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# Nutri-Score – Assessment of Modified Algorithm Impact on Breakfast Cereals Category

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## Abstract

**Background:** The Nutri-Score (NS) algorithm has been revised to be more discriminating. We wanted to evaluate its reliability in arbitrating food choices within the category of breakfast cereals, an emblematic breakfast food for children.

**Methods:** Comparison of the initial and modified Nutri-Score scores, indicated on the packaging and simulated, of breakfast cereals available in the largest supermarkets, discount stores and organic chains in France, Belgium and Luxembourg.

**Results:** The Nutri-Score of breakfast cereals is strongly impacted by the modification of the algorithm with a decrease in A (35.4% to 24.2%) and B (15.4% to 8.2%) scores, an increase in D (14.1% to 28.6%) and the appearance of E. 86.0% of the originally B products go to C and 52.6% of the C to D. The modified NS penalizes sugars more and therefore impacts breakfast cereals marketed to children more, with 71.4% of NS degraded, 75.0% of A recipes degraded to C and the disappearance of NS B. The modified version exacerbates the nutritional superiority of organic cereals compared to non-organic cereals with increased gaps in NS A (35.5% vs. 10.3%) and D (19.9% vs. 39.3%). Our study shows a linear consistency between the NS and the degree of food processing expressed by the NOVA score, improved by the update. UPFs (n=448) are more severely rated with the modified version: drastically fewer NS A and B, more D and appearance of E.

**Conclusions:** The modified Nutri-Score allows a stricter rating of cereal products' nutritional quality by penalizing recipes according to their sugar content and in improved consistency with their degree of food processing.

**Keywords:** Breakfast cereals; Children; Nutritional quality; Nutrient profiling system; Nutri-Score; Food composition; Nutrition labelling; NOVA; Public Health; Sugar; Ultra-processed foods

## Introduction

One of the main public health strategies to reduce the prevalence of chronic diseases in children and adolescents is the implementation of preventive policies aimed at promoting healthier diet [1]. Among many measures, the expert groups recommended the use of front-of-pack labelling, to better inform consumers about the nutritional quality of foods through visible and understandable labels [2,3]. France's 2019–2024 National Nutrition and Health Programme (PNNS) [4] and Recommendations for the Development of the 5th PNNS [5] recommend that families use the Nutri-Score (NS) indicator to identify the nutritional value of food products and compare them within a category, limiting NS D and E foods and beverages aimed at improving public health and encouraging healthier eating habits [6,7]. Different studies demonstrate the effectiveness of NS to influence food choice, a positive effect of NS on purchases more reliable with public health recommendations

in adults, adolescents and their parents [8,9]. To date in Europe, France, Belgium (2017), Spain (2018), Germany, Switzerland, the Netherlands (2019) and Luxembourg (2020) have voluntarily adopted the Nutri-Score, while a discussion is underway within the European Commission to identify and choose the most appropriate voluntary labelling, with a view to European harmonization [10]. The international scientific committee composed of scientists from the seven countries, was tasked by transnational governance with updating the algorithm underlying the NS by proposing a combination of modifications to strengthen its effectiveness in "discriminating products based on their content of certain nutrients of concern (e.g., sugars and salt) supported by available evidence on their health benefits and nutrient density, as well as current national dietary and nutrition guidelines" [11]. Adopted on July 26, 2022, the new algorithm came into force on January 1, 2024 in Germany, Belgium, Switzerland and the Netherlands, in



Luxembourg on March 5, 2024 and in France on March 16, 2025 [12].

Although the initial algorithm was validated for its consistency with national dietary recommendations [12, 13] and its ability to assess the nutritional quality of diets [6,12] [14-16] its update has made it possible to correct certain identified limitations, allowing better alignment with current nutritional recommendations [17] notably via more demanding criteria on sugar and salt [17]. Thus, Sarda et al. [18] based on 41 criteria, confirmed that the updated NS system assesses foods more consistently with the French nutritional recommendations and improves the existing system. Recent studies have found that consumption of foods with a higher updated NS (reflecting a lower overall nutritional quality of the diet) was associated with higher risks of total cardiovascular events (hazard ratio (HR) per standard deviation of 1: 1.03 (95% confidence interval: 1.01-1.05)), particularly myocardial infarction (HR = 1.03 (1.01-1.07)) [19] of stroke (RR = 1.04 (1.01-1.07)) as well as a moderate association with an increased risk of colorectal cancer.

Iconic breakfast food for children, breakfast cereals are very common in homes (54.4% penetration rate among 6-17-year-olds in France [20]) and are an emblematic category of the choice guided by the NS which has led to numerous reformulations of recipes on the market [21]. The algorithm was updated to be more restrictive, then as a professional association of paediatric dietitians (CEDE - Club Européen des Diététiciens De l'Enfance), we wanted to measure the impact of this recent modification of the algorithm on this category of breakfast cereals, in order to know if it is more suitable in arbitrating food choices within the category of breakfast cereals offered in France, Belgium and Luxembourg for children.

## Materials and Methods

### Data collection

For a previous study [22] we selected based on market share the main supermarket, discount store and organic retailer in France, Belgium and Luxembourg. We visited these stores to record, through full-length photographs of the packaging, all the breakfast cereals sold between January 3 and 25, 2022. This data was entered into a record, which was verified each time by a different operator.

### Nutri-Score

We noted the NS present on each package and calculated it when it was not present, as well as all modified NS, using the calculation file provided by Santé Publique France.

### Degree of food processing

In line with the PNNS recommendation to reduce the consumption of ultra-processed foods (UPF) (as defined by the

NOVA classification) by 20% for the entire population [4] we used this classification to classify the cereals in our sample un-/minimally processed foods (NOVA 1), culinary ingredients (NOVA 2), processed foods (NOVA 3) and UPF (NOVA 4) based on the analysis of the ingredients lists [23].

### Statistical Analysis

Quantitative variables were described using means and standard deviations, or medians and interquartile ranges when distributions were non-normal. Categorical variables were summarised as counts and percentages. Associations between the binary outcome and selected covariates (sugar, fibre, saturated fatty acids, cereal content) were analysed using logistic regression. Results are presented as regression coefficients with standard errors or as odds ratios with 95% confidence intervals. Statistical significance was set at  $\alpha = 0.05$ . Analyses were conducted using SAS 9.4.

## Results

### Sample Characteristics

A total of 559 products were analysed. The products were classified based on their legal sales name according to the classification developed by Oqali [24] used in the previous publication [22]. The main categories represented are Muesli, Oats and Flakes (MOF) (62.1%) followed by stuffed, extruded or puffed cereals (26.3%). Kids oriented marketing have been identified using the International Network for Food and Obesity/NCDs Research Monitoring protocol [25]: gifts, games, licences, cartoons and references to children. Chocolate, chocolate caramel, honey / caramel, filled cereals and sugar cereal flakes are mostly marketed aimed at children (68.0 to 100.0%). We will therefore consider the cereals from these 5 families as 'child-targeted breakfast cereals' in the rest of the study (n=161; 28.8% of the sample). More than half of the sample is organic (54.9%; n=307), but few (29.2%) child-targeted breakfast cereals are organic.

### Nutri-Score

Less than half (n=235; 42.0%) of the products are voluntary carriers of NS in our sample.

The distribution of NS in the total sample is strongly impacted by the change of algorithm (Figure 1) with a decrease in scores A and B, an increase in score D and the appearance of score E for 4.5% of the sample. 48.3% of cereals saw their NS downgraded following the algorithm change, mainly by one letter (43.1%). Products originally rated NS B and above at the margin C were the most impacted, with 86.0% moving to C and 52.6% moving to D respectively (Table 1). Products initially rated A and D remained in their category for more than 60.0%.

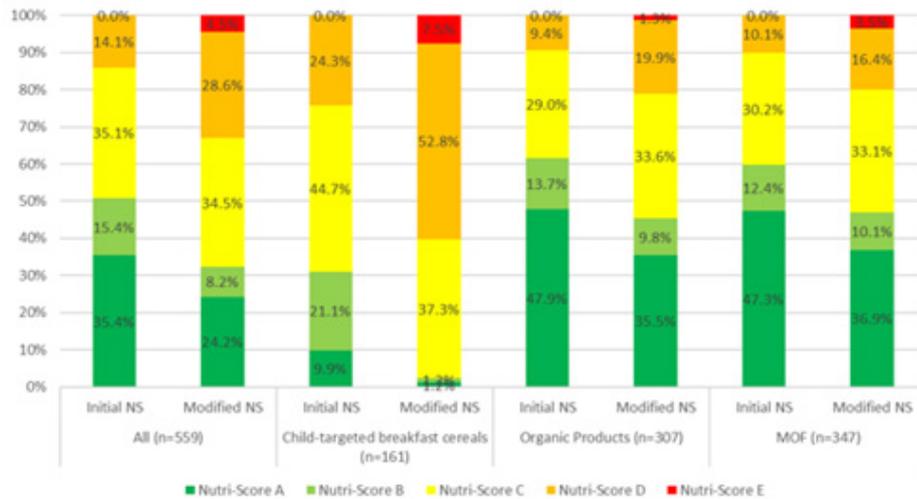


Figure 1: Evolution of Nutri-Score after modification of the algorithm

Table 1: Evolution by level of the modified Nutri-Score vs. initial Nutri-Score of the total sample (n=559)

Modified Nutri-Score		A	B	C	D	E
Initial Nutri-Score.						
A	198	67.2%	19.7%	13.1%	0.0%	0.0%
B	86	2.3%	8.1%	86.0%	3.5%	0.0%
C	196	0.0%	0.0%	47.4%	52.6%	0.0%
D	79	0.0%	0.0%	0.0%	68.4%	31.6%
E	0	-	-	-	-	-
		<b>Bonus Score +1</b>	<b>Invariant Score</b>	<b>Degraded Score -1</b>	<b>Degraded Score -2</b>	
All scores	559	0.4%	51.3%	43.1%	5.2%	

**Determinants of Nutri-Score changes**

Modified NS further discriminates between breakfast cereals by their sugar content, with more stringent thresholds (Figure 2) and a better distribution of sugar content over 5 letters rather than 4, as well as reduced overlap phases, especially between B and C. The new algorithm also more accurately distributes cereals according to their fatty acid content across the five classes, with the emergence of a class E concentrating the highest levels of saturated fatty acids (SFA) (Supplemental Figure S1). The two most influential components in the NS were nevertheless reversed: in the initial

NS, saturated fatty acids were the most influential; in the modified version, sugar became the predominant nutrient (Supplemental Tables S1 and S2). For both NSs, salt was the third most influential nutrient (along with fiber for the modified version). Energy was a relatively unimportant factor due to its low content. For the modified NS, the influence of protein at an intermediate rank was confirmed (Supplemental Tables S1 and S2). Breakfast cereals initially rated A contained an average of 9.1g/100g of sugars and 9.4g/100g of fiber; 6.4g/100g of sugars and 10.3g/100g of fiber with modified NS.

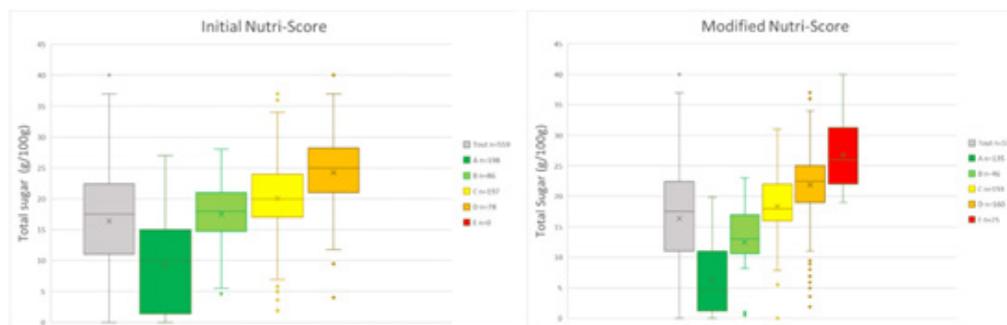


Figure 2: Comparison of sugar contents by initial (left) and modified (right) score

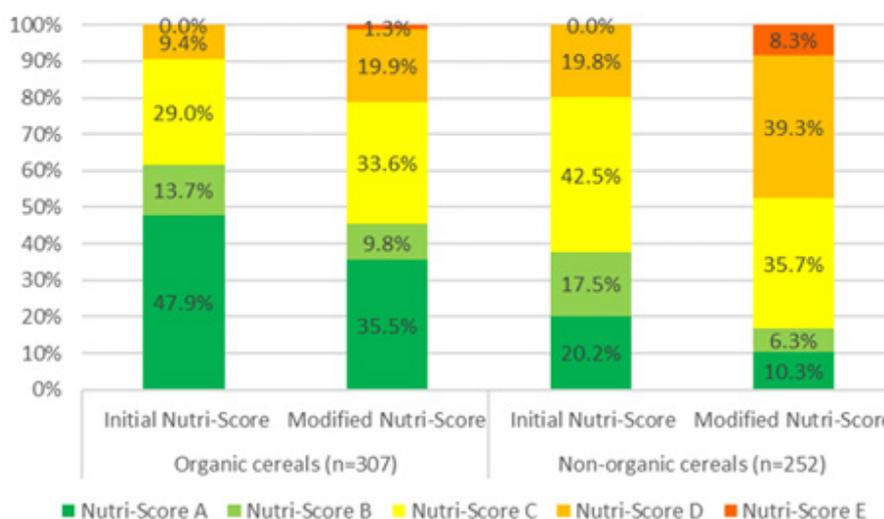
## Analysis of organic cereals

Even within organic cereals, the modified algorithm is more punitive with a decrease in NS A (47.9% to 35.5%) and B (13.7% to 9.8%), more NS C (29.0% to 33.6%) and especially D (9.4% to 19.9%); and the appearance of a category E. (Figure 1). Overall, 37.8% of the scores are degraded. The vast majority (85.7%) of B products are degraded to C. 59.6% of C products are maintained in

C but 40.4% move to D where they swell the ranks of 86.2% of D products which are maintained in D (Table 2). In the initial version of the NS, organic cereals (n=307) had significantly more A scores (47.9%) and fewer D scores (9.4%) (Figure 3) than conventional cereals, 20.2% and 19.8% respectively ( $p < 0.0001$ ). The modified NS algorithm exacerbates the nutritional superiority of organic cereals over conventional cereals with even more significant differences in NS A (35.5% vs. 10.3%) and D (19.9% vs. 39.3%) (Figure 3).

**Table 2:** Evolution by level of the modified Nutri-Score vs. initial Nutri-Score of organic references (n=307)

Modified Nutri-Score		A	B	C	D	E
Initial Nutri-Score						
A	147	72.8%	17.7%	9.5%	0.0%	0.0%
B	42	4.8%	9.5%	85.7%	0.0%	0.0%
C	89	0.0%	0.0%	59.6%	40.4%	0.0%
D	29	0.0%	0.0%	0.0%	86.2%	13.8%
E	0	-	-	-	-	-
		<b>Bonus Score +1</b>	<b>Invariant Score</b>	<b>Degraded Score -1</b>	<b>Degraded Score -2</b>	
All scores	<b>307</b>	<b>0.7%</b>	<b>61.6%</b>	<b>33.2%</b>	<b>4.6%</b>	

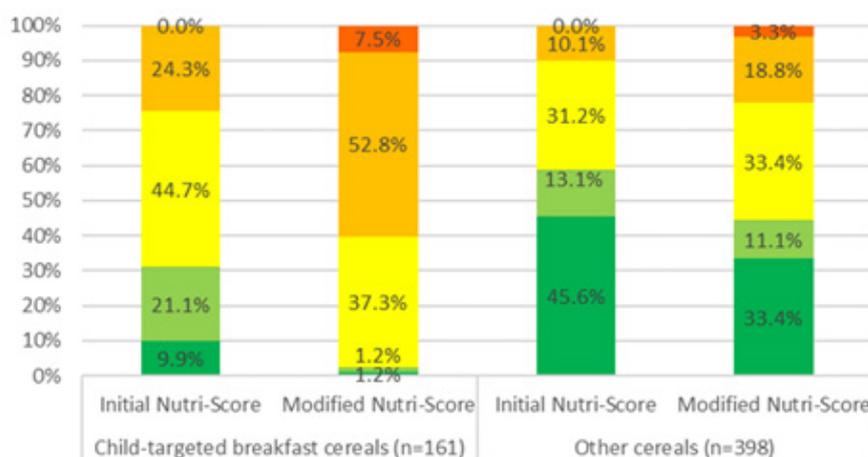


**Figure 3:** Initial and modified Nutri-Score of organic (left) and non-organic (right) cereals

## Analysis of child-targeted breakfast cereals

The child-targeted breakfast cereals (n=161) all contain added sugars and are the most impacted by the new algorithm (Figure 1) With the initial NS, child-targeted breakfast cereals have significantly fewer NS A and more NS C and D than other cereals (OR=3.6, 95% CI: 2.6-5.2) (22). The modified version of NS further accentuates the difference with other cereals (OR=6.5, 95% CI: 4.5-9.4) (22). We therefore observe, for child-targeted breakfast cereals, a virtual disappearance of NS A and B (Figure 4). 71.4% of children's recipes saw their NS downgraded (Table 3), compared to 38.9% for other cereals. A large majority (75.0%) of A recipes

were downgraded by 2 letters and moved to C. 91.2% of B recipes moved to C, 76.4% of C recipes were downgraded to D and 30.8% of D recipes became E. For child-targeted breakfast cereals, we also observe better scores for organic products than for conventional products, but to a lesser extent: 14.6% score A versus 8.0%, 16.7% score D versus 27.4%. The modified algorithm eliminates classes A and B for child-targeted breakfast cereals, whether organic or not, increasing the proportion of C (45.8% in organic versus 33.6% in conventional) and much larger shares of NS D and E, especially for non-organic child-targeted breakfast cereals (Supplemental Figure S2).



**Figure 4:** Initial and modified Nutri-Score of child-targeted breakfast cereals (left) and others (right) cereals

**Table 3:** Evolution by level of the modified Nutri-Score vs. initial Nutri-Score of the child-targeted breakfast cereals (n=161)

Modified Nutri-Score		A	B	C	D	E
Initial Nutri-Score						
A	16	12.5%	12.5%	75.0%	0.0%	0.0%
B	34	0.0%	0.0%	91.2%	8.8%	0.0%
C	72	0.0%	0.0%	23.6%	76.4%	0.0%
D	39	0.0%	0.0%	0.0%	69.2%	30.8%
E		-	-	-	-	-
		<b>Bonus Score +1</b>	<b>Invariant Score</b>	<b>Degraded Score -1</b>	<b>Degraded Score -2</b>	
All scores	<b>161</b>	<b>0.0%</b>	<b>28.6%</b>	<b>62.1%</b>	<b>9.3%</b>	

### Analysis of mueslis and flakes

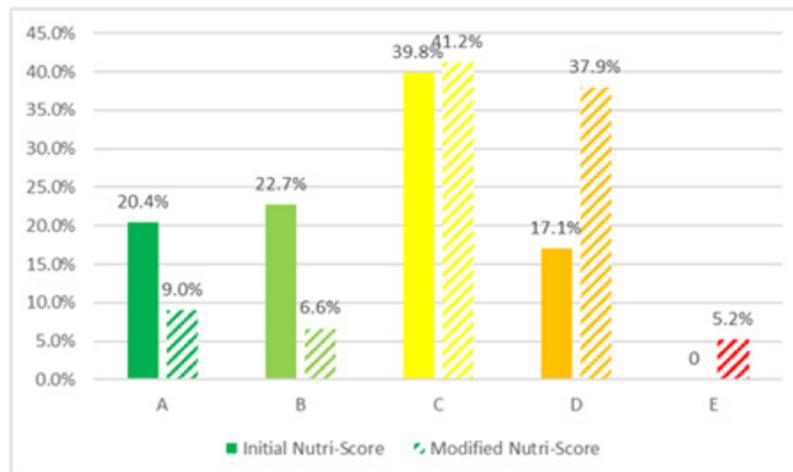
In the initial NS, the MOF category “flakes/mueslis” (n = 347) obtained a more favourable score than the other categories studied. Nearly half (47.3%) were rated A, 12.4% B, 30.2% C and 10.1% D (Figure 1). The modified NS degrades these results to 36.9% of A, 10.1% B, 33.1% C, 16.4% D and we see 3.5% of score E (p>0.0001). Overall, 34.3% of MOF are degraded (Table 4). It is mainly the NS B (81.4%) which are degraded to C. The vast majority (76.8%) of

A recipes remain in A. This group includes 104 recipes for flakes without added sugar and 243 sweetened “flakes/mueslis”, mainly mueslis, to which sugar is added in various forms (sucrose, honey, glucose syrup, etc.). It can be observed that the deterioration mainly concerns sweetened “flakes/mueslis” (44.9%) (Supplemental Table S3) while only 9.7% of “flakes/mueslis” without added sugar are degraded (Supplemental Table S4). Among the sweetened flakes and mueslis, 81.0% of the B recipes go to C, 32.4% of the C to D and 34.3% of the D to E (Supplemental Table S3).

**Table 4:** Evolution by level of the modified Nutri-Score vs. initial Nutri-Score of the MOF category (n=347)

Modified Nutri-Score		A	B	C	D	E
Initial Nutri-Score						
A	164	76.8%	17.7%	5.5%	0.0%	0.0%
B	43	4.7%	14.0%	81.4%	0.0%	0.0%
C	105	0.0%	0.0%	67.6%	32.4%	0.0%
D	35	0.0%	0.0%	0.0%	65.7%	34.3%
E	0	-	-	-	-	-
		<b>Bonus Score +1</b>	<b>Invariant Score</b>	<b>Degraded Score -1</b>	<b>Degraded Score -2</b>	
All scores	<b>347</b>	<b>0.6%</b>	<b>65.1%</b>	<b>31.7%</b>	<b>2.6%</b>	

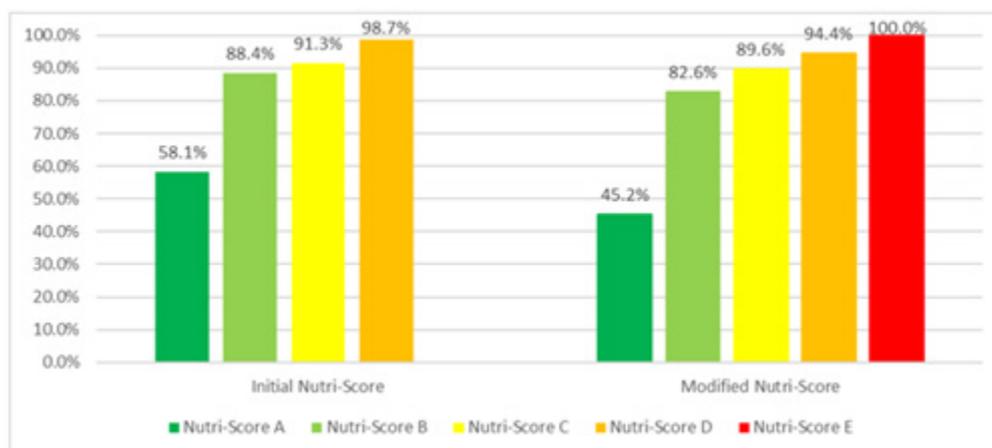
## Correlation with degree of food processing



**Figure 5:** Initial and modified Nutri-Score of ultra-processed recipes (n=448) in the sample

When reading the ingredient lists, 80.1% (n=448) recipes are ultra-processed (NOVA 4) in our sample. This rate rises to 93.8% in the child-targeted breakfast cereals categories and is lower in organic cereals (66.1%). These ultra-processed recipes (n=448) are more severely rated in NS with the modified version: drastically less

NS A and B, more D and appearance of E (Figure 5). Furthermore, we observe a consistent gradient with increasingly high rates of UPF between A and E and an over-representation in D and E (more than 90% of products are UPF) in the 2 versions of the NS (Figure 6).



**Figure 6:** Distribution of initial and modified Nutri-Score of ultra-processed recipes (n=448) in the sample

## Discussion

Our analysis focused on the impact of changes to the Nutri-Score algorithm on the category of breakfast cereals sampled in stores in France, Belgium and Luxembourg. Calculations from the Public Health France calculation file [11] shows that the new algorithm is significantly more discriminating in the breakfast cereal category, in our sample: decrease in scores A and B, increase in score D and appearance of score E. The products originally NS B and C are the most impacted: 86.0% of NS B go to C and 52.6% of C go to D. These results are consistent with the work of Sarda et al. [18] which showed that the updated algorithm was more discriminating than the initial algorithm for critical nutrients

for 63% (5/8) of the criteria. The authors observed, as here, a shift from the most favourable classes to less favourable classes, particularly for breakfast cereals. According to the authors « the algorithm became stricter with sweet and highly salty products, with the increase in the maximal number of points in the sugar and salt component, whereas higher amounts of fiber and protein are required to receive points for the positive components. » [18]. Indeed, as part of the algorithm rework, the discrimination of products based on their content of certain nutrients of concern such as salt and sugar, supported by the available evidence concerning their health benefits and their nutritional density, as well as on the dietary and nutritional recommendations in force in the countries, was a priority for improvement [11]. The breakfast cereal category

was explicitly cited with the aim of better « to discriminate between sugar-rich breakfast cereals and those containing less sugar» [11]. Our analyses confirm that the reworking objective has been achieved with better discrimination of cereals according to their sugar content with more demanding thresholds and a better distribution of sugar contents over 5 letters and no longer 4, as well as more reduced overlap phases, especially between B and C. Breakfast cereals rated A using the original algorithm contained an average of 9.1g/100g of sugar; with the updated algorithm, it was 6.4g/100g. Sugar has become the most influential component in determining a breakfast cereal's score.

These results are consistent with the conclusions of the report [11] « there was higher discrimination for products according to their sugar content, in particular in the dairy and the breakfast cereal categories, with a limited number of products with relatively high amounts of sugars (reflecting most likely free/added sugars) reaching the A or B categories. In these categories, a discrimination was operated between non-sweetened and sweetened variants ». Similarly, according to Sarda et al. [18]. The updated algorithm improved the initial classification, increasing the penalty for sugary breakfast cereals in line with nutritional recommendations. Other studies have shown that the sugar reformulation of breakfast cereals was decisive for their NS score. In a Dutch simulation scenario, reformulating breakfast cereals by reducing SFA and sugars actually improved the NS [26]. Moreover, a reformulation of breakfast cereals was observed between 2017 and 2018 in Belgium, in anticipation of the implementation of the NS, with statistically significant reductions in total sugar (-5%) and sodium (-20%) and increases in fiber (+3%) and protein (+2%). Conversely, the work of Kroury et al. [27] found that the modified NS altered the overall classification of breakfast cereals with a rating in favour of the less favourable. This change tended to group products according to similar ratings and somewhat reduced the discriminatory ability of the algorithm within this specific food group, resulting in a relatively lower discriminatory ability compared to the initial version.

In our study, cereals initially rated higher, in A, were also downgraded to B or C by 32.8%. These cereals were often Muesli, Oats and Flakes (MOF) (347) of which almost half (47.3%) were initially rated A. In this category, 34.3% of recipes were downgraded. This is actually the fraction of flakes and mueslis with added sugars (n=243) which were downgraded by 44.9% compared to only 9.7% for flakes without added sugars.

These results indicate a better sensitivity of the modified algorithm to the presence of added sugars, which helps to correct the overestimated perception of the nutritional quality of sweet mueslis which benefit from a favourable image among consumers, perceived as healthy due to their richness in fiber and their cereal content. This change in the classification scale is all the more marked since cereal products marketed as “natural” or “high in fiber” often benefit from a health halo effect, which influences consumer perceptions regardless of the actual sugar content. This effect has been widely documented. Stoltze et al. have shown that positive nutritional claims (e.g., “source of dietary fiber”) often mask nutritional imbalances, including high sugar content, by artificially

improving their health image in the eyes of consumers [28]. Similarly, García et al. observed that this bias is particularly strong in marketing aimed at children, with an increased risk of poor food choices [29]. Similarly, the change of algorithm exacerbates the nutritional superiority of organic cereals (n=307) which already in the initial version presented significantly more A scores (47.9%) and fewer D scores (9.4%) than non-organic (respectively 20.2% and 19.8% (p<0.0001)) with even more significant gaps in NS A (35.5% vs. 10.3%) and D (19.9% vs. 39.3%). However, the new calculation can also be penalizing for organic cereals, with 37.8% of the scores degraded, mainly NS B passing into C for 85.7%.

All child-targeted breakfast cereals (n=161) contain added sugars and are therefore particularly impacted by the new algorithm: 71.4% have their NS downgraded compared to 38.9% for other cereals. A phenomenon not observed in the other categories, a large majority (75.0%) of A recipes are downgraded by 3 letters and become C. 91.2% of B recipes become C, 76.4% of C recipes are downgraded to D and 30.8% of D recipes become E. With the initial NS already, child-targeted breakfast cereals were significantly less scored A and more C and D than other cereals (OR=3.6, 95% CI: 2.6-5.2) [22]. The modified version of NS further accentuates the gap with other cereals (OR=6.5, 95% CI: 4.5-9.4) [22] and in particular a near disappearance of NS A and B. This inferior nutritional profile of child-targeted breakfast cereals has been observed in other studies [30,31], in France [13] and Belgium [21], child-targeted breakfast cereals being higher in energy, sugars and salt and lower in protein and fiber [32]. For child-targeted breakfast cereals also, the modified NS further highlights the nutritional gap between organic and non-organic cereals. However, even organic child-targeted breakfast cereals remain of low nutritional quality with a NS D rate of 45.8%, the absence of NS A and a very low NS B rate (4.2%).

The failure to consider the degree of processing has been a point of criticism of the label. Numerous studies examining the associations between exposure to UPF, as defined by the NOVA food classification system, and adverse health effects have been published. In 2024, a systematic review including 45 meta-analyses, and 10 million participants, showed convincing evidence of an increased risk of mortality from cardiovascular disease, type 2 diabetes, and mental health disorders associated with increased exposure to UPF [33]. It has been suggested that these findings could be explained by the poor average nutritional profiles of UPF, which is supported by a meta-analysis conducted in 13 countries showing that high consumption of these foods is associated with poor nutritional quality [34], ultra-processed foods tend to contain more energy, salt, sugar or fat [35-38]. NS and NOVA are therefore correlated but are not collinear and correspond to complementary concepts [36,37] relevant to combine [39]. A large review of 37 cohort studies suggests that the observed negative association between TUEs and health outcomes cannot be explained solely by poor nutritional quality [40]. Our study shows a linear consistency between these two classification systems, improved by the algorithm update. We observe a linear gradient in the share of UPF per NS score with increasingly high rates of UPF between A and E and an over-representation in D and E, in both versions of

the NS. The modified version of the NS also scores ultra-processed recipes more severely: significantly fewer NS A and B, more D and appearance of E. These results confirm previous results [37,41, 42], as Sarda et al. [35] on 129,950 food products from Open Food Facts database, which found the most represented D and E scores for NOVA 4 products (initial algorithm 55.4% and updated algorithm 63.2%), and a lower proportion rated A or B (initial algorithm 22.1% and updated algorithm 12.5%). The breakfast cereal category also represented one of the categories with the greatest drop in the proportion of NOVA 4 products rated A or B thanks to the algorithm update.

### Study Limitations

The data used in this analysis come from a sampling for a previous study [22], but the objective of this publication was not to analyse the current market but to test the impact of the new algorithm on a pool of real data and being able to compare with the previous version of NS. NS may have limitations in its use for young children [43] not taking into account in particular the increased needs for essential fatty acids and LC-PUFA and tending to favour a protein intake higher than the nutritional reference values, even if the authors conclude that « Overall, warning against foods that are too rich in energy, sugar, SFA or sodium is also beneficial for children».

### Conclusion

The results presented here validate the hypothesis that the modified Nutri-Score constitutes a more robust tool for nutritionally discriminating between products, by penalizing products more closely based on their added sugars and with greater consistency with their degree of processing. The modified Nutri-Score allows for a more rigorous and accurate assessment of the nutritional quality of cereal products. It thus promotes more transparent nutritional information, in line with public health recommendations. In the long term, it could also encourage manufacturers to reformulate their products to meet a growing demand for foods with less sugar and more fiber.

### Supplementary Information

The online version contains supplementary material available at

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### Authors' Contributions

All authors conceptualised the project. E.F., F.M. and C.R. collected data. C.R., M.R. and F.M. supervised data analyses and interpretation. C.R. drafted the paper. M.R., F.M., E.F., F.M. interpreted the data and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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### Availability of data and materials

Data will be made available upon request from the authors.

### Declarations

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare no competing interests

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