Three criteria are enough: a MR-Sort model as an alternative to the Nutri-Score

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A quick question

INFORMATIONS NUTRITIONNELLES		
Valeurs nutritionnelles moyennes pour : / Average nutritional information for:	100 g / 100 g	1 barre (25 g) / 1 bar (25 g)
Energie / Energy (kJ)	1436	359
Energie / Energy (kcal)	343	86
Matières grasses / Fat	10 g	2,6 g
dont acides gras saturés / of which saturates	1,3 g	0,3 g
Glucides / Carbohydrate	48 g	12 g
dont sucres / of which sugars	0,8 g	0,2 g
dont polyols / of which polyols	23 g	5,8 g
Fibres alimentaires / Fibre	11 g	2,7 g
Protéines / Protein	18 g	4,5 g
Sel / Salt	0,48 g	0,12 g

1. Who knows the Nutri-Score label?
2. Who uses it to choose food products?

Plan

What is the Nutri-Score ?

- Front-of-pack nutritional label (A to E)
- Goal: provide a simple summary of nutritional quality
- Based on a single numerical score
- A unique formula for all the solid foods
- First version : 2017
- Second and updated version (in order to be more restrictive): 2025

Important

Behind this apparent simplicity lies an aggregation model.

Status of Nutri-Score by country

- Voluntary (official recommendation): France, Belgium, Spain, Germany, the Netherlands, Luxembourg and Switzerland.
- Officially rejected : Italy, Poland, Czech Republic, Greece
- Not used (no official recommendation): the other countries in the world

Plan

Nutri-Score's algorithm (2017 version)

Step 1: Calculate points for each nutrional information

Points	Energy (kJ)	Sugar (g)	Saturated fatty acids (g)	Sodium (mg)
0	≤ 335	≤ 4,5	≤ 1	≤ 90
1	> 335	> 4,5	> 1	> 90
2	> 670	> 9	> 2	> 180
3	>1005	> 13,5	> 3	> 270
4	> 1340	> 18	> 4	> 360
5	> 1675	> 22,5	> 5	> 450
6	> 2010	> 27	> 6	> 540
7	> 2345	> 31	> 7	> 630
8	> 2680	> 36	> 8	> 720
9	> 3015	> 40	> 9	> 810
10	> 3350	> 45	> 10	> 900

Points	Fruit, vegetables (%)	Fibers (g)	Proteins (g)
0	≤ 40	≤ 0,9	≤ 1,6
1	> 40	> 0,9	> 1,6
2	> 60	> 1,9	> 3,2
3	-	> 2,8	> 4,8
4	-	> 3,7	> 6,4
5	> 80	> 4,7	> 8,0

Positive points : 10

Nutritional information	Value (per 100 g)	Points
Proteins (g)	18	**5** / 5
Fibers (g)	11	**5** / 5
Fruits/vegetables (%)	4	**0** / 5

Negative points : 7

Nutritional information	Value (per 100 g)	Points
Energy (kJ)	1435	**4** / 10
Sugar (g)	0.8	**0** / 10
Saturated fatty acids (g)	1.3	**1** / 10
Sodium (mg)	192	**2** / 10

Step 2: Nutri-Score calculation

$$\text{Nutritional score} = \text{Negative points} - \text{Positive points}$$

Nutritional score of $a = 7 - 10 = -3$

Step 3: Nutri-Score label

POINTS SOLID FOOD	POINTS BEVERAGES	NUTRI-SCORE
-15 to -1	Water	A
0 to 2	≤ 1	B
3 to 10	2 to 5	C
11 to 18	6 to 9	D
19 to 40	10 to 40	E

Nutri-Score label of a = **A**

Nutri-Score's algorithm (2025 version): scales

Points	Energy (KJ/100 g)	Saturated fatty acids (g/100 g)	Sugars (g/100 g)	Salt (g/100 g)
0	≤ 335	≤ 1	≤ 3.4	≤ 0.2
1	> 335	> 1	> 3.4	> 0.2
2	> 670	> 2	> 6.8	> 0.4
3	> 1005	> 3	> 10	> 0.6
4	> 1340	> 4	> 14	> 0.8
5	> 1675	> 5	> 17	> 1
6	> 2010	> 6	> 20	> 1.2
7	> 2345	> 7	> 24	> 1.4
8	> 2680	> 8	> 27	> 1.6
9	> 3015	> 9	> 31	> 1.8
10	> 3350	> 10	> 34	> 2
11			> 37	> 2.2
12			> 41	> 2.4
13			> 44	> 2.6
14			> 48	> 2.8
15			> 51	> 3
16				> 3.2
17				> 3.4
18				> 3.6
19				> 3.8
20				> 4

Points	Proteins (g/100 g)	Fibers (g/100 g)	Fruits, vegetables & legumes (%)
0	≤ 2.4	≤ 3.0	≤ 40
1	> 2.4	> 3.0	> 40
2	> 4.8	> 4.1	> 60
3	> 7.2	> 5.2	-
4	> 9.6	> 6.3	-
5	> 12	> 7.4	> 80
6	> 14		
7	> 17		

Nutri-Score's algorithm (2025 version) : labels

Score range	Class	Color
[-17;0]	A	Dark green
[1;2]	B	Light green
[3,10]	C	Yellow
[11;18]	D	Light orange
[19;55]	E	Red or Dark orange

Plan

MultiCriteria Decision Aid (MCDA)

Aim

To help a decision-maker (DM) to select one or more alternatives among several alternatives evaluated on $|N|$ criteria often contradictory.

$\Rightarrow$ We need to construct a preference relation over the set of all alternatives X

Nutri-Score viewed as a MCDA problem

N is a set of nutritional information and X is a set of foods

- 4 criteria to be minimized (negative nutrients)
  1. Energy (kJ)
  2. Sugar (g)
  3. Saturated fatty acids (g)
  4. Sodium (mg)

- 3 criteria to be maximized (positive nutrients)
  1. Proteins (g)
  2. Fibers (g)
  3. Fruits/vegetables (%)

Marginal utility functions for the criteria to be minimized

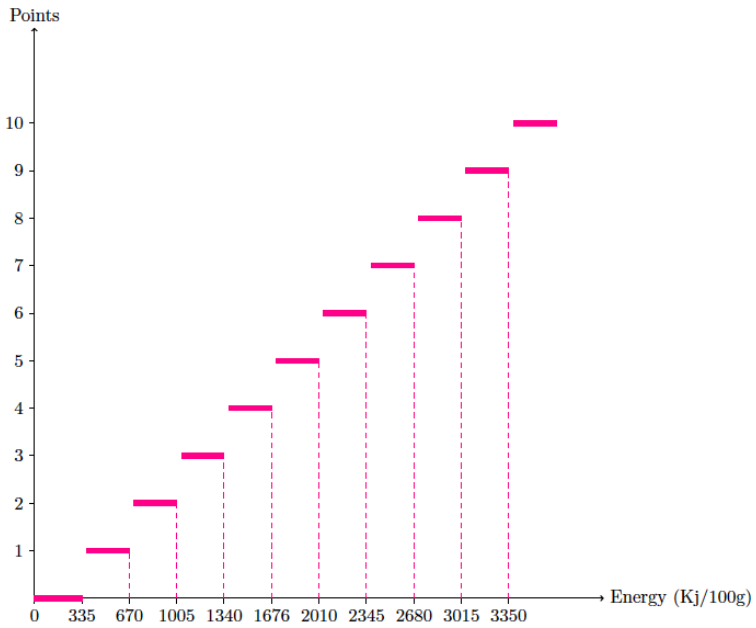

Figure: Scale of Nutri-Score

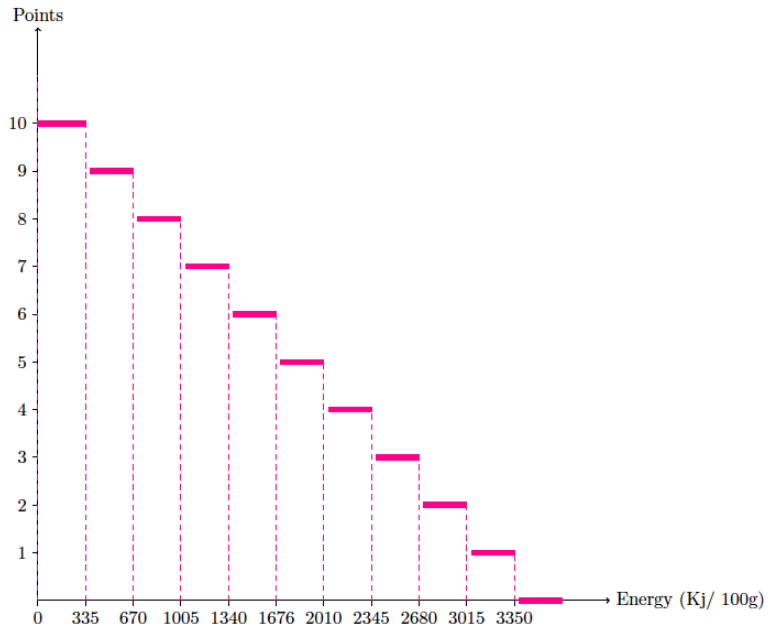

Figure: Our marginal utility function

$$u_i(x_i) = 10 - \text{ points given by the Nutri-Score}$$

Marginal utility functions for the criteria to be maximized

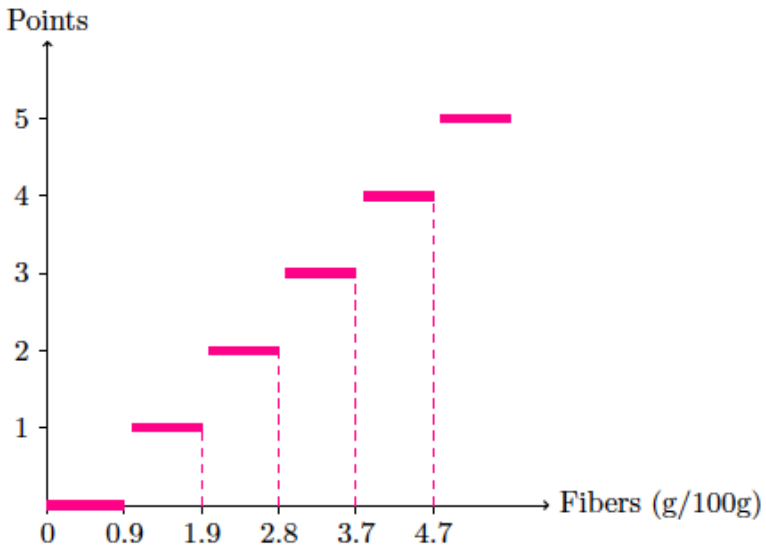

Figure: Scale of Nutri-Score

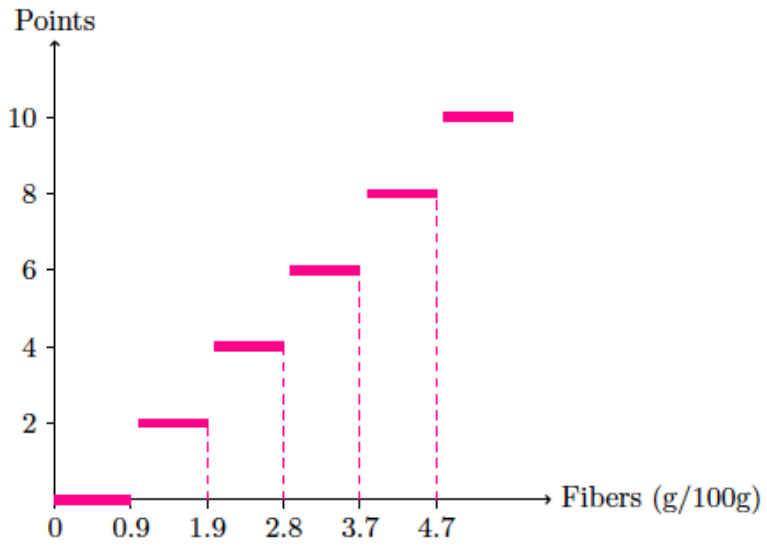

Figure: Our marginal utility function

$$u_i(x_i) = 2 \times \text{ points given by the Nutri-Score}$$

Example

Nutritional information	Value (per 100 g)	Points	Marg. uti. func.
Energy (kJ)	1435	**4** / 10	$u_{en}(a) = 6$
Sugar (g)	0.8	**0** / 10	$u_{su}(a) = 10$
Saturated fatty acids (g)	1.3	**1** / 10	$u_{sa}(a) = 9$
Sodium (mg)	192	**2** / 10	$u_{so}(a) = 8$
Proteins (g)	18	**5** / 5	$u_{pr}(a) = 10$
Fibers (g)	11	**5** / 5	$u_{fi}(a) = 10$
Fruits/vegetables (%)	4	**0** / 5	$u_{fr}(a) = 0$

Our additive model

$$F(x_{en}, x_{su}, x_{sa}, x_{so}, x_{pr}, x_{fi}, x_{fr}) = x_{en} + x_{su} + x_{sa} + x_{so} + \frac{1}{2}(x_{pr} + x_{fi} + x_{fr})$$

Example

Nutritional information	Value (per 100 g)	Points	Marg. uti. func.
Energy (kJ)	1435	**4** / 10	$u_{en}(a) = 6$
Sugar (g)	0.8	**0** / 10	$u_{su}(a) = 10$
Saturated fatty acids (g)	1.3	**1** / 10	$u_{sa}(a) = 9$
Sodium (mg)	192	**2** / 10	$u_{so}(a) = 8$
Proteins (g)	18	**5** / 5	$u_{pr}(a) = 10$
Fibers (g)	11	**5** / 5	$u_{fi}(a) = 10$
Fruits/vegetables (%)	4	**0** / 5	$u_{fr}(a) = 0$

$$F(a) = 6 + 10 + 9 + 8 + \frac{1}{2}(10 + 10 + 0) = 43$$

The Nutri-Score is equivalent to a weighted sum model

- 2017 version:

$$F(x_{en}, x_{su}, x_{sa}, x_{so}, x_{pr}, x_{fi}, x_{fr}) = x_{en} + x_{su} + x_{sa} + x_{so} + \frac{1}{2}(x_{pr} + x_{fi} + x_{fr})$$

$$\text{Nutri-Score}(x) = 40 - F(x)$$

- 2025 version:

$$W(x_{en}, x_{su}, x_{sa}, x_{so}, x_{pr}, x_{fi}, x_{fr}) = \frac{1}{42} \sum_{i \in \{en,sa\}} w_i(x_i) + \frac{1}{28} w_{su}(x_{su}) + \frac{1}{21} w_{so}(x_{so}) + \frac{1}{60} w_{pr}(x_{pr}) + \frac{1}{84} \sum_{i \in \{fi,fr\}} w_i(x_i)$$

$$\text{Nutri-Score}(x) = 55 - W(x)$$

The Nutri-Score is equivalent to a weighted sum model

Consequences

- Nutri-Score allows compensation between criteria
- The normalization of scales is needed
- The criteria are strongly correlated : Energy depends on sugar, fat, protein, ...

$$\begin{aligned} \text{Energy} = \; & (9 \times \text{fat}) + (7 \times \text{alcohol}) + (4 \times \text{protein}) \\ & + (4 \times \text{sugar}) + (2.4 \times \text{organic acids}) \\ & + (2.4 \times \text{polyols}) + (2 \times \text{fibers}) \end{aligned}$$

Example (Which food is healthy?)

Figure: Food *a*

Figure: Food *b*

Figure: Food *c*

Figure: Food *d*

Example (Which food is healthy?)

The Nutri-Score's answer: $b \succsim a \succ c \succ d$

Nutritional information	a	b	c	d
Energy (kJ)	1913	1506	1595	1838
Sugar (g)	12	14	9.1	26
Saturated fatty acids (g)	2	0.8	1	3.5
Sodium (mg)	0	16	620	440
Proteins (g)	8.5	11	11	7
Fibers (g)	10	9.4	7.5	3.5
Fruits/vegetables (%)	10	20	0	2.6
Nutri-Score (2017)	-2	-3	6	14
Nutri-Score Label (2017)	A	A	C	D
F(x)	42	43	34	26
Nutri-Score (2025)	1	-2	8	19
Nutri-Score Label (2025)	B	A	C	E
W(x)	57	58	49	41

Example (Which food is healthy ?)

Human judgments (and even LLMs) tend to follow Nutri-Score's recommendations

Rank	Product	Key Strengths	Potential Downsides
1	Bjorg Muesli Superfruits	High fiber, natural ingredients	Smaller package size
2	Cruesli - Mixed Nuts - Quaker	Nuts, whole grains	Possible added sugars
3	Cracotte Céréales Complètes - LU	Whole grains	May contain added sugars or fats
4	Kellogg's Trésor Chocolat	Tasty, larger package	High sugar, less nutritious ingredients

Rank	Product	Overall health value
🥇	**Bjorg Muesli Superfruits**	✅✅✅ Excellent
🥈	**Quaker Cruesli Mixed Nuts**	✅ Moderate
🥉	**LU Cracotte Complètes**	⚠️ Limited
🚫	**Kellogg's Trésor**	❌ Poor

Plan

Our Proposal

- Avoid redundant and correlated criteria
- Keep only:
  - Energy
  - Sodium
  - Fruits / Vegetables
- Keep also 5 ordered categories (A', B', C', D', E')
- Use a non-compensatory sorting model
- The model depends on the category of foods

Method

MR-Sort (Majority Rule Sorting)

Formal definition of MR-Sort

Let ordered categories $C^1(E')$, $C^2(D')$, ..., $C^5(A')$ be separated by limiting profiles π_k.

An alternative a is assigned to the highest category C^k such that:

$$\sum_{i \in N,\, a_i \geq \pi_{k,i}} w_i \geq \lambda$$

- w_i: criteria weights
- λ: majority threshold

Illustration : breakfast cereals

- 50 selected real breakfast cereals
- One specific food category
- Normative choice : no product should reach category A' easily

A MR-Sort model for breakfast cereals

- Limiting profiles

	en (kcal)	*so* (mg/100g)	% *fr*
Limiting profile A'/B'	350	200	40
Limiting profile B'/C'	380	300	30
Limiting profile C'/D'	420	400	20
Limiting profile D'/E'	470	500	10

- Weights: $w_{en} = 0.5$, $w_{so} = 0.3$ and $w_{fr} = 0.2$.
- Majority threshold: $\lambda = 0.6$

These parameters are explicit and debatable

	en (kcal)	*so* (mg/100g)	% *fr*
Limiting profile A'/B'	350	200	40
Limiting profile B'/C'	380	300	30
Limiting profile C'/D'	420	400	20
Limiting profile D'/E'	470	500	10
	0.5	0.3	0.2

$\lambda = 0.6$

Example (Which food is healthy?)

Nutritional information	*a*	*b*	*c*	*d*
Energy (kcal)	462	357	377	456
Sodium (mg)	0	16	620	440
Fruits/vegetables (%)	10	20	0	2.6
Nutri-Score Label (2017)	A	A	C	D
Nutri-Score Label (2025)	B	A	C	E
MR-Sort model	D'	B'	E'	D'

Results

Real Nutri-Score	MR-Sort classification				
	A'	B'	C'	D'	E'
A	0	5	2	3	0
B	0	3	2	5	0
C	0	0	2	7	1
D	0	0	2	5	3
E	0	0	0	6	4

- MR-Sort model is restrictive than Nutri-Score
- No cereal reaches category A'
- Systematic downward shifts compared to Nutri-Score

Plan

What have we learned ?

- Nutri-Score's algorithm is transparent
- Nutri-Score embeds strong normative assumptions
- MCDA makes these assumptions explicit
- Even simple models can be meaningful
- *Three criteria can be enough - if used properly.*

What next ?

- Eliciting the parameters of a such of MR-Sort model by using the preferences of a panel of experts (How to choose the experts ?)?
- Is the Nutri-Score can be explained by a MR-Sort model (if you believed to the Nutri-Score) ?
- . . . or Nothing ?

So ...

- Algorithms do not replace human judgment
- Perhaps it's enough to cook with fresh ingredients and, whenever possible, avoid processed foods.
- Yesterday, we enjoyed a wonderful meal, without thinking about the Nutri-Score !