a single score, the whole nutritional features of a food item, by considering both the quantities and the qualities of all of its macronutrients. In particular, this parameter averages the mean scores of proteins, carbohydrates (including their GI), fats (including their kinds) and fibre.

Evaluation of the nutritional profile

The nutritional profiles of main meals are processed similarly to the method described by the FSA, whereas calculations for BMEE have been modified according to their lower energy load. This novel system takes into account all of the composite variables of a food item, in terms of both macro- and micronutrients, and evaluates from 1 to 10 the adherence of a product to international guidelines for a healthful diet. The system provides different evaluation criteria according to different scientific rationales and allows for simulations of various compositions; hence, the assessment of the impact of potential modifications on the final outcome is feasible.

Results generated from the potential models of nutritional profile of four example foods are shown in Table 1 using the following novel systems; flow diagrams illustrating the key steps in the computational pathway are shown.

Food Standards Agency: nutritional profile according to the parameters of the Food Standards Agency. The system averages the scores of total energy, saturated fats, simple sugars, Na, fruits, and vegetables (Fig. 2).

Table 1. An example of nutritional profiles generated by the proposed, novel system, by computing four paradigmatic food items*†

	Apple	Rice salad	Whole milk	Canned tuna
FSA	-5	4	1	2
FSA modified	7.08	4.2	3.73	3.82
FSA Q&Q	7.93	5.01	5.48	3.95
Portioning 200 + add-on	8.17	4.35	5.68	4.47
Energy score	9.43	7.65	9.2	7.6
Portioned energy score	8.4	3.8	9.58	8.5
Energy portioning BMEE score	7.4	0	10	9.4
Macronutrient score	2.31	5.16	3.28	1.7
Proteins score	0.61	9.31	6.65	0
Fats Q&Q score	4.6	3	3.66	4.3
Total fats score	1.2	0.9	2.3	3.6
Fat quality score	8	5.2	5	5
Carbohydrates Q&Q score	0.7	6.2	2.81	2.5
Carbohydrates score	1.4	6.7	5.6	5
Sugar score	0	5.7	0	0
Fibres score	3.33	2.17	0	0
Fruit and vegetable score	10	2	0	0
Na score	9.98	5.23	9.45	6.49
Add-on	(+)0.5	(+)0.3	(+)0.1	(+)0.3

FSA, UK Food Standards Agency; Q&Q, Quantity and Quality, BMEE, between meals eating episodes.

* FSA system thresholds: < 4, more healthy; > 4, less healthy.

† New system thresholds: 0–3.33, low nutritional value; 3.34–6.66, medium nutritional value; 6.67–10, high nutritional value.

Food Standards Agency Quantity and Quality: nutritional profile according to the parameters of the Food Standards Agency, but modified by computing the whole macronutrient profile. The system averages the scores of total energy, Na, fruits, vegetables, and macronutrients. Furthermore, the macronutrient score is an average of protein, fibre, lipids (the mean value of total and saturated fats), and carbohydrates (the mean value of total and simple sugars) (Fig. 3).

Portioning 200: nutritional profile that takes into account macronutrients and the portioning and energy load of between meals eating episodes. The system averages the scores of portioned energy (mean between energy and portion for a BMEE snack), Na, fruits and vegetables, and macronutrients. The macronutrient score is obtained by averaging the results of protein, fibre, lipids (mean of total and saturated fats), and carbohydrates (mean of total and simple sugars).

Portioning 400: nutritional profile that takes into account macronutrients and the portioning and energy load of breakfast. The system averages the scores of portioned energy (mean value of energy and portion for breakfast), Na, fruits and vegetables, and macronutrients. The macronutrient score is obtained by averaging the results of protein, fibre, lipids (mean value of total and saturated fats), and carbohydrates (mean value of total and simple sugars).

Portioning 200 + add-on: nutritional profile that takes into account macro- and micronutrients and the portioning and energy load of between meals eating episodes. Calculations

are identical to those of Portioning 200, with the exception that the final score includes a sum of micronutrients' parameters (Fig. 4).

Portioning 400 + add-on: nutritional profile that takes into account macro- and micronutrients and the portioning and energy load of breakfast. Calculations are identical to those of Portioning 400, with the exception that the final score includes a sum of micronutrient parameters.

Portioning 200 + add-on (glycaemic index): nutritional profile that takes into account macro- and micronutrients, the glycaemic index, and the portioning and energy load of between meals eating episodes. Calculations are identical to those of Portioning 200, with the exception that the final score includes a sum of micronutrient parameters and that the simple sugar score is replaced by the GI.

Portioning 400 + add-on (glycaemic index): nutritional profile that takes into account macro- and micronutrients, the glycaemic index, and the portioning and energy load of breakfast. Calculations are identical to those of Portioning 400, with the exception that the final score includes a sum of micronutrient parameters and that the simple sugar score is replaced by the GI.

Conclusions

The novel system is fully available at www.foodprofile.org, where calculations of nutritional profiles can be made via an

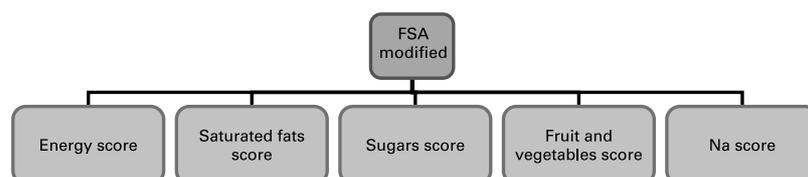


Fig. 2. Nutritional profile according to the parameters of the Food Standards Agency (FSA), as modified by the novel system. The system averages the scores of total energy, saturated fats, simple sugars, Na, fruits, and vegetables.

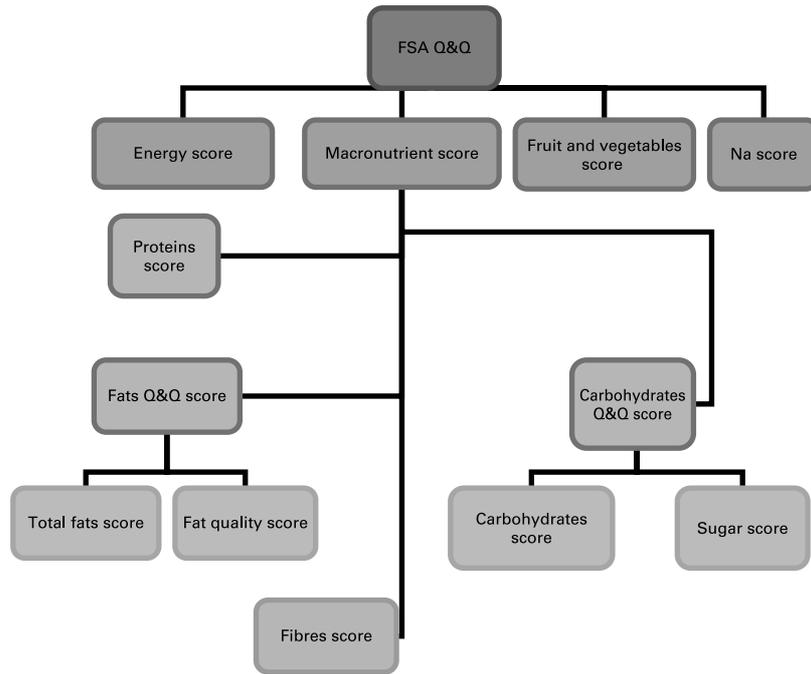


Fig. 3. Nutritional profile according to the parameters of the Food Standards Agency (FSA), but modified by computing the whole macronutrient profile. Q & Q, Quantity and Quality.

information technology platform. Its principal innovative aspects are (1) the comprehensive accuracy with which the system analyses and computes the impact of a wide range of components of individual food items and (2) the distinction among eating occasions, namely main meals and BMEE.

Moreover, this approach allows for rapid modification and great flexibility to suit individual needs and gastronomic habits. The former consideration is important for industrial innovation, because simulations of different food compositions can be easily performed on-line, hence driving the

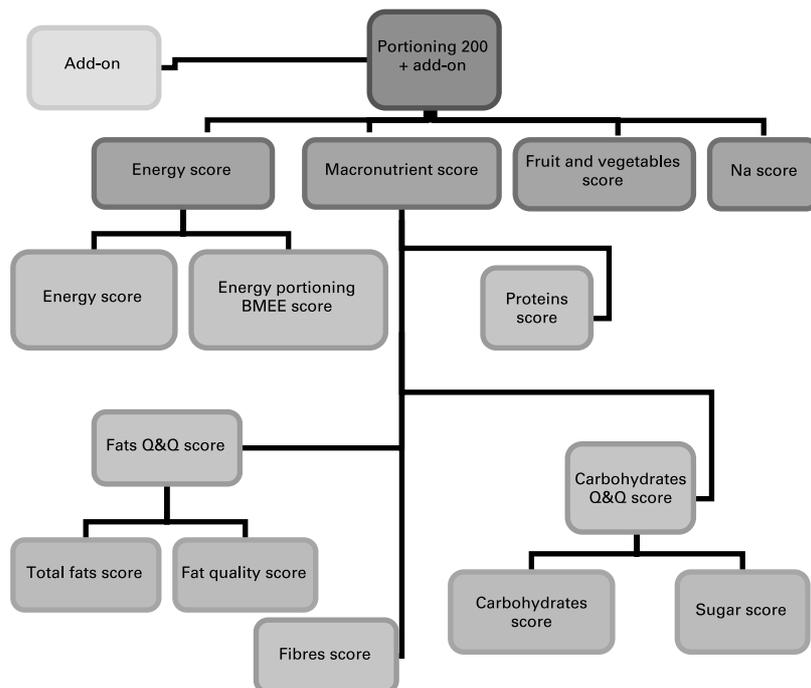


Fig. 4. Nutritional profile that takes into account macro- and micronutrients and the portioning and energy load of between meals eating episodes (BMEE) of 838 kJ. Q & Q, Quantity and Quality.

development of new foods and their manufacturing. Concerning the latter, the distinction between main meals and BMEE, along with the detailed analysis of macro- and micronutrients, relieve some of the constraints that consumers perceive during deliberations on their nutrition and health. As the system is easily exploitable and available to the general public and professionals, implementations are expected in the near future.

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Conflict of Interest

The authors have no conflicts of interest to report.

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