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POSITION PAPER ON FRONT-OF-PACK LABELS: “directive” versus “informative” approaches

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Summary

1
2 Front-of-pack labels (FOPL) aim at communicating to consumers the health value of food items in
3 support of public health policies. Two main types can be discerned: “directive and semi-directive” FOPL
4 using colour schemes (e.g., Nutri-Score) and “informative” FOPL (e.g., Nutrinform Battery). “Directive”
5 approaches tend to show a “wear out effect” and, in addition, they suffer from various underlying
6 conceptual problems. Usually, their nutritional scores are calculated using changing, arbitrary
7 algorithms and involve a reductionist set of parameters of debateable validity. Thus, they overstate
8 the effects of selected nutritional factors, such as saturated fat and energy, while overlooking the food
9 matrix and the more holistic aspects of nourishment. Moreover, they do not reflect the portion that is
10 actually consumed, ignore the preparation steps at home, and fail to serve as a useful basis for
11 composing a healthy diet. Also, so long as the nutritional formulations match the algorithmic
12 standards, they tend to allow ultra-processed products. Altogether this might confuse and mislead
13 consumers. Overconfidence in “green”-coloured labels could even result in unbalanced dietary
14 choices, whereas avoidance of “red” products may eliminate certain foods from the diet that are rich
15 in essential nutrients (e.g., cheese), leading to opposite results than aimed for. The latter is particular
16 relevant to vulnerable populations, such as the young, pregnant women, and older adults, or for
17 individuals with specific needs. Taken together, “directive” FOPL such as Nutri-Score contradict the
18 declared intent of the European Commission to empower consumers to undertake healthy and
19 balanced diets based on easy accessible and robust information. Although “informative” systems
20 usually also keep the focus on a few selected nutritional parameters, they have the merit of being less
21 paternalizing and obviate the need to classify foods as “healthy” or “unhealthy”. They also focus their
22 attention on the individual portions that are consumed (even if the definition of portion size remains
23 contentious). Given the importance of dietary patterns, rather than individual foods or nutrients,
24 “directive” FOPL of the Nutri-Score type represent a regretful case of “nutritionism”. Finally, attempts
25 to associate the adoption of a FOPL with an improvement in the health status are few and mainly
26 applied in virtual settings; none of which are longitudinal nor have they been able to identify a causal
27 link.
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38 **Key words** front-of-pack labelling (FOPL), NutriInform Battery, Nutri-Score, eating pattern, nutrient
39 composition, nutrition information, overall balanced diet
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1. Introduction

The prevalence of obesity and non-communicable diseases (NCD), such as cardiovascular diseases, cancer, chronic respiratory diseases, and type-2 diabetes, is increasing with a significant impact on morbidity, mortality, and quality of life (Bracale R et al, 2013; Popkin BM et al, 2020). Eating habits, as an important aspect of overall lifestyle, play a major role in this development (Smethers AD et al, 2018). Providing information to consumers on what constitutes healthy eating has therefore the potential to impact positively on dietary habits (Fruhbeck G et al 2016; Carruba MO et al, 2021), an opinion which has been endorsed by both the European Commission (art.35 of Regulation No 1169/2011) and the United Nations (art. 34 of the Political Declaration of the Summit of the Heads of State and Government of 09/27/2016, adopted by the UN General Assembly on 10 October 2018).

Prior strategies, which were based on “back of pack labels” (BOPL), unfortunately did not succeed in that mission, with public health policies increasingly finding themselves in dire straits due to the worsening situation of community health, especially regarding the continuing increase in NCDs. Therefore, the European Commission decided in 2011 to adopt a simpler procedure, but this time based on front-of-back labels (FOPL). The purpose of the latter strategy was to inform consumers more clearly, while also having an "educational" function.

FOPLs can be distinguished according to the complexity of the information that is provided (e.g., displaying nutrient-specific information or declaring a global judgement on the whole product), as well as their “directionality” (e.g., the kind of steering or evaluative message with regard to healthiness) (Muzzioli L et al, 2022). On these bases, they can be categorized as follows (Table 1):

- Informative “non-directive” labels that provide information such as the name of nutrients included, their amount in grams, and their percentage in relation to total daily needs and allowances (e.g., Nutrinform Battery)
- “Semi-directive” labels that do not only provide nutritional information but are also completed by an evaluative element such as a color, a word, or a sign that gives additional information on the healthiness level of the single nutrients, thereby emphasizing them [e.g., the English traffic light or *Multiple Traffic Light* (MTL) and Warning Signs which may feature the octagon “stop” or the words “rich in” or the Israeli system of red pictures for excess salt, fat or sugar and positive green symbols for healthy products (Gillon-Keren M et al, 2020)].
- “Directive” labels that include little information, often aggregated in a single symbol (e.g., Swedish Keyhole, Nutri-Score) and combining several criteria. Some of the “directive” labels (e.g. Swedish Keyhole and Dutch Healthy Choices) are part of a communication strategy aimed at increasing nutrition literacy in the population and are applied on products in combination with nutritional FOPL or BOPL. Other variants (e.g. Nutri-Score) only give an indication about the healthiness of the product, expressing judgements, opinions and/or recommendations, without providing specific information on single nutrients.

The aim of this opinion paper is to verify the usefulness of “directive” FOPL, and in particular of Nutri-Score, and make a briefly comparison with “informative” tools (such as the Nutrinform Battery system; NIB) as a means to promote a better nutritional and health status within the general population.

2. “Directive” front-of-pack labels

"Directive" systems (e.g., Nutri-Score) normally impose a "traffic light" system or colour code on

1 consumers, offering suggestions on what to purchase but without providing information on the
2 nutritional characteristics of a food, or on its recommended portion size and frequency of
3 consumption. The most widespread FOPL in Europe is represented by Nutri-Score (NS), which has
4 been adopted in France in 2017. It is based on a colour scale ranging from green to red, accompanied
5 by letters from A to E.
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7 Choice of parameters in the algorithm

8 A major concern is that "Directive" systems (and NS in particular) score the nutritional value of foods
9 based on a narrow set of selected nutritional criteria (e.g., energy, saturated fat, salt content, fibre,
10 proteins, fruit/vegetables), without taking into account the extremely important relevance of other
11 important nutritional factors (e.g., the contents of important micronutrients that are already
12 limiting in many populations, such as iron, zinc, and vitamin B12, or other nutrients of importance,
13 such as choline and long-chain omega-3 fatty acids). This results in both a lack of robustness of the
14 nutritional message and a substantial degree of arbitrariness of the algorithms underpinning it.
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19 Moreover, the true *causal* effect of the selected criteria on the health value of a food is in many
20 cases highly uncertain and contextual. Energy content (in kcal), for instance, is not a very helpful
21 basis as it overlooks the true drivers of overeating, which are the satiety-inducing effects of certain
22 foods (or their craving effects, for that matter) and endocrine responses to the type and status of
23 specific food components. As an example, it is known that some ultra-processed foods give rise to
24 overeating (Hall KD et al, 2019), but the level of processing has not been taken into account in
25 systems like NS (in contrast to other systems such as NOVA) (Monteiro CM et al, 2018). Differences
26 in food processing of bakery products, for instance, affect the nutritional attributes of baked goods,
27 which remains unaddressed by NS (Dewettinck et al, 2008).
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32 The role of the food and diet matrix

33 The role of the food matrix is essential when addressing the nutritional effects of a given food
34 product, which tends to be more than the sum of its individual nutrients, among other reasons due
35 to nutrient interactions and the presence of a wide (and usually poorly charted) spectrum of
36 bioactive compounds. The dairy matrix constitutes an often-cited example (Weaver CM, 2021).
37 Therefore, the isolation of a few nutrients will be poorly informative of the true nutritional impact,
38 especially when their health effects are uncertain. The situation becomes even more intricate when
39 considering the diet matrix and the health effects that relate to dietary patterns, consisting of
40 various food combinations over a period of time.
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45 For instance, the evidence in support of the use of the single and simplified category of "saturated
46 fat" as a health discriminator for food-based recommendations is debatable to say the least, given
47 that many systematic reviews and meta-analyses fail to substantiate harmful effects (see, e.g.,
48 Gershuni VM, 2018). Moreover, the category contains different types of fatty acids with varying
49 biologic effects, which also depend on the food matrix. Therefore, some foods that are rich in
50 saturated fat are *not* associated with increased disease (e.g., whole-fat dairy) (Astrup A et al, 2020).
51 Similar concerns as for saturated fats relate to the setting of specific sodium targets to improve
52 health in normotensive populations, realizing that the effects of sodium also depend on the dietary
53 pattern, including modulation by potassium (Mente A et al, 2021).
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58 As an example of a "positive" nutritional factor underpinning the algorithms, fibre content is indeed
59 associated with improved health in various epidemiological studies, but this may be mainly because
60 of its proxy role in the wholesomeness of foods (rather than fibre *per se*). The findings for fibre also
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1 are contingent on the dietary and metabolic context (Sholl J et al, 2021). Therefore, the health bonus
2 in NS may be overstated for *added* fibres (of which the effects are fibre- and context-dependent).
3 The latter can be added to unhealthy products to create a health halo and for mere nutri-washing
4 purposes (translated into a positive nutritional score), without necessarily making such foods
5 intrinsically more healthful.
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7 By ignoring all of the above-mentioned complexities, the simplified scores of “directive” FOPL like
8 NS suffer from nutritional reductionism (*nutritionism*). They excessively focus on a narrow set of
9 nutrients while ignoring both the wider scientific discussion and the holistic and versatile aspects of
10 human diets (Leroy F et al, 2022). Reliance on the so-called transitive property of the individual
11 nutritional factors mentioned above is problematic to begin with [“if a certain nutrient is statistically
12 or epidemiologically linked to a certain disease, changing the concentration of that nutrient will
13 have a positive effect on the prevention of the disease” (Donini LM et al, 2022)]. This principle has
14 been disproved on many occasions (e.g., even if increased intake of folic acid, B6, and B12 vitamins
15 reduces homocysteine levels, it fails to affect cardiovascular risk; Clarke R et al, 2010; Maruyama K
16 et al, 2019). Upon scrutiny, many food items or groups (cheese, butter, total dairy, red meat) and
17 single nutrients (saturated fat, sodium), in epidemiological studies, fail to lead to epidemiological
18 meaningful harmful associations with clinical health outcomes (Chen G-C et al 2017; Dehghan M et
19 al 2018; Zhang H et al, 2021; Pimpin L et al, 2016; Pala V et al, 2019;110:1220–30; Fontecha J et al
20 2019; Hirahatake KM et al 2020; Astrup A et al, 2019; Schmidt KA et al 2021).
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27 Internationalization of an algorithm based on a national consumption pattern and food 28 compositions

29 To further illustrate the arbitrariness of the setup and the inherent difficulties in establishing
30 unambiguous nutrient profiles at the EU level, it has to be underlined that 1) it is difficult to set the
31 application of the nutrient intake recommendations for the general diet to individual foods, that 2)
32 there is a lack of uniform data for the composition and consumption of foods across the EU, and
33 that 3) there are differences in nutrient intake recommendations and dietary guidelines within EU
34 countries themselves (EFSA scientific opinion, 2008). Because the NS system gives an overall
35 evaluation of an individual food, it also does not outline the information on the individual factors
36 included in the algorithms. The latter, however, could be the result of a large number of
37 combinations of levels of different factors [high levels of one or more factors that are considered
38 negative (energy, total sugar, saturated fatty acids and sodium content) and/or low levels of one or
39 more factors that are considered positive (fruit, vegetables and nuts, fibre, protein and seed, walnut
40 and olive oils content)]. As a consequence, whole-meal short-bread biscuits made with different
41 recipes, almost invariably obtain the same scores regardless of the presence of characterizing
42 ingredients (whole-meal flour varies from 20 to 70% of the total ingredients) and the lower or higher
43 sugar content (from less than 2 to more than 20 g per 100 g) (Visioli F et al, 2021).
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50 These uncertainties make the definition of FOPL (in particular that of the "directive" type) very
51 complex, which may lead, not surprisingly, to the need for annual updates of the Nutri-Score
52 algorithm as made in 2021 and 2022 by the Scientific Committee of NS ([https://solidarites-
53 sante.gouv.fr/IMG/pdf/annual_report_2021.pdf](https://solidarites-sante.gouv.fr/IMG/pdf/annual_report_2021.pdf); [https://gouvernement.lu/dam-
54 assets/documents/actualites/2022/07-juillet/29-mpc-nutriscore/rapport-du-comite-scientifique-
55 du-nutri-score-juin-2022.pdf](https://gouvernement.lu/dam-assets/documents/actualites/2022/07-juillet/29-mpc-nutriscore/rapport-du-comite-scientifique-du-nutri-score-juin-2022.pdf))
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59 In that context, nutrient-centric FOPL are often endorsed by multinational corporations that
60 produce ultra-processed foods. Even if this term is generating a great deal of confusion in certain
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1 consumer groups and in the sector of food production, since its interpretation is controversial
2 (Triptolemos foundation, 2020), given their expertise in extensive processing, this allows them to
3 reformulate ("tweak") their products by somewhat reducing the levels of some of the negative
4 nutrients with synthetic sweeteners (to decrease sugar), salt replacers, combinations of texturizers
5 and flavouring agents to compensate for fat reduction, or by adding ingredients with a healthy
6 aureole (e.g., fiber).
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9 The following is an example of how this may translate into confusion and arbitrariness. The original
10 algorithm of NS attributed one negative point both to 4.5 g of sugar and 1 g of saturated fatty acids.
11 Subsequent adjustments led to the attribution of one point for 5 g of sugar and 1.5 g of saturated
12 fatty acids, with highly questionable influences on health outcomes. A recent update report
13 ([https://gouvernement.lu/dam-assets/documents/actualites/2022/07-juillet/29-mpc-
14 nutriscore/rapport-du-comite-scientifique-du-nutri-score-juin-2022.pdf](https://gouvernement.lu/dam-assets/documents/actualites/2022/07-juillet/29-mpc-nutriscore/rapport-du-comite-scientifique-du-nutri-score-juin-2022.pdf)) wishes to further modify
15 the algorithms to accommodate criticism related to some highly questionable outcomes of the
16 original NS setup (for instance, by ameliorating the outcome for fatty fish, which is currently
17 receiving a discouraging NS).
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22 The example of unprocessed red meat further confirms the arbitrariness of the scoring process. To
23 accommodate the caution related to excessive consumption levels expressed by several health
24 organizations (e.g., WHO/IARC), NS downgraded the score of unprocessed red meat using "a
25 reduction in the number of maximal protein points [of red meat] to 2 points". Currently, red meat's
26 positive score is "due to the favourable points allocated in the protein element of the algorithm,
27 while lean plain meat will have relatively little unfavourable points on energy density, saturated fat
28 or salt". To do so, the algorithmic modification is built on a hypothesis connecting red meat
29 consumption to health risks, arguing that this would be caused by haem iron. As for saturated fat,
30 it has to be underlined that such assumptions are based on a scientific debate still in progress (Leroy
31 F et al, 2020; Stanton AV et al, 2022). A comprehensive analysis using the GRADE system has shown
32 that the evidence for a causal role of red meat in the development of NCDs is of (very) low certainty
33 and not fit for strong recommendations (Johnston BC et al, 2019). The haem iron rationale advanced
34 by the NS committee contributes to this uncertainty, as potential harmful effects of haem iron are
35 mitigated in a balanced dietary context, following risk assessment (Kruger C et al., 2018). This once
36 more stresses the importance of the diet matrix (see above). Moreover, even if discouragement of
37 red meat may be pertinent for some (e.g., those at risk of iron overload), blanket recommendations
38 may exacerbate the health problems of others due to a reduced intake of valuable nutrients that
39 are highly bioavailable in red meat, among which haem iron, especially in at risk populations. The
40 latter include children, older adults at risk of sarcopenia, and pre-menopausal women (many of
41 which already suffer from iron deficiency, even in the West, due to changing dietary patterns; Sun
42 H et al, 2021; Mei Z et al, 2021).
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50 An additional problem related to the use of a single algorithmic setup for very different product
51 groups is that it does not sufficiently separate foods that are high in some nutrients with a negative
52 or positive score effect, i.e. saturated fat or fiber. For instance, the lack of discriminating criteria
53 within a specific product group leads to an unbalanced distribution of cheeses within the NS
54 spectrum, with >80% of the products receiving a D score (Van Tongeren et al., 2020). As argued
55 above for meat, cheeses also serve as an important source of important and highly bioavailable
56 nutrients (e.g., calcium and proteins). Also, white bread and whole-meal breads are scoring very
57 similarly, while the latter would have to be promoted over the former, as to stimulate fibre and
58 micro-nutrient intake. Finally, several studies show that the NS is not aligned with the national
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1 dietary guidelines (see for example, for The Netherlands, Konings et al, 2022 and Van Tongeren et
2 al 2020)

3 4 Consumption aspects related to portion size and preparation

5 In addition to the problems of robustness and arbitrariness mentioned above, the resulting
6 information is disconnected from the reality of consumer behaviour and may therefore be
7 misleading. "Directive" systems are often based on a standard quantity of food (per 100g or 100ml),
8 which is not necessarily and, arguably, rarely corresponding to the portions actually consumed.
9 Some foods that obtain a favourable score can be consumed in large quantities that may lead to
10 concern (e.g., industrial vegetable pizza), while other foods may obtain unfavourable scores
11 although they are generally consumed in small portions and have well-documented health benefits
12 (e.g., olive oil) (Carruba MO et al, 2021). Also, some foods with green scores at retail level will still
13 undergo cooking procedures at consumer level, potentially involving unhealthy preparation steps
14 (e.g., frying).
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19 Consumer education

20 For consumers, "directive" FOPL like NS are not a useful basis for choosing the overall composition
21 of their diets, nor do they allow them to appropriately combine foods and adhere to a specific food
22 pattern (Visioli F et al, 2021). Therefore, they lack the "educational" purpose originally envisaged by
23 the European Commission. Worse still, "directive" FOPL like NS risk becoming misleading, for
24 instance by distracting attention from the Nutrition Facts tables reported on the package (Oswald C
25 et al, 2022). Typically, consumers associate a green colour with "healthiness" or "naturalness",
26 regardless of the nutritional information provided on the BOPL. In fact, when the packaging for the
27 same product was experimentally prepared with two different labels (green and red), consumers
28 choose the product labelled in green and did not read the information featured on the nutritional
29 label (Schuldt JP et al, 2013). Perceived and actual understanding of nutritional information can
30 indeed differ considerably (Oswald C et al, 2022), so that it is not necessarily to be expected that
31 "directive" FOPL may promote an improvement of nutritional literacy. Consumers will also be led to
32 value a "green"-coloured food as healthier than a "red" one regardless of the food category they
33 belong to, even if it is sometimes claimed that the system is not intended as a tool for comparing
34 the nutritional value of products from different categories. A recent study has used NS for the
35 standardized comparison of very different foods, leading to various debatable and questionable
36 outcomes (Clark M et al, 2022). For instance, foods such as frozen chips, rolls, and wraps were
37 presented as nutritionally superior to seafood, milk, cheese, and eggs. As an undesired outcome, an
38 inexperienced consumer may mistakenly try to follow a diet composed only of products in groups A
39 (dark green) and B (light green), which is not necessarily nutritionally adequate and could even lead
40 to unbalanced diets. Therefore, the effectiveness of "directive" FOPL to lead to the adoption of
41 healthy dietary patterns and a reduced risk of developing NCDs has yet to be demonstrated (Ikonen
42 I et al, 2020; Peters S et al, 2022).
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51 Effects on purchase behaviour

52 All the determinants that influence food choices are often assessed individually rather than in a
53 holistic, synergistic and multidimensional context, while a representative purchasing scenario would
54 need to be characterized by multiple stimuli to which the consumer is subjected ("bombarded") at
55 the point of purchase. Information, condensed into a color or number, has sometimes been found
56 to facilitate better food choices and improve the nutritional quality of the shopping basket (Egnell
57 M et al, 2018; Ducrot P et al, 2015), but may also have the opposite effect and misguide consumers
58 which could result in higher consumption of unhealthy food (Orquin JL et al, 2015; Roberto CA et al,
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2012). More recent studies seem to acknowledge the capacity of FOPL to improve the overall quality of the shopping basket, in particular when they are part of a communication strategy aimed at increasing nutrition literacy in the population (Swedish Keyhole and Dutch Healthy Choices) (Smed S et al, 2017 and 2019). However, the actual effect of FOPLs on consumers' behaviour and their direct positive correlation with the individual health status has yet to be proven (Donini et al, 2022).

Validity over time of FOPL messages

"Directive" warnings frequently show a wear out (fatigue) effect tendency, resulting in decreasing effectiveness of a warning message over time. The experience with cigarette warning labels has shown that, after a first success, they required the implementation of pictorial labels in addition to the text for more effective outcomes. Even so, after a prompt increase in effectiveness, the wear-out effect was re-observed again, so that some governments decided in response to frequently change the displayed images frequently in order to maintain results over time (Hammond D et al, 2007; White V et al, 2015). More "informative" approaches, provided that they are able to achieve educational effectiveness, by contributing to a broader nutritional awareness, may reduce this effect by empowerment of consumers. Ideally, consumers should be enabled to situate more appropriately individual foods and nutrients within a context of overall nutritional needs and dietary patterns, rather than being misled by simplistic colour schemes or other examples of "health halos" based on simplified claims, such as being "low in calories" or "low in fat" (Oostenbach LH et al, 2019). The experience with "light" food products, whose association with alleged healthier qualities lead to a greater consumption but failed to materialise in reduced obesity, suggests caution in classifying single foods as "good" or "bad" based on simplistic assumptions (Wansink B et al, 2006; Geyskens K et al, 2007; Cleeren K et al, 2016). Moreover, the use of artificial sweeteners may come with negative health trade-offs that are not captured in the score, thereby undermining the validity of the current favourable NS of, for instance, light sodas (Suez et al. 2022).

3. "Informative" front-of pack labels

An example of an "informative" FOPL is provided by the Italian Nutrinform Battery (NIB), which adopts the cell phone battery symbol to summarize the daily consumption of five elements: calories, fat, saturated fat, sugar, and salt. These batteries show the amount of each element contained in a portion of the food considered, as well as its contribution to the daily requirement according to the Dietary Reference Values established by the European Food Safety Authority (EFSA). The filling of the batteries is compared to the recommended amount for each nutritional element. In this way, the system informs the consumer to situate the intake of these nutrients per food in their overall daily meal formulations, so that they can manage the daily constitution in balanced manners.

As for "directive" FOPL, restricting the information to five parameters only offers a narrow view on the true nutritional value of a food and the importance of the food matrix. Also, the same objections to the validity of these criteria, in view of the totality of the scientific evidence, can be raised as the ones mentioned above for NS. However, "informative" approaches are less paternalizing and judgemental towards consumers and do not have the intention to label individual foods as "healthy" and "unhealthy". They also focus their attention on the average portions size as defined by national organisations, helping to understand how these will fit into the daily dietary consumption pattern in combatting obesity (Berry EM, 2020). The inclusion of portions in the setup is key, especially in the current foodscape with its emphasize on the oversizing of ultra-processed foods, which is likely responsible for overeating. "Informative" FOPL may help consumers to be aware of proper food servings and encourage the food industry, not only to reformulate potentially health-critical

1 products, but also to reduce the portion sizes (Carruba MO et al, 2021). That being said, it is difficult
2 to identify true portion sizes, especially in “family packs” and other formulations with suggested
3 portion sizes, as these depend on individual preferences and eating cultures. The definition of food
4 portions is not always specified in the different national nutritional guidelines and can sometimes
5 vary from one manufacturer to another. It also opens pathways for producers of unhealthy foods
6 to manipulate the declared portion size and, therefore, the FOPL message.
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9 Starting from an “informative” principle, systems such as the NIB attempt to respond to the
10 European Commission’s and United Nations’ request for better empowerment of consumers to
11 induce them to undertake healthy and balanced diets. By referring to the overall characteristics of
12 the diet, these systems overcome the limits represented by the difficulties in defining the nutritional
13 profile of foods. There are several models available (e.g. Ofcom/FSA NP model, WHO-Euro model,
14 Health Canada Surveillance Tool system), but still today there is no consensus on which of these has
15 should be considered as a reference (Rayner M, 2017; Hagmann D et al, 2020). In contrast to
16 “directive” FOPL, such as NS, “informative” FOPL, such as NIB, offer a better option to achieve
17 proper combinations of various foods (e.g., the choice of food for which the system assigns a high
18 content of fats and sugar can be “balanced” by eating other foods with lower content of these
19 nutrients). Likewise, when relevant, they also facilitate the selection of foods according to specific
20 individual needs (energy content, sodium, or saturated fat content) (Carruba MO et al, 2021). The
21 presence of the battery symbol may enable respondents to see if their consumption aligns with the
22 recommended daily intake, so that meals can be balanced accordingly [Mazzù MF et al, 2021 (a)].
23 Improved understanding and preference for “informative” (NIB) over “directive” (NS) FOPL was
24 confirmed in different studies performed in various European countries [Sampalean NI et al, 2021;
25 Baccelloni A et al, 2021; Mazzù MF et al, 2021 (b and c)].
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32 Taken together, the above-mentioned arguments suggest that a strategy of “informative” FOPL is
33 more suitable to optimize dietary *patterns*, instead of focusing on individual foods and nutrients, an
34 approach which is well-supported by the scientific evidence (e.g., Hu FB, 2002; Serra-Majem L et al,
35 2020; Wahl D et al, 2016). Eating patterns are made up of the combination of a variety of different
36 foods. For example, foods like olive oil, cheeses, preserved meats, baked goods, and even sweets,
37 may seem harmful on an individual and simplistic assessment, but are nevertheless an integral part
38 of Mediterranean diets, widely acknowledged as a healthy eating pattern. Based on NS, salad
39 dressings may have a better score compared to olive oil due to differences in energy density and
40 saturated fat, but this is fully overlooking the healthy benefits that olive oil offers within a
41 Mediterranean diet culture (supported by the rationale that it also is rich in monounsaturated fatty
42 acids and antioxidants). The often subtle interactions between different foods and between
43 different nutrients, as well as the complexities of food matrices and how these are affected by food
44 processing (for the better or worse), make a model more or less effective in preventing NCDs. An
45 approach based on the dichotomic classification of foods into “healthy” and “unhealthy” products
46 may present several pitfalls related to the oversimplifications of this approach (Visioli F et al, 2021).
47 The validity of focusing on single nutrients (as it happens in particular in “directive” FOPL) has been
48 challenged in a report from the European Food Safety Authority (EFSA, 2022): “even though the
49 effects of some individual nutrients and non-nutrient components of food on chronic disease risk
50 are well established, these are usually found in foods and diets as complex mixtures, where
51 synergistic or antagonistic effects may come into play”.
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60 As a drawback, the provision of somewhat more detailed information, as with the NIB system, could
61 be challenging for communication purposes due to the numerous numerical references present.
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1 This problem conflicts with the need for simple and immediate information, by requiring a graphic
2 and advertising design that may not always be effective. Also, the contextualization of the
3 information offered requests basic nutritional knowledge. Be that is it may, it is in our opinion still
4 preferable to the simplistic approach of a single colour or letter.
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6 **4. Front-of-pack labels and health status**

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9 “Directive” FOPL are mostly focused on the content of nutrients with “unfavourable” effects. In the
10 NS setup, such nutrients confer up to 40 negative points compared to nutrients with “favourable”
11 effects, which bear a maximum of 15 positive points (Visioli F et al, 2021). This is in contrast with
12 the observations that dietary policies focusing on the promotion of the intake of under-consumed
13 beneficial components likely will likely have a greater effect than policies targeting “negative”
14 nutrients. Among a list of fifteen nutritional factors of which the influence on health is allegedly
15 highest, eleven were shown to refer to foods and nutrients that are consumed in insufficient
16 quantities (e.g., whole grains, nuts, seeds, and seafood). Regardless of the fact that their true causal
17 role in the development of disease is still controversial , only four of them (i.e., sodium, red meat,
18 processed meat, and sugar-sweetened beverages) were consumed in excessive amounts (GBD Diet
19 Collaborators, 2019; Foreman KJ et al, 2018).
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25 Currently, the number of studies that associate the adoption of a FOPL with an improvement in
26 health status are very few and mainly concern NS. None of them are longitudinal or have been able
27 to identify a causal link between the adoption of the FOPL and the change in health status (Peters S
28 eta al, 2022). At best, the association is with the consumption of a certain food (an association with
29 the variation of a risk biomarker was rarely found, and associations outlining impact on morbidity
30 or mortality are missing). Many of the studies have only virtually applied the NS to pre-existing
31 cases, thereby assuming that the adoption of the NS could - if applied to that specific case series -
32 influence the adoption of different dietary patterns (which in reality were spontaneously adopted
33 by the enrolled subjects) and their eventual health effects. The use of data extracted from existing
34 studies, to which the possible effect of NS was subsequently applied with mathematical models, is
35 a very questionable experimental approach from a methodological point of view, which by
36 definition cannot demonstrate the presence of causal relationships between the considered
37 parameters. Moreover, a real-life setting may give significantly different results due to important
38 interfering and confounding factors (Storcksdieck Genannt Bonsmann S et al, 2020; Clarke N et al,
39 2021). Prospective controlled studies are missing (Donini LM et al, 2022): consumers were not
40 exposed to the labels and did not choose the products accordingly, nor were their choices of labelled
41 products observed over the long term, assessing the potential effect of FOPL on health against no
42 FOPL exposure. These studies examined FOPLs in isolated conditions, unaffected by external factors.
43 Thus, they overlooked confounding factors such as compensatory consumption, increased physical
44 activity, biases, overconsumption of foods perceived as more nutritious or healthy and, whether or
45 not consumers use FOPLs as a mean of information before purchase (Smed S et al, 2007). The few studies
46 that have been carried out in real-world supermarkets (most of them using NS) gave conflicting results [some
47 studies found no significant effects on consumer behaviour, whereas others found positive results in terms
48 of a significant reduction in the purchase of products considered unhealthy; Donini LM et al, 2022]. This
49 indicated that FOPL or shelf labels may at best achieve a small degree of success (< 2.0%) at persuading
50 shoppers to buy healthier foods (Temple NJ, 2020; Smed S et al, 2007). Smed et al (2017,
51 2019)(DOI: [10.1017/S1368980019001423](https://doi.org/10.1017/S1368980019001423)) showed that the placement of the Dutch Choices logo on products
52 fulfilling the criteria for the logo, lead in some product groups to the switch from non-logoproducts to logo
53 products. In other product groups no change was observed. These studies were done by reporting alal the
54 products purchased in ahouseholds as well by analysing data from retail selling of products. A meta-analysis,
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1 including 114 articles on the impact of FOPL on outcomes (consumers' ability to identify healthier
2 options, product perceptions, purchase behaviour, and consumption), has shown that, although
3 FOPL help consumers to identify healthier products, their ability to nudge consumers toward
4 healthier choices is more limited (Ikonen L et al, 2020).
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6 A labelling system with a positive character that incorporates more informative nutrition signals,
7 may contribute to educative empowerment, and avoids messaging connoting judgment about what
8 consumers are eating (e.g., red lights) (Seward MW et al, 2018). Focusing on positive "to-do" rather
9 than on "not-to-do" behaviors can arguably increase the percentage of people adopting healthier
10 eating habits (Pem D et al, 2015). Positive, gain-framed messages give an actionable message that
11 seems to be effective with the general audience who are likely to have limited knowledge of the
12 message's topic, leaving a positive feeling and a motivated attitude (Buckton CH et al, 2015; Rolls BJ
13 et al, 2004).
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18 **5. Conclusions**

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20 There is no robust evidence that the adoption of a "directive" FOPL system like NS will improve the
21 nutritional skills and awareness of consumers, thereby improving their purchasing choices in a real-
22 life context. Neither should we assume that this will consequently improve the effective quality of
23 their diets and that this would favourably modify their health status and reduce the incidence of
24 NCD or mortality from any cause. Moreover, the structure and logic of a "directive" FOPL like NS
25 does not provide much valuable and meaningful educational information (Andrés X et al, 2020). An
26 information campaign putting emphasis on single nutrients or individual foods (which is the logical
27 basis of "directive" FOPL as NS) does not consider the synergistic interactions occurring between
28 different food items and food components, ignores the relevance of important micronutrients
29 (vitamins, minerals, and other bioactive compounds), and neglects the potential influences related
30 to the frequency of consumption, the influence of (ultra)processing and the food matrix, and the
31 further preparation and cooking by consumers. Many of the assumptions, such as those that relate
32 to the health impact of saturated fat, are much less evidence-driven than often assumed. A
33 "negative-based" communication approach, relying on bans or simplistic summaries and limiting
34 information to single nutrients, does not capture the complexity of dietary patterns as part of a
35 thorough lifestyle modification (Dean M et al, 2011; Donini LM et al, 2022; Martini D et al, 2022). In
36 contrast, and despite also coming with limitations, "informative" FOPL at least have the advantage
37 of situating the FOPL information in a broader dietary context of daily intake and recommendation,
38 thereby opening a broader dietary perspective on overall equilibrium.
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46 Given that food is more than the sum of nutrients or mere "fuel for the body" (which, albeit, should
47 be of the highest octane), and acknowledging that eating is deeply rooted in culture and has
48 important social meaning and functions, it is our opinion that more constructive approaches are
49 needed. Preferably, these should *positively* emphasize the importance of dietary patterns that have
50 a proven record of healthiness and are typified by a long-standing contribution to the benefits of
51 commensality, culinary legacy, and food traditions.
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57 **Conflicts of interests**

58 On a non-remunerated basis, FL is a board member of various academic non-profit organizations
59 including the Belgian Association for Meat Science and Technology (president), the Belgian Society
60 for Food Microbiology (president), and the Belgian Nutrition Society, and has a seat in the scientific
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committee of the Institute Danone Belgium, the World Farmers' Organization, the Advisory Commission for the "Protection of Geographical Denominations and Guaranteed Traditional Specialties for Agricultural Products and Foods" of the Ministry of the Brussels Capital Region, and a Scientific Advisory Committee of the Food and Agriculture Organization of the United Nations.

LMD is member of different boards of scientific societies dealing with eating behaviours and food science (Italian Soc for the Study of Eating Disorders (SISDCA), Italian Society of Obesity (SIO); Eur Soc of Clinical Nutrition and Metabolism (ESPEN)).

All other authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

- Andrés et al, 2020. [Report on the front labeling of foods: nutritional traffic lights, Nutri-Score and others, pdf](#). ISSN 2938-0731
- Astrup A, Geiker NRW, Magkos F. Effects of full-fat and fermented dairy products on cardiometabolic disease: food is more than the sum of its parts. *Adv Nutr* 2019;10:924S–30S.
- Astrup A, Magkos F, Bier DM, Brenna JT, de Oliveira Otto MC, Hill JO, King JC, Mente A, Ordovas JM, Volek JS, Yusuf S, Krauss RM. Saturated Fats and Health: A Reassessment and Proposal for Food-Based Recommendations: JACC State-of-the-Art Review. *J Am Coll Cardiol*. 2020 Aug 18;76(7):844–857. doi: 10.1016/j.jacc.2020.05.077
- Baccelloni A, Giambarresi A, Mazzù MF. Effects on Consumers' Subjective Understanding and Liking of Front-of-Pack Nutrition Labels: A Study on Slovenian and Dutch Consumers. *Foods*. 2021 Dec 1;10(12):2958. doi: 10.3390/foods10122958
- Berry EM. The Obesity Pandemic-Whose Responsibility? No Blame, No Shame, Not More of the Same. *Front Nutr*. 2020 Jan 31;7:2. doi: 10.3389/fnut.2020.00002
- Bracale R, Milani L, Ferrara E, Balzaretto C, Valerio A, Russo V, Nisoli E, Carruba MO (2013) Childhood obesity, overweight and underweight: a study in primary schools in Milan. *Eat Weight Disord* 18:183–191. doi: 10.1007/s40519-013-0036-9
- Buckton CH, Lean MEJ, Combet E. 'Language is the source of misunderstandings'—impact of terminology on public perceptions of health promotion messages. *BMC Public Health* (2015) 15:579. doi: 10.1186/s12889-015-1884-1
- Carruba MO, Busetto L, Bryant S, Caretto A, Farpour-Lambert NJ, Fatati G, Foschi D, Giorgino F, Halford, JCG, Lenzi A, Malfi G, O'Malley G, Napier D, Santini F, Sbraccia P, Spinato C, Woodward E, Nisoli E (2021) The European Association for the Study of Obesity (EASO) Endorses the Milan Charter on Urban Obesity. *Obes Facts* 14: 163–168 doi: 10.1159/000514218
- Carruba MO, Malavazos A, Valerio A, Nisoli E. Front-of-pack (FOP) labelling systems, nutrition education, and obesity prevention: nutri-score and nutrinform battery need more research. *Eat Weight Disord*. 2021 Dec 2. doi: 10.1007/s40519-021-01342-x.
- Chen G-C, Wang Y, Tong X, Szeto IMY, Smit G, Li Z-N, et al. Cheese consumption and risk of cardiovascular disease: a meta-analysis of prospective studies. *Eur J Nutr* 2017;56:2565–75.
- Clark M, Springmann M, Rayner M, Scarborough P, Hill J, Tilman D, Macdiarmid JI, Fanzo J, Bandy L, Harrington RA. Estimating the environmental impacts of 57,000 food products. *Proc Natl Acad Sci U S A*. 2022 Aug 16;119(33):e2120584119. doi: 10.1073/pnas.2120584119
- Clarke N, Pechey E, Kosıte D, König LM, Mantzari E, Blackwell AKM, Marteau TM, Hollands GJ (2021) Impact of health warning labels on selection and consumption of food and alcohol products: systematic review with meta-analysis, *Health Psychology Review*, 15:3, 430–453. doi: [10.1080/17437199.2020.1780147](#)
- Clarke R, Halsey J, Lewington S, Lonn E, Armitage J, Manson JAE, et al. Effects of lowering homocysteine levels with B vitamins on cardiovascular disease, cancer, and cause-specific mortality:

meta-analysis of 8 randomized trials involving 37 485 individuals. Arch Intern Med 2010;170:1622–31.

- 1
2 - Cleeren, K., Geyskens, K., Verhoef, P. C., & Pennings, J. M. E. (2016). Regular or low-fat? An
3 investigation of the long-run impact of the first low-fat purchase on subsequent purchase volumes
4 and calories. International Journal of Research in Marketing, 33(4), 896-906 doi:
5 [10.1016/j.ijresmar.2016.04.001](https://doi.org/10.1016/j.ijresmar.2016.04.001)
6
- 7 - Dean M, Lahteenmaki L, Shepherd R. Nutrition communication: consumer € perceptions and
8 predicting intentions. Proc Nutr Soc 2011;70:19–25.
- 9 - Dehghan M, Mente A, Rangarajan S, Sheridan P, Mohan V, Iqbal R, et al. Association of dairy intake
10 with cardiovascular disease and mortality in 21 countries from five continents (PURE): a prospective
11 cohort study. Lancet 2018;392:2288–97.
- 12 - Dewettinck, Koen & Van Bockstaele, Filip & Kühne, Bianka & Walle, Davy & Courtens, T.M. &
13 Gellynck, Xavier. (2008). Nutritional value of bread: Influence of processing, food interaction and
14 consumer perception. Journal of Cereal Science. 48. 243-257. 10.1016/j.jcs.2008.01.003.
- 15 - Donini LM, Penzavecchia C, Muzzioli L, Poggiogalle E, Giusti AM, Lenzi A, Pinto A. Efficacy of front-of-
16 pack nutrition labels in improving health status. Nutrition. 2022 Jun 9;102:111770. doi:
17 10.1016/j.nut.2022.111770
18
- 19 - Ducrot P, Méjean C, Julia C, Kesse-Guyot E, Touvier M, Fezeu LK, Hercberg S, Péneau S. Objective
20 Understanding of Front-of-Package Nutrition Labels among Nutritionally At-Risk Individuals.
21 *Nutrients* (2015) 7:7106–7125. doi: 10.3390/nu7085325
22
- 23 - EFSA Scientific Opinion: The setting of nutrient profiles for foods bearing nutrition and health claims
24 pursuant to Article 4 of the Regulation (EC) No 1924/2006 - Scientific Opinion of the Panel on Dietetic
25 Products, Nutrition and Allergies,” *EFSA J.*, vol. 6, no. 2, 2008, doi: 10.2903/j.efsa.2008.644.
- 26 - EFSA. Food Scientific advice related to nutrient profiling www.efsa.europa.eu/efsajournal 27 EFSA
27 Journal 2022;20(4):7259 Food Scientific advice related to nutrient profiling
28 www.efsa.europa.eu/efsajournal 27 EFSA Journal 2022;20(4):7259
29
- 30 - Egnell M, Ducrot P, Touvier M, Allès B, Hercberg S, Kesse-Guyot E, Julia C. Objective understanding
31 of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects:
32 Comparisons with other format labels. *PLoS One* (2018) 13:1–16. doi: 10.1371/journal.pone.0202095
33
- 34 - Fontecha J, Calvo MV, Juarez M, Gil A, Martínez-Vizcaino V. Milk and dairy product consumption and
35 cardiovascular diseases: an overview of systematic reviews and meta-analyses. *Adv Nutr*
36 2019;10(suppl 2):S164–89.
37
- 38 - Foreman KJ, Marquez N, Dolgert A, Fukutaki K, Fullman N, McGaughey M, Pletcher MA, Smith AE,
39 Tang K, Yuan CW, Brown JC, Friedman J, He J, Heuton KR, Holmberg M, Patel DJ, Reidy P, Carter A,
40 Cercy K, Chapin A, Douwes-Schultz D, Frank T, Goettsch F, Liu PY, Nandakumar V, Reitsma MB, Reuter
41 V, Sadat N, Sorensen RJD, Srinivasan V, Updike RL, York H, Lopez AD, Lozano R, Lim SS, Mokdad AH,
42 Vollset SE, Murray CJL. Forecasting life expectancy, years of life lost, and all-cause and cause-specific
43 mortality for 250 causes of death: reference and alternative scenarios for 2016-40 for 195 countries
44 and territories. *Lancet*. 2018 Nov 10;392(10159):2052-2090. doi: 10.1016/S0140-6736(18)31694-5
45
- 46 - Frühbeck G, Sbraccia P, Nisoli E, Woodward E, Yumuk V, Farpour-Lambert NJ, Halford JG, Toplak H,
47 Carruba MO (2016) 2015 Milan declaration: a call to action on obesity - an EASO position statement
48 on the occasion of the 2015 EXPO. *Obes Facts* 9:296–298. doi: 10.1159/000448234
49
- 50 - GBD (2019) 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990–2017: a
51 systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 393, 1958–1972; doi: 10.
52 1016/ S0140- 6736(19) 30041-
53
- 54 - Gershuni VM. Saturated Fat: Part of a Healthy Diet. *Curr Nutr Rep*. 2018 Sep;7(3):85-96. doi:
55 10.1007/s13668-018-0238-x
56
- 57 - Geyskens K, Pandelaere M, Dewitte S, Warlop L (2007) The backdoor to overconsumption: The effect
58 of associating “low-fat” food with health references. *J Pub Policy Marketing* 26:118–125. doi: 10.
59 1509/ jppm. 26.1. 118
- 60 - Gillon-Keren M, Kaufman-Shriqui V, Goldsmith R, Safra C, Shai I, Fayman G, Berry EM, Tirosh A, Dicker
61 D, Froy O, Gordon E, Chavia Ben-Yosef AC, Nitsan L, Altman H, Blaychfeld-Magnazi M, Endevelt R.
62
63
64
65

- Development of Criteria for a Positive Front-of-Package Food Labeling: The Israeli Case. *Nutrients*. 2020;12(6):1875. doi: 10.3390/nu12061875.
- Hagmann D, Siegrist M. Nutri-Score, multiple traffic light and incomplete nutrition labelling on food packages: Effects on consumers' accuracy in identifying healthier snack options. *Food Qual Prefer*. 2020;83(January):103894. doi:10.1016/j.foodqual.2020.103894
 - Hall KD, Ayuketah A, Brychta R, Cai H, Cassimatis T, Chen KY, Chung ST, Costa E, Courville A, Darcey V, Fletcher LA, Forde CG, Gharib AM, Guo J, Howard R, Joseph PV, McGehee S, Ouwkerk R, Raisinger K, Rozga I, Stagliano M, Walter M, Walter PJ, Yang S, Zhou M. Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell Metab*. 2019 Jul 2;30(1):67-77.e3. doi: 10.1016/j.cmet.2019.05.008
 - Hammond D, Fong GT, Borland R, Cummings KM, McNeill A, Driezen P. Text and Graphic Warnings on Cigarette Packages. *Am J Prev Med* (2007) 32:202–209. doi: 10.1016/j.amepre.2006.11.011
 - Hirahatake KM, Astrup A, Hill JO, Slavin JL, Allison DB, Maki KC. Potential cardiometabolic health benefits of full-fat dairy: the evidence base. *Adv Nutr* 2020;11:533–47.
 - Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol*. 2002 Feb;13(1):3-9. doi: 10.1097/00041433-200202000-00002
 - Ikonen L, Sotgiu F, Aydinli A, Verleigh PWJ: Consumer effects of front-of-package nutrition labeling: an interdisciplinary meta-analysis. *Journal of the Academy of Marketing Science* (2020) 48:360–383 <https://doi.org/10.1007/s11747-019-00663-9>
 - Johnston BC, Zeraatkar D, Han MA, Vernooij RWM, Valli C, El Dib R, Marshall C, Stover PJ, Fairweather-Taitt S, Wójcik G, Bhatia F, de Souza R, Brotans C, Meerpohl JJ, Patel CJ, Djulbegovic B, Alonso-Coello P, Bala MM, Guyatt GH. Unprocessed Red Meat and Processed Meat Consumption: Dietary Guideline Recommendations From the Nutritional Recommendations (NutriRECS) Consortium. *Ann Intern Med*. 2019 Nov 19;171(10):756-764. doi: 10.7326/M19-1621.
 - Konings, J.J.C.; Smorenburg, H.; Roodenburg, A.J.C. Comparison between the Choices Five-Level Criteria and Nutri-Score: Alignment with the Dutch Food-Based Dietary Guidelines. *Nutrients* **2022**, *14*, 3527. <https://doi.org/10.3390/nu14173527>
 - Kruger C, Zhou Y. Red meat and colon cancer: A review of mechanistic evidence for heme in the context of risk assessment methodology. *Food Chem Toxicol*. 2018 Aug;118:131-153. doi: 10.1016/j.fct.2018.04.048
 - Leroy F, Beal Ty, Gregorini Pablo, McAuliffe Graham A., van Vliet Stephan (2022) Nutritionism in a food policy context: the case of 'animal protein'. *Animal Production Science* 62, 712-720. doi: 10.1071/AN21237
 - Leroy F, Cofnas N. Should dietary guidelines recommend low red meat intake? *Crit Rev Food Sci Nutr*. 2020;60(16):2763-2772. doi: 10.1080/10408398.2019.1657063.
 - Martini D, Marangoni F, Banterle A, Donini LM, Riccardi G, Poli A and Pellegrini N (2022) Relationship between front-of-pack labeling and nutritional characteristics of food products: An attempt of an analytical approach. *Front. Nutr*. 9:963592. doi: 10.3389/fnut.2022.963592
 - Maruyama K, S Eshak E, Kinuta M, Nagao M, Cui R, Imano H, et al. Association between vitamin B group supplementation with changes in % flow-mediated dilatation and plasma homocysteine levels: a randomized controlled trial. *J Clin Biochem Nutr* 2019;64:243–9
 - Mazzù MF, Romani S, Gambicorti A. Effects on consumers' subjective understanding of a new front-of-pack nutritional label: a study on Italian consumers. *Int J Food Sci Nutr*. 2021 May;72(3):357-366. doi: 10.1080/09637486.2020.1796932 (a)
 - Mazzù, M.F.; Romani, S.; Baccelloni, A.; Gambicorti, A. A cross-country experimental study on consumers' subjective understanding and liking on front-of-pack nutrition labels. *Int. J. Food Sci. Nutr*. 2021, 72, 833–847 (c).
 - Mazzù, M.F.; Romani, S.; Baccelloni, A.; Simonetti, E. Effects on Consumers' Subjective Understanding and Liking of Front-Pack Nutritional Labels: A Study on Polish Consumers. Available online: <https://www.petruzzeditore.it/wp-content/uploads/2021/09/FUTURE-OF-THE-TRADITIONAL-DIETS.pdf> (accessed on 27 October 2021) (b).

- 1 - Mei, Z., Addo, O. Y., Jefferds, M. E., Sharma, A. J., Flores-Ayala, R. C., & Brittenham, G. M.
2 (2021). Physiologically based serum ferritin thresholds for iron deficiency in children and non-
3 pregnant women: a US National Health and Nutrition Examination Surveys (NHANES) serial cross-
4 sectional study. *The Lancet Haematology*, 8(8), e572–e582. doi:10.1016/s2352-3026(21)00168-x
- 5 - Mente A, O'Donnell M, Yusuf S. Sodium and health: another challenge to the current dogma. *Eur*
6 *Heart J*. 2021 Jun 1;42(21):2116-2118. doi: 10.1093/eurheartj/ehaa1093
- 7 - Mobley AR, Kraemer D, Nicholls J. Putting the nutrient-rich foods index into practice. *J Am Coll Nutr*.
8 2009;28(4):427S-435S.
- 9 - Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada MLC, Jaime PC. The UN Decade of Nutrition,
10 the NOVA food classification and the trouble with ultra-processing. *Public Health Nutr*. 2018
11 Jan;21(1):5-17. doi: 10.1017/S1368980017000234.
- 12 - Muzzioli L, Penzavecchia C, Donini LM, Pinto A. Are Front-of-Pack Labels a Health Policy Tool?
13 *Nutrients*. 2022 Feb 11;14(4):771. doi: 10.3390/nu14040771
- 14 - Oostenbach LH, Slits E, Robinson E, Sacks G. Systematic review of the impact of nutrition claims
15 related to fat, sugar and energy content on food choices and energy intake. *BMC Public Health*. 2019
16 Oct 15;19(1):1296. doi: 10.1186/s12889-019-7622-3.
- 17 - Orquin JL, Scholderer J. Consumer judgments of explicit and implied health claims on foods:
18 Misguided but not misled. *Food Policy* (2015) 51:144–157. doi: 10.1016/j.foodpol.2015.01.001
- 19 - Oswald C, Adhikari K, Mohan A. Effect of front-of-package labels on consumer product evaluation
20 and preferences. *Curr Res Food Sci*. 2022 Jan 5;5:131-140. doi: 10.1016/j.crf.2021.12.016.
- 21 - Pala V, Sieri S, Chiodini P, Masala G, Palli D, Mattiello A, et al. Associations of dairy product
22 consumption with mortality in the European Prospective Investigation into Cancer and Nutrition
23 (EPIC)Italy cohort. *Am J Clin Nutr* 2019;110:1220–30.
- 24 - Pem D, Jeewon R. Fruit and Vegetable Intake: Benefits and Progress of Nutrition Education
25 Interventions- Narrative Review Article. *Iran J Public Health* (2015) 44:1309–21.
26 <http://www.ncbi.nlm.nih.gov/pubmed/26576343>
- 27 - Peters, S.; Verhagen, H. An Evaluation of the Nutri-Score System along the Reasoning for Scientific
28 Substantiation of Health Claims in the EU—A Narrative Review. *Foods* 2022, 11, 2426. doi:
29 10.3390/foods11162426
- 30 - Pimpin L, Wu JHY, Haskelberg H, Del Gobbo L, Mozaffarian D. Is butter back? a systematic review and
31 meta-analysis of butter consumption and risk of cardiovascular disease, diabetes, and total mortality.
32 *PLoS One* 2016;11: e0158118.
- 33 - Popkin BM, Corvalan C, Grummer-Strawn LM (2020) Dynamics of the double burden of malnutrition
34 and the changing nutrition reality. *Lancet* 395:65–74. doi: 10. 1016/ S0140-6736(19) 32497-3
- 35 - Rayner M. Nutrient profiling for regulatory purposes. *Proc Nutr Soc*. 2017;76(3):230-236.
36 doi:10.1017/S0029665117000362
- 37 - Roberto CA, Shivaram M, Martinez O, Boles C, Harris JL, Brownell KD. The Smart Choices front-of-
38 package nutrition label. Influence on perceptions and intake of cereal. *Appetite* (2012) 58:651–657.
39 doi: 10.1016/j.appet.2012.01.003
- 40 - Smed S, Edenbrandt AK, Jansen L. The effects of voluntary front-of-
41 pack nutrition labels on volume shares of products: the case of the Dutch Choices. *Public Health Nutr*.
42 2019 Oct;22(15):2879-2890. doi: 10.1017/S1368980019001423
- 43 - Rolls BJ, Ello-Martin JA, Tohill BC. What Can Intervention Studies Tell Us about the Relationship
44 between Fruit and Vegetable Consumption and Weight Management? *Nutr Rev* (2004) 62:1–17. doi:
45 10.1111/j.1753-4887.2004.tb00001.x
- 46 - Romero Ferreiro C, Lora Pablos D, Gómez de la Cámara A. Two Dimensions of Nutritional Value: Nutri-
47 Score and NOVA. *Nutrients*. 2021 Aug 13;13(8):2783. doi: 10.3390/nu13082783
- 48 - Sampalean NI, Rama D, De Magistris T. Consumer preferences for front-of-pack nutrition labels: the
49 case of Nutri-Score labelling in Spain. XIII Congreso de Economía Agroalimentaria. Cartagena, 1-2
50 Sept 2021. Libro de Actas.
- 51 - Schmidt KA, Cromer G, Burhans MS, Kuzma JN, Hagman DK, Fernando I, et al. Impact of low-fat and
52 full-fat dairy foods on fasting lipid profile and blood pressure: exploratory endpoints of a randomized
53 controlled trial. *Am J Clin Nutr* 2021;114:882–92.

- 1 - Schuldt JP (2013) Does green mean healthy? Nutrition label color affects perceptions of
2 healthfulness. *Health Commun* 28:814–821. doi: 10.1080/10410236.2012.725270
- 3 - Serra-Majem L, Tomaino L, Dernini S, Berry EM, Lairon D, Ngo de la Cruz J, Bach-Faig A, Donini LM,
4 Medina FX, Belahsen R, Piscopo S, Capone R, Aranceta-Bartrina J, La Vecchia C, Trichopoulou A.
5 Updating the Mediterranean Diet Pyramid towards Sustainability: Focus on Environmental Concerns.
6 *Int J Environ Res Public Health*. 2020 Nov 25;17(23):8758. doi: 10.3390/ijerph17238758
- 7 - Seward MW, Block JP, Chatterjee A. Student experiences with traffic-light labels at college cafeterias:
8 a mixed methods study. *Obes Sci Pract* (2018) 4:159–177. doi: 10.1002/osp4.159
- 9 - Sholl J, Mailing LJ, Wood TR. Reframing Nutritional Microbiota Studies To Reflect an Inherent
10 Metabolic Flexibility of the Human Gut: a Narrative Review Focusing on High-Fat Diets. *mBio*. 2021
11 Apr 13;12(2):e00579-21. doi: 10.1128/mBio.00579-21.
- 12 - Smed S, Edenbrandt AK, Jansen L. The effects of voluntary front-of-pack nutrition labels on volume
13 shares of products: the case of the Dutch Choices. *Public Health Nutr*. 2019 Oct;22(15):2879-2890.
14 doi: 10.1017/S1368980019001423
- 15 - Smed, S., Edenbrandt, A.K., Koch-Hansen, P. and Jansen, L. (2017), "Who is the purchaser of
16 nutrition-labelled products?", *British Food Journal*, Vol. 119 No. 9, pp. 1934-
17 1952. <https://doi.org/10.1108/BFJ-11-2016-0552>
- 18 - Smed S, Jensen JD Denver S. Socio-Economic Characteristics and the Effect of Taxation as a Health
19 Policy Instrument," *Food Policy*, 2007;32 (5-6): 624-639.
20 <http://dx.doi.org/10.1016/j.foodpol.2007.03.002>
- 21 - Smethers AD, Rolls BJ (2018) Dietary management of obesity: cornerstones of healthy eating
22 patterns. *Med Clin North Am* 102:107–124. doi: 10.1016/j.mcna.2017.08.009
- 23 - Stanton AV, Leroy F, Elliott C, Mann N, Wall P, De Smet S. 36-fold higher estimate of deaths
24 attributable to red meat intake in GBD 2019: is this reliable ?. *The Lancet Correspondance*, 2022:
25 399: 10332, E23-E26. doi: 10.1016/S0140-6736(22)00311-7
- 26 - Storcksdieck Genannt Bonsmann S, Marandola G, Ciriolo E, Van Bavel R, Wollgast J, Front-of-pack
27 nutrition labelling schemes: a comprehensive review, EUR 29811 EN, Publications Office of the
28 European Union, Luxembourg, 2020, ISBN 978-92-76-08971-1, doi:10.2760/436998, JRC113586.
- 29 - Suez J, Cohen Y, Valdés-Mas R, Mor U, Dori-Bachash M, Federici S, Zmora N, Leshem A,
30 Heinemann M, Linevsky R, Zur M, Ben-Zeev Brik R, Bukimer A, Elyahu-Miller S, Metz A,
31 Fischbein R, Sharov O, Malitsky S, Itkin M, Stettner N, Harmelin A, Shapiro H, Stein-Thoeringer
32 CK, Segal E, Elinav E. Personalized microbiome-driven effects of non-nutritive sweeteners on
33 human glucose tolerance. *Cell*. 2022 Sep 1;185(18):3307-3328.e19. doi:
34 10.1016/j.cell.2022.07.016
- 35 - Sun H, Weaver CM. Decreased Iron Intake Parallels Rising Iron Deficiency Anemia and Related
36 Mortality Rates in the US Population. *J Nutr*. 2021 Jul 1;151(7):1947-1955. doi: 10.1093/jn/nxab064.
- 37 - Temple NJ. Front-of-package food labels: A narrative review. *Appetite*. 2020 Jan 1;144:104485. doi:
38 10.1016/j.appet.2019.104485.
- 39 - Triptolemos foundation. Food classification report: the concept "ultra processed". June 2020.
40 www.triptolemos.org
- 41 - Van Tongeren C, Jansen L. Adjustments Needed for the Use of Nutri-Score in the Netherlands: Lack
42 of Selectivity and Conformity with Dutch Dietary Guidelines in Four Product Groups. *Intern J Nutrition
43 and Food Sciences* 2020; 9(2): 33-42 doi: 10.11648/j.ijnfs.20200902.11
- 44 - Visioli F, Marangoni F, Poli A, Ghiselli A, Martini D (2021) Nutrition and health or nutrients and health?
45 *Int J Food Sci Nutr* doi: 10.1080/09637486.2021.1937958
- 46 - Wahl D, Cogger VC, Solon-Biet SM, Waern RV, Gokarn R, Pulpitel T, Cabo Rd, Mattson MP,
47 Raubenheimer D, Simpson SJ, Le Couteur DG. Nutritional strategies to optimise cognitive function in
48 the aging brain. *Ageing Res Rev*. 2016 Nov;31:80-92. doi: 10.1016/j.arr.2016.06.006
- 49 - Wansink B, Chandon P (2006) Can, "Low-Fat" nutrition labels lead to obesity? *J Marketing Res* 3:605–
50 617. doi: 10.1509/jmkr.43.4.605
- 51 - Weaver CM. Dairy matrix: is the whole greater than the sum of the parts? *Nutr Rev*. 2021 Dec
52 8;79(Suppl 2):4-15. doi: 10.1093/nutrit/nuab081

- White V, Bariola E, Faulkner A, Coomber K, Wakefield M. Graphic Health Warnings on Cigarette Packs: How Long Before the Effects on Adolescents Wear Out? *Nicotine Tob Res* (2015) 17:776–783. doi: 10.1093/ntr/ntu184
- Zhang H, Greenwood DC, Risch HA, Bunce D, Hardie LJ, Cade JE. Meat consumption and risk of incident dementia: cohort study of 493,888 UK Biobank participants. *Am J Clin Nutr* 2021;114:175–84.

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Table 1: Different examples of Front-of-Pack Labels

	Informative Non-Directive	Semi-directive	Directive
Definition	Provides information such as the name of nutrients included, their amount in grams, and their percentage in relation to total daily requirements	Provides not only nutritional information, but also an evaluative element such as a color, a word, or a sign that gives additional information emphasizing the healthiness levels of single nutrients	Includes little information, often aggregated in a single symbol, and combining several criteria. Some of them (Swedish Keyhole and Dutch Healthy Choices) are applied on products in combination with nutritional information labels front-of-pack or back-of-pack. Other (e.g. Nutri-Score) only give an indication about the healthiness of the product, expressing judgements, opinions and/or recommendations, without providing specific information on single nutrients.
Examples	<p>Nutriform Battery</p>	<p>1) English traffic light or <i>Multiple Traffic Light - MTL</i></p> <p>2) Warning Signs which may feature the octagon "stop" or the words "rich in" (Chile)</p> <p>3) Israeli system of red pictures for excess salt, fat or sugar and positive green symbols for healthy products</p>	<p>1) Swedish Keyhole</p> <p>2) Nutri-Score</p> <p>3) Dutch Healthy Choices</p>