

1 *Article*

2 **Comparison of the efficacy of five front-of-pack** 3 **nutrition labels in helping the Brazilian consumer** 4 **make a healthier choice**

5 Wendy A.M. Blom ^{1,*}, Chantal Goenee ², Lucia Juliano ³, Els M. de Groene ⁴ and Fernanda de
6 Oliveira Martins ⁵

7 ¹ Unilever Foods Innovation Centre Wageningen; Wendy.Blom@unilever.com

8 ² Unilever R&D Vlaardingen; chantalgoenee@hotmail.com

9 ³ Harris Interactive UK Ltd; LJuliano@harrisinteractive.co.uk

10 ⁴ Unilever Foods Innovation Centre Wageningen; Els-de.Groene@unilever.com

11 ⁵ Unilever Brazil; Fernanda.O.Martins@unilever.com

12

13 * Correspondence: Wendy.Blom@unilever.com; Tel.: +31 6 5040 9518

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16 **Abstract:** We tested, in an online survey, how well five different front-of-pack (FOP) labels helped
17 Brazilian consumers make a healthier choice between two food products as compared to a no FOP
18 label control. All 1072 respondents were randomly allocated to one of six groups 1) no FOP label
19 (control), 2) ABIA label, 3) GGALI[®] Nutrient Profile label, 4) IdeC label, 5) Hybrid label or 6) Nutri-
20 Score label and were all shown 9 food stimuli consisting of two products. The nutrient profiles of
21 ABIA and Hybrid labels consider serving size of the food whereas the other three labels score per
22 100g. Respondents were asked which of the two products they perceived to be the healthier choice.
23 Overall, the Hybrid and ABIA labels performed best, resulting in a statistically significantly higher
24 percentage of correct answers as compared to the control for 9/9 and 8/9 of the food stimuli,
25 respectively. The IdeC and GGALI[®] NP warning labels were least helpful, outperforming the control
26 group only once and twice, respectively. In conclusion, the Hybrid and the ABIA FOP labels, two
27 interpretative traffic light labels that use colours and provide nutritional information per serving,
28 were best suited to help Brazilian consumers choose the healthier product.

29 **Keywords:** online consumer research; front-of-pack label; Nutri-Score; warning label; traffic light
30 label; Brazil

31

32 **1. Introduction**

33 Although many countries and health organizations have issued dietary guidelines with clear
34 recommendations as to which food groups fit into a healthy diet and which foods and nutrients
35 should be consumed in moderation, adherence to dietary recommendations is low.

36 Nutrient declarations on the back of the pack provide important information about the
37 nutritional composition of food products, but consumers find this information complex and difficult
38 to understand [1,2]. That's why, Front-of-Pack (FOP) nutrition labelling systems are designed to help
39 the consumer make a quick, informed decision about the nutritional content or relative healthfulness
40 of a food or beverage.

41 There is no international standardization of FOP labels and therefore many different FOP labels
42 have been developed and implemented across the world [3-5]. These FOP labels differ not only in
43 graphic presentation, but also in the type and level of information they provide, the nutritional
44 profiles used, the food products covered and the implementation (i.e. voluntary or mandatory). This
45 is at least partly explained by the fact that the model must meet the needs for each country, taking

46 into consideration cultural and dietary patterns, education level and alignment with national dietary
47 guidance.

48 FOP labels can be roughly divided into two types namely interpretative and non-interpretative
49 labels. Non-interpretative FOP labels provide information on the amount of key nutrients (e.g. fat,
50 sugar and sodium) and percent recommended intakes, with little interpretation of this information
51 (e.g. Guideline Daily Amounts [GDA] or Reference Intake [RI]) logos [6]). Interpretative FOP labels
52 contain an interpretation of the nutritional quality of the products, with or without information about
53 the amount of key nutrients. Some FOP labels use colours (e.g. Multi Traffic Light [MTL] [7]) to
54 indicate whether the level of a nutrient is high (red), medium (amber) or low (green). Other
55 interpretive FOP labels provide a simple summary score of a product's overall nutritional profile (e.g.
56 Keyhole logo [8], Choices Programme Logo [9]), a ranking (e.g. Health Star Rating [10], Nutri-Score
57 [11]) or warn for high levels of certain critical nutrients in products (e.g. Warning labels [12]).

58 Many studies have examined the different attributes of effectiveness of FOP labels, but there are
59 numerous inconsistencies in the results. This can be explained by the fact that the definition of
60 effectiveness differs from study to study. Some studies focus on consumer liking, understanding or
61 preference for FOP labels, others on food choice or actual or intended food purchase and some on
62 food intake. There are also major differences in methodologies used. However, research into the
63 effectiveness of FOP labels on consumer behavior in practice is lacking [13].

64 Studies focusing on consumers' understanding of FOP labels and product choice generally show
65 that FOP labels appear to help consumers determine which foods are healthier and which are less
66 healthy [14,15]. Simple FOP labels such as MTL, warning labels and Nutri-Score appear to be most
67 effective [15].

68 The MTL label has been implemented in the United Kingdom [7]. It provides information on
69 energy, fat, saturated fat, sugar and salt content per 100 gram and as percentage of reference intake,
70 combined with traffic lights colours (green, amber and red) to highlight low, medium or high levels
71 of the nutrients. It also provides serving size information that is expressed in easily recognizable and
72 meaningful ways to the consumer (e.g. $\frac{1}{4}$ of a pie). Nutri-Score is an interpretive FOP label that uses
73 letters and colours to rank healthiness of products [11]. The French government adopted the Nutri-
74 Score in 2017 and since then governments of other countries such as Belgium, Switzerland and
75 Germany have also chosen to adopt the Nutri-Score [16,17]. In Latin America, the implementation of
76 warning labels is spreading. Ecuador was the first to implement a mandatory FOP label system, i.e.
77 a traffic light system [18]. They were followed by Chile which implemented mandatory warning
78 labels in 2016 [19]. Since then, Peru [20], Paraguay and Uruguay also decided to implement warning
79 labels and Mexico has recently followed suit [21]. Brazil recently reviewed mandatory nutrition
80 labelling. Anvisa, the National Health Surveillance Agency of Brazil established a working group on
81 Nutrition Labelling to identify problems in the transmission of nutritional information and
82 alternatives that could help improve the effectiveness of nutrition labelling [22]. Several FOP labels
83 were proposed to Anvisa and reviewed. In October 2020, ANVISA approved a FOP label for food
84 and beverages, which is a warning label that uses a nutrient profile based on added sugar, saturated
85 fat and sodium content per 100g or 100 ml of product [23,24].

86 This study was performed in 2019 and designed to determine which of five different types of
87 nutritional front-of-pack labels best helps Brazilian respondents identify the healthiest choice
88 between two food products, compared to a non-label control. Four of the tested FOP labels were also
89 reviewed by Anvisa. We wanted to test the robustness of the efficacy of different FOP labels by also
90 comparing products from different product categories, consumed in different serving sizes or with
91 closer nutritional profiles. As a result, wide range of products were tested.

92 **2. Materials and Methods**

93 *2.1. Study population*

94 Study participants were recruited from an existing research panel of Brazilian consumers that
95 represent general members of the public. The aim was to have a representative sample of

96 respondents and an even gender split. Participants were eligible for participation if they were aged
97 between 18 and 65 years.

98 2.2. Front-of-pack labels

99 Five FOP labels were tested in this study, i.e. GGALIⁱⁱⁱ Nutrient Profile, IdeC, ABIA, Nutri-
100 Score and a hybrid label which was developed for this study. The first four FOP labels were
101 selected because they were proposed by different stakeholders to Anvisa, the National Health
102 Surveillance Agency of Brazil [22]. The selected labels cover three different visual expressions of
103 nutritional labelling. GGALIⁱⁱⁱ Nutrient Profile and IdeC labels are warning style labels, Nutri-Score
104 is an interpretative colour coded label. The ABIA label is a traffic light system that provides
105 nutritional information. The hybrid label is an adaptation of the Evolved Nutrition Label [25] and
106 contains both nutritional information and a red colour code, as warning sign, if levels of an
107 ingredient are high. The Control Group received visual expressions of products without a FOP
108 label. This group was used as a reference.

109 This study focused on the three nutrients of concern that were initially proposed by Anvisa, i.e.
110 saturated fat, sugar and sodium [22]. Hence other nutrients were not taken into account.

111 GGALIⁱⁱⁱ NP label: GGALI (Gerência-Geral de Alimentos) is Anvisa's General Food
112 Management who prepared the "regulatory impact analysis" published by Anvisa in 2018 [22].
113 GGALI proposed two nutrient profiles. We selected the stricter one – GGALIⁱⁱⁱ –. The GGALIⁱⁱⁱ NP
114 label is a warning style label highlighting high levels of nutrients of concern. It is based on the
115 nutrient content per 100 g or 100 ml for food and beverages, having as reference the guidelines of
116 the World Health Organization (WHO) and Codex Alimentarius [22]. Criteria were defined for low,
117 medium and high content of free sugars, saturated fat, total fat and sodium [22]. For the GGALIⁱⁱⁱ
118 NP label in this study criteria for high levels were applied. When this study was designed and
119 conducted, Anvisa had not chosen the nutrient profile or visual model. The nutrient profile that
120 was approved by ANVISA in 2020, is more lenient than the nutrient profile that we used in this
121 study. The magnifying glass visual that we used is similar to the visual approved by Anvisa [23,24].
122 This visual is also under discussion in Canada.

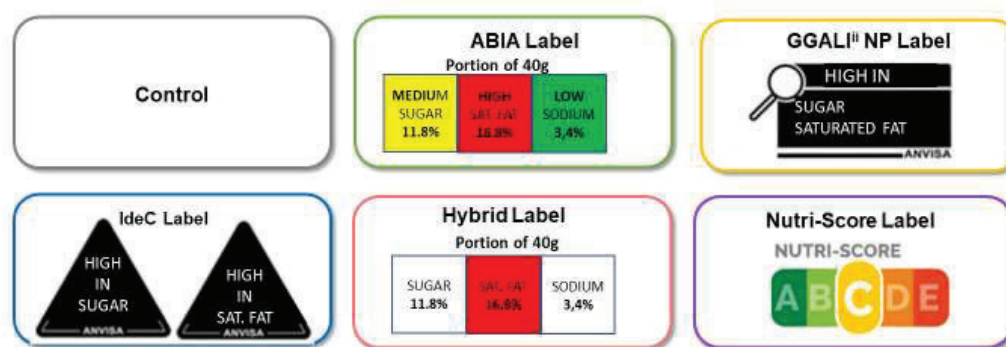
123 IDEDEC label: IDEC (Instituto Brasileiro de Defesa do Consumidor) is a civil society in Brazil.
124 They proposed a FOP label that is a warning style label and uses black triangles to inform the high
125 content of sugars, total fat, saturated fat and sodium, and the presence of trans fats and sweeteners.
126 The nutritional profile model was adapted from the Pan American Health Organization (PAHO)
127 profile model and is based on percentage of energy [22].

128 ABIA label: ABIA (Associação Brasileira das Indústrias da Alimentação), representing the
129 Brazilian food industry sector, proposed a Multiple Traffic Light (MTL) FOP label, based on the
130 United Kingdom traffic lights, which reports the absolute quantities of sugars, saturated fats and
131 sodium per serving. It uses the red, amber and green colours to indicate the high, medium and low
132 levels of each nutrient according to criteria per serving [22].

133 Nutri-Score: Nutri-Score is an interpretative, graded, colour-coded FOP label that has been
134 developed by French researchers [11]. It is based on the nutrient profiling system of the United
135 Kingdom Food Standards Agency which uses the nutrient content per 100 g for food and beverages.
136 Positive points (0-10) are allocated for energy, total sugar, saturated fat and sodium content and
137 negative points (0-5) are allocated for fruit, vegetables and nuts, fibre and protein content. Products
138 scores range from -15 (most healthy) to +40 (least healthy) [11] and are translated into five
139 categories of nutritional quality ranging from A (green) to E (red).

140 Hybrid label: The hybrid FOP label is a model developed for this study and is an adaptation of
 141 the Evolved Nutrition Label (ENL) [25]. Criteria for sugar, saturated fat and sodium were defined
 142 for small serving sizes (<60 g), medium serving sizes (60-120 g) and large serving sizes (>120 g). In
 143 line with ENL, calculations were done per serving size, except for serving sizes between 60 and 120
 144 g, in which case calculations were done per 100 g. The label provides quantitative nutritional
 145 information per serving and uses the red colour to indicate high amounts of the nutrient in a
 146 serving of the product.

147 An example of the five labels is provided in **Figure 1**. The specific criteria used for the ABIA,
 148 GGALIⁱⁱⁱ, IdeC and Hybrid labels are presented in **Table S1**. For the Nutri-Score label, the Nutri-
 149 Score algorithm was used to calculate the score for each product [11].



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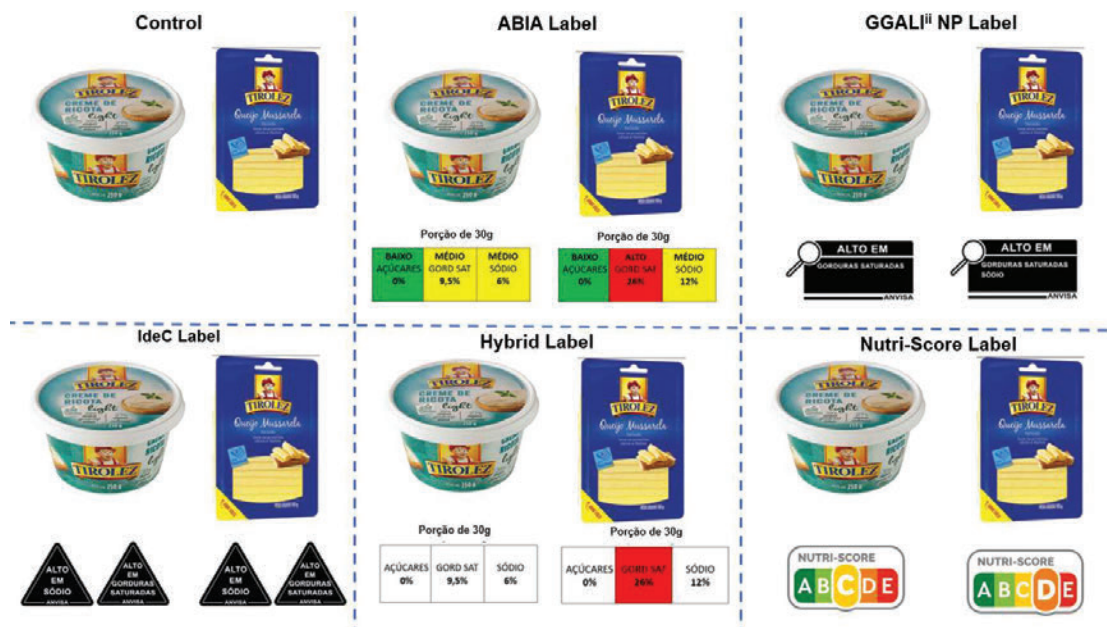
151 **Figure 1.** Example of front-of-pack labels used in this study (translated from Portuguese to English)

152 2.3. Food stimuli

153 This study included 18 food items, which were presented to the respondents in sets of two. The
 154 respondents were asked to indicate which of the two products they thought was healthier. The correct
 155 answer was defined considering the contents of the three nutrients highlighted on the front of pack
 156 label. That is, the product with the lowest sugar, saturated fat and sodium content per serving was
 157 considered the healthiest choice. When a product was higher in one nutrient and lower in another,
 158 the larger difference was considered most important. In a few cases, one nutrient was slightly lower
 159 and one much higher. Subsequently the much higher nutrient was considered more important for
 160 the classification.

161 The food sets (food stimuli) were carefully selected to test the robustness of the labels to help the
 162 consumer identify the healthier option. The food stimuli differed with regard to the following
 163 variables: similar products consumed in small serving size, similar products consumed in large
 164 serving size, similar product but consumed in different serving sizes, and products from different
 165 food categories but consumed in same eating occasion. The food categories included in the study
 166 were soft cheeses, fat spreads, ice creams, lasagne, frozen meals, fermented milks & chocolate oat
 167 drinks, sweet snacks, cereal bars & yoghurt and chocolate bars. The products corresponded to
 168 different consumption occasions (e.g. breakfast, lunch or main meal and in-between meal snack).
 169 **Figure 2** shows an example of one of the stimuli as presented to the respondents. In Brazil it is not
 170 mandatory to declare sugar content of food products on the packaging. For some of the products
 171 used in this study, i.e. ice creams, frozen meals, the dairy alternative drink and sweet snacks, we had
 172 to estimate the sugar content. Estimations were based on similar products marketed in countries
 173 where sugar content is declared in the nutrition table. **Table 1** summarizes the nutritional profiles of
 174 the food stimuli. Other, detailed information about the food stimuli can be found in **Figure S1**.

175



176

177 **Figure 2:** example of stimulus used for each randomized group178 **Table 1.** Nutritional profile of food stimuli

179

Food category	Product	Serving size (g)	Per serving			Per 100 g		
			Sugar (g)	Saturated fat (g)	Sodium (mg)	Sugar (g)	Saturated fat (g)	Sodium (mg)
Soft Cheese	Product 1*	30	NA	1,9	118	NA	6,3	393
Soft Cheese	Product 2	30	NA	5,2	239	NA	17,3	796
Fat spreads	Product 1*	10	NA	0,9	70	NA	9	700
Fat spreads	Product 2	10	NA	4,8	90	NA	48	900
Ice cream	Product 1	86	21,5	7,7	40	25	8,9	46,5
Ice cream	Product 2*	60	13	1,8	12	21,7	3	20
Lasagne	Product 1	400	12	10	1280	3	2,5	320
Lasagne	Product 2*	400	11,2	5,2	1440	2,8	1,3	360
Frozen meals	Product 1*	300	NA	2,9	250	NA	0,9	83,3
Frozen meals	Product 2	275	NA	9,3	1242	NA	3,4	451,6
Fermented milk drink	Product 1	200	32,5	0	75	16,25	0	37,5
Chocolate oat drink	Product 2*	260	12	0,6	60	4,6	0,2	23
Sweet snacks	Product 1	40	10,6	3,4	68	26,6	8,4	170
Sweet snacks	Product 2*	20	6,6	2,1	26	33	10,5	130
Cereal Bar	Product 1*	21	6,9	0,8	0	32,8	3,8	0
Yoghurt	Product 2	170	20,4	4,6	160	12	2,7	94
Chocolate bars	Product 1*	16,7	8	2,6	16	47,9	15,5	100
Chocolate bars	Product 2	40	19,9	6,6	40	49,8	16,5	100

* Healthier option

180

181 2.4. Data collection

182 A 5-minute online survey was conducted in July 2019, using Toluna QuickSurveys. All
183 respondents were randomly allocated to one of six groups 1) no label (control), 2) ABIA label, 3)
184 GGALIⁱⁱ NP label, 4) IdeC label, 5) Hybrid label or 6) Nutri-Score label.

185 Apart from the control group, the respondents were shown the FOP label. The FOP label was
186 briefly explained. The respondents were then shown 9 food stimuli consisting of two products and,
187 based on the information they received, they were asked which product they thought was the
188 healthier choice. The respondents in the control group were also shown the same 9 choice sets of
189 products, but without a label. Respondents were provided with four potential answers: 1) Product 1;
190 2) Product 2; 3) No difference and 4) I don't know. Respondents were also asked to rate, on a scale
191 from 0 to 10, how useful the label was in helping them make a healthy food choice and what they
192 liked and disliked about the specific type of label that they had evaluated.

193 2.5. Statistical analyses

194 Descriptive statistics were calculated for the sociodemographic data of the participants. The
195 percentage of participants selecting the answers "Product 1", "Product 2", "No difference" or "Don't
196 know" were calculated for each set of food stimuli, for each FOP label group as well as for the control
197 group. Significance testing (Z-test) was performed to test if the proportion of participants correctly
198 identifying the healthier product differed between the FOP label groups. Significance tests were
199 performed within these subgroups to test whether participants who correctly chose the healthier
200 option differed according to education level or income. The mean scores for usefulness of the labels
201 were calculated. T-tests were used to test for statistical differences between mean scores.

202 Statistics were performed with the Toluna Analytics tool. A significance testing at a 95%
203 confidence level was used.

204 3. Results

205 3.1. Respondents

206 A total of 1072 Brazilian men and women participated in the online survey. Sociodemographic
207 data are presented in **Table S2**. A total of 176 respondents were included in the control group, 181
208 respondents were allocated to the ABIA group, 177 respondents were allocated to the GGALIⁱⁱ NP
209 warning label, 181 respondents to the IdeC – triangle warning label, 178 respondents to the hybrid
210 colour code label and 179 respondents were allocated to the Nutri-Score label.

211 There were no consistent significant differences in terms of education and income levels between
212 the different groups.

213 3.2. Accuracy of choosing the healthier product

214 **Table 2** summarizes for each of the labels and the control group the percentages of respondents
215 that correctly identified the healthier product for each of 9 stimuli.

216 When the soft cheese food stimuli were presented, most respondents accurately identified the
217 healthier product. Respondents who were shown the IdeC warning label performed significantly
218 worse than the control group; a third of the respondents in this group indicated that there was no
219 difference between the two products and only 51% of the respondents correctly identified the
220 healthier product.

221 Respondents who were shown the ABIA or hybrid labels were most likely to identify the
222 healthier choice from the fat spreads category. Most respondents who were shown the GGALIⁱⁱ or
223 IdeC warning style labels selected the least healthy product of the two (41% and 44%, respectively)
224 or indicated that there was no difference between the two products (32% and 24%, respectively). The
225 GGALIⁱⁱ label scored worse than the control group. Also 55% of the respondents in the control group
226 chose the less healthy product.

227 For the ice cream stimuli, the group of respondents who were shown the IdeC labels had most
228 difficulty choosing the healthier option; only 13% of the respondents chose the healthier product.
229 Forty percent of the respondents in the control group and 60% of the respondents from the IdeC
230 group indicated that there was no difference between the two ice cream products. The ABIA and
231 hybrid labels helped the respondents best to make the healthier choice, with 85% and 88%,
232 respectively selecting the healthier product.

233 Many respondents had difficulty identifying the healthier lasagne. Only the respondents who
234 were shown the hybrid label performed significantly better (64% correct) than the control group (48%
235 correct). The Nutri-Score label helped only 20% of respondents make the right choice, compared to
236 48% of the respondents in the control group. Seventy percent of the respondents who were shown
237 the Nutri-Score label indicated that there was no difference between the products.

238 Respondents in the control group and those shown the IdeC label found it particularly difficult
239 to choose the healthier option from the frozen meals. A total of 56% of the respondents in the control
240 group and 62% of respondents in the IdeC label group indicated that there was no difference between
241 the two frozen meals. The ABIA and hybrid label performed best.

242 In the category fermented milk and chocolate oat drinks, the ABIA, Hybrid and Nutri-Score
243 labels performed best and the GGALIⁱⁱ and IdeC labels performed worse with about one-third of
244 respondents choosing the less healthy option and about one-third indicating that there was no
245 difference between products.

246 There was a marked difference between labels in their ability to help choose the healthier sweet
247 snack. The majority of the respondents in the control group (56%) and those who were shown the
248 GGALIⁱⁱ (73%) or Idec (57%) label considered that there was no difference between the two products
249 with regard to health. The labels ABIA, Hybrid and Nutri-Score performed significantly better.

250 When respondents were shown a cereal bar and a yoghurt product, i.e. two very different
251 products, the ABIA, IdeC and hybrid labels were most successful in helping them make a healthier
252 choice. Forty-five percent of respondents who were shown the GGALIⁱⁱ label believed that there was
253 no difference between products and 72% of respondents who were shown the Nutri-Score label
254 selected the less healthy product.

255 There was confusion amongst the majority of the respondents for the chocolate bar category
256 (showing two different sizes of the same brand chocolate bar). Most respondents seeing the GGALIⁱⁱ
257 (59%), Idec (56%) or Nutri-score (63%) labels, which do not consider serving size, thought that there
258 was no difference between the two products. The ABIA and Hybrid labels, which do consider serving
259 size, resulted in the highest numbers of respondents choosing the healthier option.

260 Overall, the IdeC warning label was least helpful for consumers to make the healthier choice.
261 Eight out of nine times, the IdeC label for the healthier product was the same as for the less healthy
262 product, providing no guidance to the consumer. Only once, when comparing the cereal bar and
263 yoghurt, the IdeC label outperformed the control group. In that case, 70% of the respondents chose
264 the healthier option. The other warning label, GGALIⁱⁱ NP, performed a bit better than the IdeC label,
265 but also failed to distinguish products six out of nine times. It outperformed the control group in only
266 two out of nine cases. Nutri-Score performed reasonably well but also failed two times in guiding the
267 consumer to the healthier choice when products were given the same rating. This happened for
268 example when the serving sizes of the two products differed significantly. In case of the cereal bar
269 (21g) versus yoghurt (170g) food stimulus, a better Nutri-Score was given for the least healthy
270 product (yoghurt).

271 The hybrid label performed best, resulting in statistically significantly higher percentage of
272 correct answers as compared to the control in all cases. The ABIA label outperformed the control
273 group eight times out of nine.

274 **Table 2:** Percentage of participants correctly choosing the healthiest option within each food stimulus, by
 275 randomization assignment to FOP label or control

	Soft cheese	Fat spreads	Ice cream	Lasagne	Frozen meals	Milk drinks	Sweet snacks	Cereal bar & yoghurt	Chocolate bars
Control	76 ^d	37 ^c	31 ^d	48 ^{d,f}	13	40	26 ^c	44 ^{c,f}	39 ^{c,f}
ABIA	88 ^{a,c,d}	82 ^{a,c,d,f}	85 ^{a,c,d,f}	46 ^{d,f}	81 ^{a,c,d,f}	73 ^{a,c,d}	77 ^{a,c,d,f}	85 ^{a,c,d,f}	76 ^{a,c,d,f}
GGALIⁱⁱ	77 ^d	24	65 ^{a,d}	41 ^f	59 ^{a,d}	32	15	31	29
IdeC	51	32	13	33 ^f	12	34	23	70 ^{a,c,f}	33
Hybrid	88 ^{a,c,d}	75 ^{a,c,d,f}	88 ^{a,c,d,f}	64 ^{a,b,c,d,f}	85 ^{a,c,d,f}	78 ^{a,c,d}	79 ^{a,c,d,f}	86 ^{a,c,d,f}	72 ^{a,c,d,f}
Nutri-Score	87 ^{a,c,d}	58 ^{a,c,d}	60 ^{a,d}	20	67 ^{a,d}	74 ^{a,c,d}	66 ^{a,c,d}	22	26

276 Performing significantly ($p < 0.05$) better than a: Control; b: ABIA; c: GGALIⁱⁱ NP; d: IdeC; e: Hybrid; f: Nutri-
 277 Score within the same category

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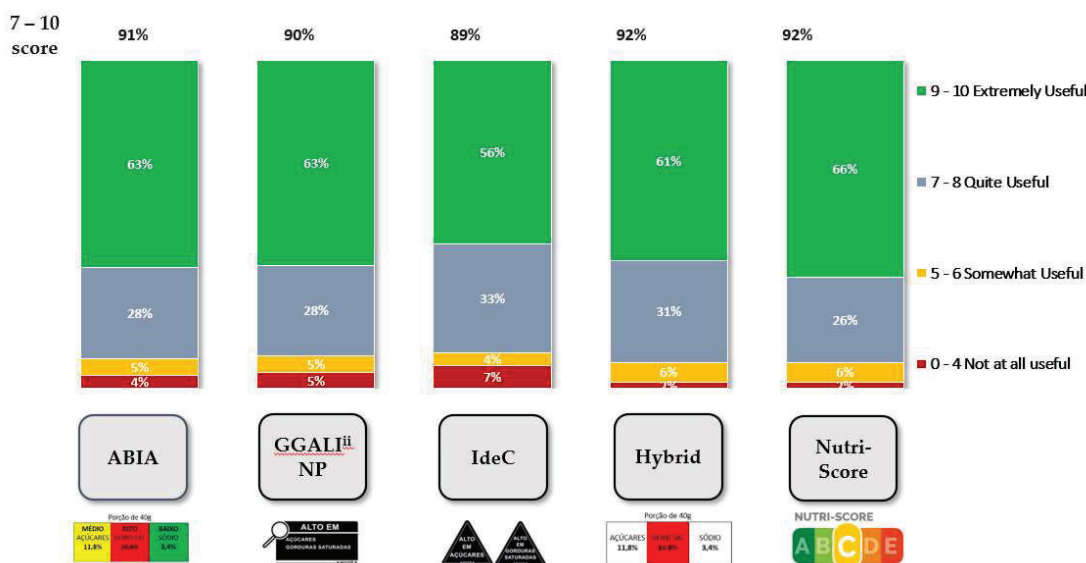
279 If we look at the participants who correctly identified the healthier options, there appears to be
 280 no effect of education level or income. Statistical tests showed a statistically significant effect for only
 281 3 of the 36 subgroups tested (9 food stimuli x 6 FOP label groups). Low-income participants from the
 282 control group scored significantly higher than high-income participants in selecting the healthier ice
 283 cream. Participants with a higher income who were shown the ABIA label scored significantly higher
 284 participants with a lower income in selecting the healthier milk drink. Finally, the less educated in
 285 the control group scored higher than the higher educated when selecting the healthier chocolate bar.

286 3.3. Usefulness ratings

287 Respondents were asked to indicate on a scale of 0-10 how useful the label was in helping to
 288 choose the healthier product. Between 89% and 92% of respondents rated their label as either very
 289 useful (7-8) or extremely useful (9-10). Mean usefulness scores were 9.7, 9.6, 9.4, 9.6 and 9.8 for the
 290 ABIA, GGALIⁱⁱ NP, IdeC, Hybrid and Nutri-Score labels, respectively, and did not differ statistically
 291 significant. The IdeC and GGALIⁱⁱ NP warning labels had the highest proportion (7% and 5%,
 292 respectively) of respondents indicating that the label was not at all useful (0-4). The proportion of
 293 respondents that rated the IdeC labels as not at all useful (7%) was significantly higher than the 2%
 294 of respondents rating the Nutri-Score and Hybrid label as not useful. See **Figure 3** for usefulness
 295 ratings of FOP labels.

296

297 **Figure 3:** Usefulness ratings of the five FOP labels



298

299 *Answer to Question: : To what extent is the label below useful when helping you make healthy food choices?*300 **3.4. Feedback on labels**301 To better understand how the FOP labels were perceived by the respondents, they were all asked
302 what they liked or disliked about the FOP label they were shown.303 ABIA label: Most respondents said they liked the label, especially the use of colours and the
304 clarity and objectivity of the information provided. When asked about what they did not like, some
305 respondents indicated that they would also like information about other nutrients and energy.306 GGALIⁱⁱ NP label: Respondents were pleased with the label's simplicity, its decisive message
307 and the fact that it attracts attention. Not all respondents were satisfied with the black colour and
308 some were missing nutritional information.309 Hybrid label: Respondents were particularly pleased with the use of the red colour as it draws
310 attention and also the clear and easy to understand information about the nutrients and serving size.
311 However, the language should be kept simpler (e.g. salt instead of sodium) and some respondents
312 want more information about other nutrients and energy.313 IdeC: Respondents were especially pleased with the simple information that helps people make
314 a quick decision. Not all respondents were happy with the black colour and said it wasn't noticeable,
315 and some would like more specific information about the amount of the nutrients in the products.316 Nutri-Score: When evaluating the Nutri-Score label, the respondents indicated that they liked
317 the simple, clear message and the use of colours. Negative aspects of the Nutri-Score were the lack of
318 information about nutrient levels and the underlying model. Some respondents misinterpreted the
319 label as they believed that the colours and letters represented the presence of vitamins in the
320 products.321 In summary, respondents prefer simple FOP labels that use colours (not black) to convey the
322 message. They would like to receive information about the amount of nutrients in the products, but
323 in simple language.324 **4. Discussion**325 FOP labels are designed to help consumers choose healthier food and drinks. This study
326 compared how well five different FOP labels helped Brazilian consumers make a healthier choice

327 between two food or drink products. It showed that the Hybrid label and the ABIA label,
328 performed best under the tested conditions. Both labels provide both nutritional information per
329 serving as well as concise interpretation using colours (i.e. traffic light or red light only).

330 Most of the other studies that investigated how well different FOP labels helped consumers
331 make a healthier choice between products, compared products within the same food category and
332 with the same serving size, but with marked differences in nutrient profiles. These studies often
333 found that simple interpretative labels such as Nutri-Score or warning labels were effective in
334 helping the consumer make a healthier choice [26-29]. This makes sense, because when a label
335 clearly distinguishes between products (e.g. different score, colour or with or without a warning
336 label), the consumer can easily make a choice. However, this does not reflect the complexity
337 consumers face when shopping as this clear distinction does not always exist. Our research showed
338 that when labels do not clearly distinguish between two products, or when products from different
339 product categories or with different serving sizes are compared, these simple labels do not help the
340 consumers to make an informed choice.

341 Many factors influence how consumers process information on a FOP label and how deeply
342 this information is processed [30]. Consumers may only glance at the FOP label, process partial
343 information or process the FOP label in depth. For example, the level of nutritional knowledge
344 influences the type of information the consumer processes. Knowledgeable consumers are more
345 likely to use the more complex nutrient information on complex labels, while a less knowledgeable
346 consumer may look for calorie and color-coded information. Average consumers are more likely to
347 process the information on the FOP label in depth. Under time pressure consumers will only
348 quickly inspect the information on the FOP label and not process all available information [30].
349 Health-motivated consumers may also look more actively for nutritional information, while
350 hedonically-motivated consumers may not look at nutritional information, but more at brand
351 names [30]. So, depending on the situation, different types of FOP labels can be the most effective.

352 Our study showed that simple summary labels are effective when there is a clear distinction
353 between products, but if a quick decision cannot be made, consumers will consider the nutritional
354 information on the FOP label, when available. In those cases, interpretative labels that provide
355 nutritional information to the consumer better assist the consumer in making an informed choice.
356 This study showed that, even when the colours on the Hybrid and ABIA labels did not differ
357 between products, participants could choose the healthier option based on the nutritional
358 information presented on these labels. This suggests that the nutritional information facilitates the
359 comparison of the nutritional content of the products, allowing the consumer to make a healthier
360 choice. The two warning labels, i.e. Idec and GGALIⁱⁱ NP were in most cases not sensitive enough
361 to help the consumer distinguish products based on healthiness. They did not outperform the
362 control group. Both the Idec and GGALIⁱⁱ labels use very strict nutrient profiles and therefore most
363 products bear the logo [22], making them less sensitive to distinguish products. The nutrient profile
364 that will be implemented in Brazil is more lenient and if we would have used this more lenient
365 profile, the number of warning labels would have been different for two food stimuli; only one of
366 two frozen meals would have carried a warning logo for sodium and the yogurt would have
367 carried no warning label for added sugar. Besides the lack of discrimination between products,
368 these labels are also very simplistic and do not contain additional nutritional information to help
369 the consumer make an informed decision, where the number of warning labels for sugars, saturated
370 fats and sodium does not differ between two foods.

371 When labels on two different products are the same, respondents interpret this as if products
372 are equally healthy, or respondents base their decision on other information that they have about
373 the product (e.g. packaging, type of product, claims on product, presence of other ingredients,
374 knowledge of the brand). For example, the vegetable-oil based spread used in this study contained
375 less saturated fat and sodium than the presented butter, so it is nutritionally, the healthier choice.

376 However, Brazilian Dietary guidelines promote butter consumption, not vegetable-oil based
377 spreads. Butter can therefore be seen as more natural and healthier than vegetable-oil based spreads
378 in Brazil and this is also reflected in the results. When the FOP labels indicated that the vegetable-
379 oil based spread was the healthier choice, most respondents chose that product. However, if no
380 label was shown, or if labels on butter and vegetable-oil based spreads did not differ (in case of
381 IdeC and GGALIⁱⁱ NP), more than 40% of participants chose butter as the healthier option.

382 A recent review of FOP schemes performed by the European Commission concluded that FOP
383 schemes providing nutritional information per 100g were better understood than portion-based
384 schemes [13]. However, more than 90% of the food categories in Brazil have regulated serving sizes
385 less than 100g / 100ml. When a nutrient profile is standard applied in 100g or 100mL distorted
386 comparisons are generated. For products consumed in serving sizes <100g or ml, the amount of
387 nutrients to calculate the FOP label is overestimated, while for products consumed in portions of
388 >100g/ml it is underestimated. As a result, some products with small serving sizes will unfairly
389 receive a warning label, while some products with large serving sizes that are high in nutrients of
390 concern receive no warning label. For example, in this study, two lasagnas with a 400g serving size
391 were compared. According to the nutritional profile criteria defined by GGALIⁱⁱ, based on 100g,
392 neither of the two products would receive a warning label, and with Nutri-Score both lasagnas
393 would receive a score of B. These two FOP labels would thus suggest that products are healthy,
394 despite the relatively high saturated fat and sodium contents per serving as % GDA.

395 While the GGALIⁱⁱ NP and IdeC warning labels were the least successful in helping
396 participants make the healthier food choice, the labels were considered by the respondents to be as
397 useful as the other FOP labels. It is important to note that the respondents did not receive any
398 feedback on how well they did. So, they were not aware of the correct answer and how often they
399 correctly identified the healthier option or mistakenly assumed there was no difference. One could
400 speculate that if they got this feedback, ratings of usefulness would be lower. In any case, the
401 ratings show that any FOP label that could help make the consumer an informed choice is
402 considered useful by consumers. For research purposes, asking this question without providing
403 feedback to the participants does not seem relevant. Feedback from the participants suggests that
404 simple FOP labels that use bright colours and contain nutritional information in simple language,
405 are liked.

406 Grunert et al hypothesized that consumers' liking for FOP labels is guided by three
407 considerations: 1) consumers like simplicity, 2) when provided with simplified information
408 consumers still want to know what it stands for and how the simplified message (e.g. warning- or
409 health logo) has been derived, and 3) nutrition information can create a consumer resistance when
410 they feel pushed to make choices that they do not want to take [31].

411 This is also confirmed by a recent study conducted by Talati et al [32] who investigated
412 consumer perception of five FOP labels, i.e Health Star Rating, MTL, Nutri-Score, RI and a warning
413 label. The coloured FOP labels MTL and Nutri-Score stood out and were most liked by consumers
414 in all countries. Although the most simplified FOP labels, Nutri-Score and warning labels, were
415 easy to understand, they were perceived as providing insufficient information and the least trusted.
416 The RI label was perceived as the most confusing but scored high on trust. Overall, the MTL label,
417 which combines nutrient-specific information and a summary interpretation using colour, was most
418 liked and trusted in this study.

419 A strength of the current study was that it really tested the robustness of five FOP labels that
420 differed not only in visual expression and the amount of information provided, but also in the
421 underlying nutrient profile. Unlike other studies that mostly tested products within the same food
422 category and with the same serving size, this study was designed to compare how well these five
423 FOP labels enabled consumers to choose between products that differ in nutritional composition,

424 serving size and/or food category as consumers face in real life. Another strength is that a control
425 group has been included and that the effectiveness of the FOP labels in helping the consumer to
426 choose the healthier product could therefore be compared with a reference group that was not
427 given a FOP label. This provides insight into whether the presence of a specific FOP label is of
428 added value for a consumer when making an informed choice.

429 Participants were also asked to select the healthier product. This demonstrates how effective
430 the FOP label is in helping the consumer make a choice and whether it fits its purpose. In other
431 studies consumers were asked which product they would buy [33-37], but this may be influenced
432 by factors such as familiarity and liking of the product and cost of the product [31]. Other studies
433 only asked which FOP label is preferred [32,38]. As demonstrated by our study, all FOP labels were
434 rated as very useful, irrespective of their efficacy in helping the consumer choose the healthier
435 option. Only asking for preference is thus not very useful.

436 This study also has some limitations. Participants were a representative sample of the Brazilian
437 population. Therefore, we also included participants with a lower education level, who may have
438 had difficulty understanding the information on the FOP labels. However, socio-economic status
439 and level of education was similar between the six FOP label groups and therefore we did not
440 expect this to affect the outcomes of the study. This was confirmed by statistical subgroup analyses
441 showing that participants who correctly identified the healthier options, did not differ with respect
442 to level of education or income. Another limitation is that we did not ask the participants if they
443 were colour-blind. Thus, it is possible that participants with colour-blindness were included, which
444 may have adversely affected the ability to understand the colour-coded labels. However, none of
445 the participants who were shown the Abia or Nutri-Score labels, voluntarily reported being colour-
446 blind and thus unable to interpret the labels.

447 The FOP labels that we tested in this online survey were selected because they were under
448 consideration by Anvisa, the National Health Surveillance Agency of Brazil, at the time we
449 designed this study. Anvisa proposed in its preliminary report on the regulatory impact analysis on
450 nutrition labelling [22] to focus only on the three nutrients of concern, sugar, saturated fat and
451 sodium. We therefore decided to only use the content of these three nutrients to inform the different
452 FOP labels (with exception of Nutri-Score). Focusing on just these three nutrients of concern is a
453 limitation to assessing the healthiness of a product.

454 Brazilian regulation do not require the sugar content of food products to be stated on the
455 packaging. For some of the products used in this study (ice creams, frozen meals, dairy alternative
456 drink, sweet snacks), we had to estimate the sugar content. These estimates were unlikely to deviate
457 very much from the actual sugar content and were used for all FOP labels.

458 This study was conducted online using pictures of actual products. It does therefore not reflect
459 a real-life situation in which participants can examine packaging and other information, such as the
460 nutrition table on the back, to make an informed choice. Finkelstein et al [39] attempted to mimic a
461 real-life situation by asking the participants (n=147) to purchase their weekly groceries in an online
462 grocery store with 3343 foods and 832 beverages. Participants had only access to back-of-pack
463 Nutrition Information Tables or were also shown an MTL label or Nutri-Score label. Both the MTL
464 and Nutri-Score FOP labels improved the dietary quality of the purchases as compared to the
465 control group. The Nutri-Score label performed best in improving overall diet quality, but unlike
466 Nutri-Score, the MTL label reduced calories. Thus, FOP labels had added value when purchasing
467 products, even in the presence of a Nutrition Information Table.

468 **5. Conclusions**

469 In conclusion, this study showed that the Hybrid and the ABIA FOP labels, two interpretative
470 labels that use colours and provide nutritional information per serving, were best suited to help

471 Brazilian consumers choose the healthier product. The other three labels are based on per 100g and
 472 therefore will not always discriminate enough to help consumers. The ABIA and Hybrid labels
 473 outperformed the other FOP labels when serving sizes differed significantly or when deeper
 474 consideration of nutritional information was needed to make an informed decision.

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476 Conceptualization, Chantal Goenee and Els M. de Groene; Data curation, Lucia Juliano; Formal analysis, Lucia
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 478 Lucia Juliano, Els M. de Groene and Fernanda de Oliveira Martins; Project administration, Chantal Goenee and
 479 Fernanda de Oliveira Martins; Resources, Chantal Goenee and Fernanda de Oliveira Martins; Supervision, Els
 480 M. de Groene; Visualization, Wendy A.M. Blom, Lucia Juliano and Fernanda de Oliveira Martins; Writing –
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