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## **Effects of packaging color on expected flavor, texture and liking of chocolate in Brazil and France**

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# Effects of packaging color on expected flavor, texture and liking of chocolate in Brazil and France

## Highlights

- Black packaging made consumers expect chocolates to be more bitter.
- Pink and yellow packaging made consumers expect chocolates to be sweeter.
- The effect of a packaging color on expected liking depended on chocolate type.
- Warm and cold classification of colors did not explain the effects of packaging color.
- The effects of packaging color were not significantly different between cultures.

## Abstract

Recent research has shown that the colors of plateware, glassware, cups, packaging, and even the room and its lighting are able to influence consumers' preferences, expectations and perceptions of taste, flavor and texture of food and beverages. This study contributes to the subject by investigating how packaging colors affected the expectations of sweetness, bitterness, fruitiness, melting, and liking for chocolates in Brazil and France. Two groups of 210 consumers (N = 420) from each country evaluated samples of milk and dark chocolate packaged in seven colors: black, blue, brown, green, red, pink and yellow. Analyses of variance (ANOVA) indicated that there were multiple significant effects of packaging color on consumers' expectations. Multiple factor analysis (MFA) showed that expected sweetness, fruitiness and liking were correlated to each other and inversely correlated to expected bitterness. While milk and dark chocolate were expected the least sweet and the most bitter when in black packaging, they were expected the sweetest and the least bitter when in yellow or pink packaging. Interestingly, the same black packaging made the milk chocolate the best rated and the dark chocolate the worst rated on expected liking, showing that a color may have inverse effects on expected liking depending on the type of chocolate. Although French consumers eat more chocolate and with higher cocoa content than Brazilians, the effects of packaging color were not significantly different between cultures.

## Keywords

Consumer perception; Cross-cultural; Visual cues; Packaging; Color; Chocolate.

## 1. Introduction

Research has shown that not only the color of the product itself, but also the colors of the tableware, packaging, and environment can influence expectations and perception of a food or a drink (Spence, 2018). According to the predictive coding theory, this happens because when consumers see a product, such as a bar of chocolate, their brains immediately search for cues that match previous experiences and try to anticipate what it is and what are its characteristics (Piqueras-Fizman & Spence, 2015). This process creates expectations that have been shown to affect behavioral response, sensory perception, and neural activation (Litt & Shiv, 2012; Okamoto & Dan, 2013), making the subject fundamental for food industries and food services interested in building a complete experience for their consumers.

It is argued that color is the most distinctive visual cue in a packaging (Singh, 2006), but its effects depend on many factors such as the level of attention (Brignell et al., 2009), the

45 frequency of consumption of the product (Lick et al., 2017), the cultural context (Piqueras-  
46 Fiszman et al., 2012), the consumers' sensitivity to design (Becker et al., 2011), and the  
47 product itself (Zellner et al., 2018). A recent review (Spence and Velasco, 2019) summarized  
48 the multiple roles of packaging color on consumers' expectation and perception of identity,  
49 taste, flavor, fragrance, healthiness, and willingness to pay. After the review, new  
50 contributions on the effects of packaging color reported that it may influence the emotions  
51 evoked by a burger (Merlo et al., 2018), its inside color (i.e., the side in contact with the  
52 product) may influence the desirability of yogurt (van Esch et al., 2019), and the color of the  
53 label may influence the expected taste of specialty coffee (de Sousa et al., 2020).

54 Specifically on the subject of this study, several significant effects of packaging color  
55 were reported on expected flavor, somatosensory sensations, and liking of food. Studies  
56 commonly associated these effects with the warm and cold classifications of colors. The first  
57 group includes colors of long length waves, like red, pink, and yellow; the second includes  
58 colors of short length waves, like blue, purple and green (Huang & Lu, 2015). First, Deliza  
59 and MacFie (2001) showed that an orange box made consumers expect passion fruit juice to  
60 be sweeter and less sharp, refreshing, and liked than a white box. Then, it was found that a  
61 dairy dessert in a yellow packaging was expected to be sweeter, creamier, and more liked  
62 than the same dessert in a black packaging (Ares & Deliza, 2010). Rebollar et al. (2012)  
63 reported that chewing gums in warm-colored packaging were expected to be sweeter, fruitier,  
64 and sourer than in cold colors or scale of grey; and Huang and Lu (2015) reported that cereal,  
65 ice cream, iced tea, and yogurt in red packaging were expected to be sweeter than in green or  
66 blue. Tijssen et al. (2017) found that a dairy drink in a red box was expected sweeter,  
67 creamier, more flavorful and liked than in a purple or a blue box; and that a sausage in a red  
68 box was expected to be saltier than in a green or blue box. Comparing juice, sorbet, and gums  
69 in red and yellow packaging, Matthews et al. (2019) showed significant effects on sourness  
70 and sweetness expectations. Finally, Rosa et al. (2019) reported that red-to-yellow, blue-to-  
71 green, and greyscale packaging influenced consumers' expectations for cookies tastes and  
72 liking in multiple directions.

73 Thus, besides protecting physically, chemically, and microbiologically a food product,  
74 packaging is a communication tool that draws attention, expresses identity, induces appetite,  
75 intensifies emotions, and conveys messages about the products' attributes (Velasco &  
76 Spence, 2019). Its potential to communicate might be particularly relevant for the 7.3 million  
77 tons of chocolate consumed globally (Conway, 2018), since they are usually eaten straight  
78 from the packaging and since there is a wide range of attributes that could be interesting to  
79 communicate: aromas (floral, fruity, nutty), tastes (bitterness, sweetness, sourness), oral  
80 sensations (snap, melting, silky), types (white, milk, dark), categories (confectionary,  
81 compound, bean-to-bar), varieties (forastero, criollo, trinitario), and countries of origin  
82 (Colombia, Madagascar, Ivory Coast) (Beckett, 1994).

83 There are very few studies on the effects of packaging color on the expectations of  
84 chocolate taste, flavor, texture, and liking. A master thesis (van Lith, 2015) showed that a  
85 chocolate in red packaging was expected to be significantly healthier than in yellow  
86 packaging and a chocolate in dark brown was expected to be significantly more natural than  
87 in yellow or pink, but significant effects were not found regarding attractiveness or tastiness.  
88 Another research (Kovač et al., 2019) reported that strawberry-flavored chocolate was

89 significantly more attractive when presented in vivid pink packaging than in a less saturated  
90 color. As these two studies did not tackle the effect of packaging color on tastes and texture  
91 of chocolate, further research could help pastry chefs, chocolatiers, designers, artisans, and  
92 industries to choose colors to their products' background, either it is a plate, a packaging or a  
93 shop window.

94 The purpose of this study was to evaluate the effects of seven different colors of  
95 packaging on expected sweetness, bitterness, fruitiness, melting, and liking of milk and dark  
96 chocolates. As color and taste associations were shown to vary among cultures (Wan et al.,  
97 2014), the questionnaire was simultaneously answered by a group of Brazilian and a group of  
98 French consumers. There are also expressive differences in the chocolate consumption  
99 between the two countries, although chocolate is commonly considered the most desired food  
100 in all the Western world (Richard et al., 2017). While the French eat 7.3 kg of chocolate per  
101 capita/year, with dark chocolate representing 30% of consumption among adults (Cohen,  
102 2018), Brazilians eat 2.8 kg and only 3% of it is dark chocolate (Sebrae, 2018).

103 Based on the framework described above, the hypotheses were:

104 H1: the packaging color affects the expectations of sweetness, bitterness, fruitiness,  
105 melting, and liking of chocolate;

106 H2: Cold-colored packaging increase the expected bitterness (H2a), warm-colored  
107 packaging increase expected sweetness (H2b) and fruitiness (H2c);

108 H3: packaging colors differently affect expectations for milk and dark chocolates;

109 H4: packaging colors differently affect expectations of Brazilian and French  
110 consumers.

111

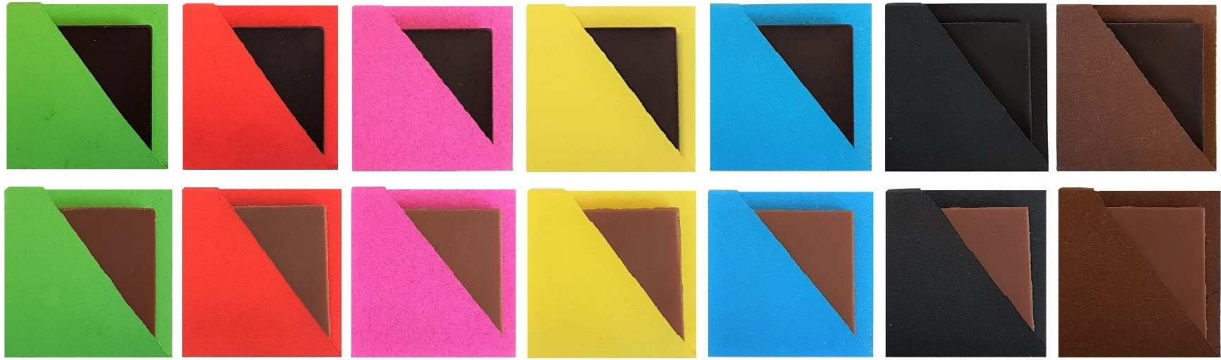
## 112 2. Methods

113

### 114 2.1 Stimuli

115 The stimuli (Figure 1) were pictures (958 x 958 pixels) of Lindt (Lindt & Sprüngli  
116 AG, Kilchberg, Switzerland) milk chocolate (min. 30% cocoa) and dark chocolate (min. 70%  
117 cocoa) in black, blue, brown, green, red, pink and yellow packaging. The packaging were  
118 folded rectangular (10.5 x 4 cm) pieces of Maldor's 130 g/m<sup>2</sup> colored paper (Clairefontaine,  
119 Etival Clairefontaine, France). The images are photographs, all taken in less than 5 minutes  
120 with a Galaxy S7 (Samsung, Manaus, Brazil) in an open space with direct sunlight. They  
121 were cropped, resized and had their contrast increased by 30% on Photoshop CS6 (Adobe,  
122 San José, CA, USA).

123



124  
125 **Figure 1.** Dark chocolate (above) and milk chocolate (below) in green, red, pink, yellow,  
126 blue, black and brown packaging.  
127

### 128 *2.2 Participants*

129 An email inviting chocolate consumers to participate in the research was sent to  
130 students and staff from AgroSup Dijon and the School of Biology, Earth and Environment  
131 Sciences of the University of Burgundy in France, and from the University of Campinas'  
132 School of Food Engineering and School of Agricultural Engineering in Brazil. They were  
133 informed that they were going to “answer a questionnaire about four chocolates” and nothing  
134 else on the subject or aim of the study. Together with the invitation, they received a link that  
135 directed to an online survey designed and hosted on Compusense Cloud (Compusense,  
136 Guelph, Canada). Before starting the questionnaires, respondents read and were given the  
137 choice to accept or decline an informed consent form. This study was approved by the  
138 University of Campinas' Ethic in Research Committee (protocol 20489019.4.0000.5404).

139 Using their own devices (i.e., smartphones, tablets or computers), 445 chocolate  
140 consumers in France and 245 in Brazil completed the questionnaire during the first two  
141 weeks of March 2020. From them, 32 in France and 27 in Brazil were not included in the  
142 study for being underage, not being French or Brazilian, or giving an invalid answer to any of  
143 the questions. The first 210 valid respondents from Brazilian group were selected. This N was  
144 chosen so the maximum of data was used and the number of evaluations for each sample was  
145 balanced. Then, French participants were also selected in “first in, first included” criterium to  
146 match the Brazilian group in number (210), age range (18-60 y.o.), gender distribution (146  
147 female), and mean age ( $26.40 \pm 8.32$  y.o. in France,  $26.40 \pm 6.69$  y.o. in Brazil). This screening  
148 process was performed to obtain comparable groups across cultures (Ares, 2018).  
149

### 150 *2.3 Data collection*

151 If respondents accepted to participate in the study, one of the samples from Figure 1  
152 was shown without any other information on the purpose of the study or on the sample brand,  
153 cocoa content, packaging color etc. Then, participants were asked to rate their expectation of  
154 sweetness, bitterness, fruitiness and melting using a 9-point intensity scale (1 = not at all, 9 =  
155 extremely) and expected liking using a 9-point hedonic scale (1 = extremely dislike, 9 =  
156 extremely like). The questions were “How sweet/bitter/melting/fruity do you think this  
157 chocolate is?” and “How much do you think you would like this chocolate?”. All  
158 communication and questionnaires were in Portuguese in Brazil and in French in France, the



159 translation to French was independently checked by three native speakers familiar with  
160 sensory analysis of food, but no equivalency test was performed.

161 Each participant monadically evaluated two samples of dark chocolate and two of  
162 milk chocolate, therefore, four of the 14 different samples. The balanced incomplete block  
163 was a Williams design provided by Compusense with 98 sets created by modifying a 14 x 14  
164 Latin Square (Williams, 1949). The presentation of the chocolate types and the order of  
165 appearance of the attributes were balanced between participants. After evaluating the  
166 samples, they were asked about what type of chocolate they usually eat (“white”, “milk”,  
167 “dark > 60% cacao”, and/or “dark < 60%”), with which frequency (“once a month”, “2 to 4  
168 times per month”, “2 to 6 times per week”, or “everyday”), which are their nationality (open  
169 answer), gender (“masculine”, “feminine”, or “other”), and age (open answer).

170

#### 171 *2.4 Statistical analysis*

172 Three-way mixed design analyses of variance (ANOVA) (model GLM, SAS Institute,  
173 Cary, USA) at 5% significance level were performed separately for each attribute, so Holm-  
174 Bonferroni was used to correct for multiple comparisons. ANOVA was performed on least  
175 square (LS) means to compensate for the incomplete block, with block as random factor  
176 because of the subjective nature of human behaviour, with country as between-subject fixed  
177 factor because each group has a different nationality and it was a controlled factor, and with  
178 sample as within-subject fixed factor because participants had different samples and it was  
179 also a controlled factor. When the sample effect was significant, Tukey-Kramer’s test was  
180 used for pairwise comparison, also corrected by Holm-Bonferroni. Further contrast analysis  
181 opposing dark and milk chocolate samples was performed using Excel 2010 (Microsoft,  
182 Remond, USA). Multiple factor analysis (MFA) was then performed on the samples by  
183 attributes by country matrix to provide a synthetic view of the data. MFA was followed by  
184 hierarchical cluster analysis (HCA) using the Ward’s agglomeration criterion on the first two  
185 dimensions of the MFA. Both MFA and HCA were performed using FactoMineR (Lê et al.,  
186 2008) for R (R Core Team, 2020).

187

### 188 **3. Results**

#### 189 *3.1 Participants*

190 Type of chocolate consumed and frequency of consumption were both significantly  
191 different ( $\chi^2 = 27.85$ ,  $df = 3$ ,  $p < .01$  and  $\chi^2 = 10.48$ ,  $df = 3$ ,  $p = .02$ , respectively) between the  
192 two groups. As shown in Table 1, more French participants reported eating dark chocolate (>  
193 60% cocoa) and more Brazilians reported eating white, milk, and dark (< 60% cocoa)  
194 chocolates. Also, while French participants are well distributed between all frequencies of  
195 consumption (1/month to everyday), most Brazilians eat chocolate on intermediary  
196 frequencies (2-4/month and 1-6/week). Furthermore, the French showed more specificity  
197 regarding the type of chocolate eaten (1.79 versus 2.05 types of chocolate per person,  $\chi^2 =$   
198 9.67,  $df = 3$ ,  $p = .03$ ).

199

200

201

202 **Table 1.** Chocolate consumption profiles of the Brazilian (N = 210) and French (N =210)  
 203 groups, in percentage.

		Brazil %	France %
Type	White	31.90	20.00
	Milk	67.62	60.95
	Dark (<60%)	66.19	49.52
	Dark (>60%)	39.05	49.05
Frequency	1/month	8.10	15.24
	2-4/month	39.52	28.10
	2-6/week	44.76	33.81
	Everyday	7.62	22.86

204

### 205 3.2 ANOVA

206 The performed analyses of variance (Table 2) showed that significant main effects of  
 207 country were found for all attributes but sweetness (means  $5.08 \pm 1.94$  vs.  $4.98 \pm 1.85$ , in  
 208 Brazilian and French groups, respectively). Brazilian participants expected the chocolates to  
 209 be fruitier ( $5.20 \pm 1.85$  vs.  $4.73 \pm 1.94$ ), more bitter ( $5.02 \pm 1.99$  vs.  $4.47 \pm 2.34$ ), melting  
 210 ( $4.07 \pm 0.51$  vs.  $3.65 \pm 0.28$ ), and liked ( $6.45 \pm 0.42$  vs.  $6.04 \pm 0.43$ ) than French. ANOVA also  
 211 revealed significant main effects of sample for all descriptors, but no significant sample by  
 212 country interaction was found.

213 The mean ratings given by participants to the milk and dark chocolate samples in  
 214 different packaging colors are shown in Table 3. Chocolate packaged in pink and yellow  
 215 were generally expected to be sweeter, less bitter, more melting, and fruitier. On the other  
 216 hand, black packaging increased bitterness ratings and lowered sweetness, fruitiness, and  
 217 melting ratings. Scores for red, blue, and green samples were rarely significantly different  
 218 from other samples. Brown packaging had the greatest number of significant differences,  
 219 being rated as the sweetest, the least bitter, and most melting and liked among dark  
 220 chocolates, as well as the most bitter and the least sweet among milk chocolates.

221 Black, blue, and green packaging had the lowest liking ratings among dark and the  
 222 highest ratings among milk chocolates, while the opposite happened to pink and yellow, that  
 223 is, they received the lowest ratings among milk and the highest among dark. Regarding  
 224 fruitiness, the dark chocolate in pink and red packaging received the highest mean rates, they  
 225 were significantly different from milk chocolate in blue and black packaging.

226



227 **Table 2.** F values and p-values for each dependent variable from the three-way ANOVA with  
 228 block, country and sample as factors. Significance of 5% after Holm-Bonferroni's correction  
 229 for multiple comparison is  $p < .01$ .

Effects	Sweetness		Bitterness		Fruitiness		Melting		Liking	
	F	<i>p</i>	F	<i>p</i>	F	<i>p</i>	F	<i>p</i>	F	<i>p</i>
Block	1.7	< .01	1.44	< .01	2.6	< .01	1.99	< .01	1.77	< .01
Country	0.83	.36	22.43	< .01	10.33	< .01	17.98	< .01	12.06	< .01
Sample	197	< .01	196.42	< .01	4.19	< .01	108	< .01	6.62	< .01
Sample* Country	1.3	.20	1.81	.04	0.74	.73	1.49	.11	.78	.68

230

231 **Table 3.** Least square means and standard deviation for sweetness, fruitiness, melting, and  
 232 liking of dark and milk chocolates in seven packaging colors (1 = not at all, 9 = extremely).  
 233 Values with the same letters in each column were not significantly different according to  
 234 Tukey-Kramer's test at 5% significance corrected by Holm-Bonferroni for multiple  
 235 comparison.

		Sweetness	Bitterness	Fruitiness	Melting	Liking
Dark	Black	2.27±1.33 <sup>c</sup>	7.77±1.49 <sup>a</sup>	3.49±2.43 <sup>bc</sup>	2.92±1.70 <sup>c</sup>	5.45±2.28 <sup>c</sup>
	Blue	2.94±1.64 <sup>de</sup>	7.07±1.96 <sup>abc</sup>	3.59±2.13 <sup>bc</sup>	3.12±1.64 <sup>de</sup>	5.68±2.02 <sup>bc</sup>
	Brown	4.11±1.69 <sup>c</sup>	5.89±1.85 <sup>d</sup>	3.53±2.15 <sup>bc</sup>	4.48±1.87 <sup>c</sup>	6.54±1.74 <sup>a</sup>
	Green	2.88±1.62 <sup>de</sup>	7.27±1.73 <sup>ab</sup>	4.05±2.22 <sup>abc</sup>	3.22±1.76 <sup>de</sup>	5.63±2.25 <sup>bc</sup>
	Pink	3.75±1.63 <sup>c</sup>	6.31±1.95 <sup>cd</sup>	4.62±2.21 <sup>a</sup>	3.79±1.15 <sup>cd</sup>	6.25±1.79 <sup>abc</sup>
	Red	3.33±1.68 <sup>cd</sup>	6.73±1.90 <sup>bcd</sup>	4.40±2.26 <sup>ab</sup>	3.48±1.77 <sup>de</sup>	6.08±1.78 <sup>abc</sup>
	Yellow	3.57±1.64 <sup>cd</sup>	6.31±1.90 <sup>cd</sup>	4.19±2.06 <sup>abc</sup>	3.70±1.89 <sup>cde</sup>	6.09±1.89 <sup>abc</sup>
Milk	Black	6.62±1.49 <sup>ab</sup>	3.06±2.00 <sup>efg</sup>	3.41±1.92 <sup>c</sup>	6.32±1.54 <sup>ab</sup>	6.80±1.45 <sup>a</sup>
	Blue	7.20±1.44 <sup>ab</sup>	2.21±1.34 <sup>fg</sup>	3.44±1.99 <sup>c</sup>	6.50±1.74 <sup>ab</sup>	6.53±1.70 <sup>a</sup>
	Brown	6.43±1.53 <sup>b</sup>	3.25±1.88 <sup>e</sup>	3.50±1.97 <sup>bc</sup>	6.42±1.70 <sup>ab</sup>	6.62±1.53 <sup>a</sup>
	Green	6.43±1.61 <sup>b</sup>	3.15±1.79 <sup>e</sup>	4.09±2.17 <sup>abc</sup>	5.86±1.93 <sup>b</sup>	6.30±1.71 <sup>ab</sup>
	Pink	7.14±1.24 <sup>ab</sup>	2.17±1.39 <sup>g</sup>	4.08±2.04 <sup>abc</sup>	6.71±1.73 <sup>ab</sup>	6.45±1.54 <sup>ab</sup>
	Red	6.60±1.58 <sup>ab</sup>	3.00±1.77 <sup>ef</sup>	3.98±2.20 <sup>abc</sup>	6.29±1.86 <sup>ab</sup>	6.60±1.55 <sup>a</sup>
	Yellow	7.31±1.32 <sup>a</sup>	2.30±1.36 <sup>fg</sup>	3.82±2.22 <sup>abc</sup>	6.74±1.49 <sup>a</sup>	6.35±1.70 <sup>ab</sup>

236

### 237 3.3 Contrast analysis

238 Further contrast analysis opposing dark and milk chocolate samples showed that type  
239 of chocolate had a greater significant influence on sweetness ( $F(1,1342) = 2,395.42, p < .01$ ),  
240 bitterness ( $F(1,1342) = 2,390.83, p < .01$ ), and melting ( $F(1,1342) = 1,304.47, p < .01$ ); and  
241 a smaller significant effect on fruitiness ( $F(1,1342) = 4.24, p < .05$ ) and liking ( $F(1,1342) =$   
242  $44.77, p < .01$ ). In addition to the contrast analysis, the greater standard deviations of the  
243 mean ratings (0.62 vs 0.38 in sweetness, 0.65 vs 0.48 in bitterness, 0.45 vs 0.30 in fruitiness,  
244 0.52 vs 0.30 in melting, 0.39 vs 0.17 in liking) and the greater number of significant  
245 differences between samples (27 vs 9 in total) indicate that packaging color affected more the  
246 expectations for dark chocolate than for milk chocolate.

247

### 248 3.4 MFA and HCA

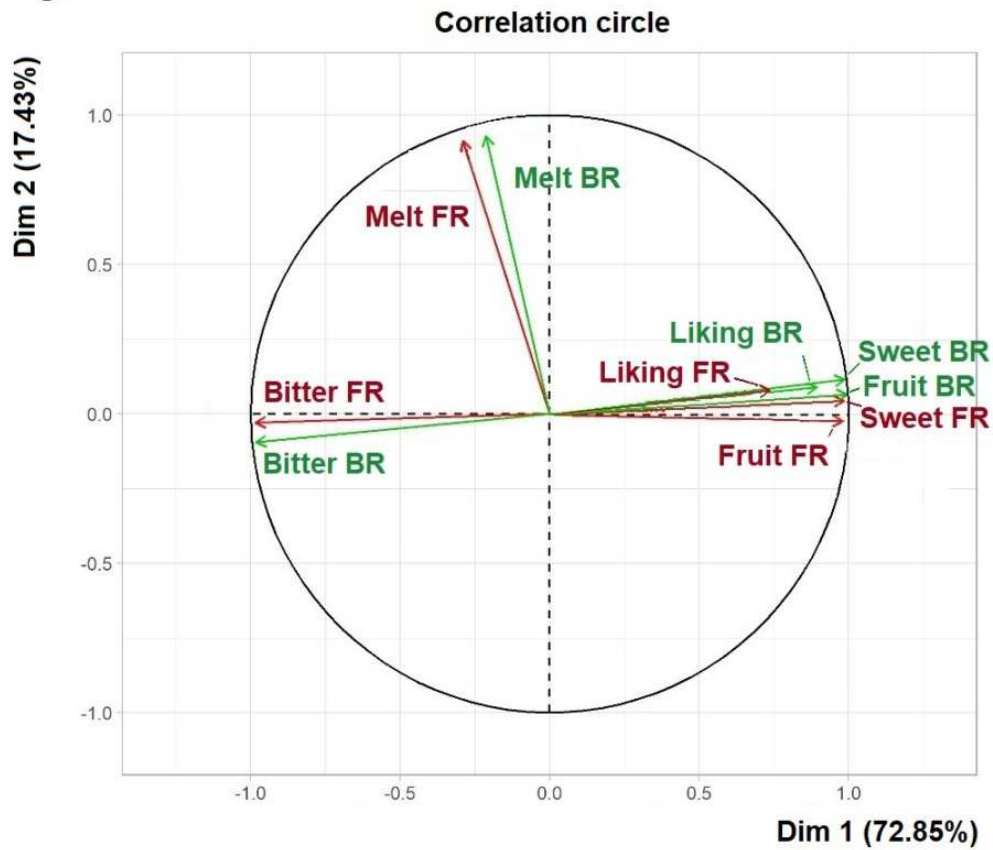
249 The correlation circle (Figure 2A) indicates small differences between the Brazilian  
250 and French groups. The first dimension explains 72.85% of the variance and is negatively  
251 correlated to bitterness (-.99 and -.99) and melting (.23 and -.32), while positively correlated  
252 to sweetness (.99 and .99), fruitiness (.99 and .99), and liking (.85 and .67) in Brazil and  
253 France, respectively. The second dimension is mostly correlated to melting (.93 and .90) and  
254 explains 17.43% of the variance so that the first two components of the MFA account for  
255 90.28% of total variance.

256 The individual factor map (Figure 2B) shows a clear separation between the milk  
257 (right) and the dark chocolates (left) on the first dimension. As shown by Table 3, milk  
258 chocolates were generally expected to be sweeter (means  $6.82 \pm 0.38$  vs.  $3.26 \pm 0.62$ ), less bitter  
259 ( $2.73 \pm 0.48$  vs.  $6.76 \pm 0.65$ ) and fruity ( $3.76 \pm 0.30$  vs.  $3.98 \pm 0.45$ ), more melting ( $6.41 \pm 0.30$  vs.  
260  $3.53 \pm 0.52$ ) and liked ( $6.52 \pm 0.17$  vs.  $5.96 \pm 0.39$ ) than dark chocolate. The second dimension  
261 shows both chocolates packaged in pink, red, yellow, and green (up) in opposition to blue,  
262 black, and brown (down). Overall, the projections of each country for a same sample are  
263 more distant vertically than horizontally, indicating that melting is an important attribute to  
264 discriminate the answers from the Brazilian and French groups.

265 HCA revealed three clusters, the first with all milk chocolate samples (left), the  
266 second with dark chocolate samples in pink, red, yellow and green packaging (right/up), and  
267 third with dark chocolate packaged in brown, blue and black (right/down). The first cluster is  
268 correlated with sweeter, fruitier, and more liked samples; the two others are correlated with  
269 more bitter samples. The difference between the second and the third clusters is on the second  
270 dimension, the former being positively correlated to melting and the latter negatively.

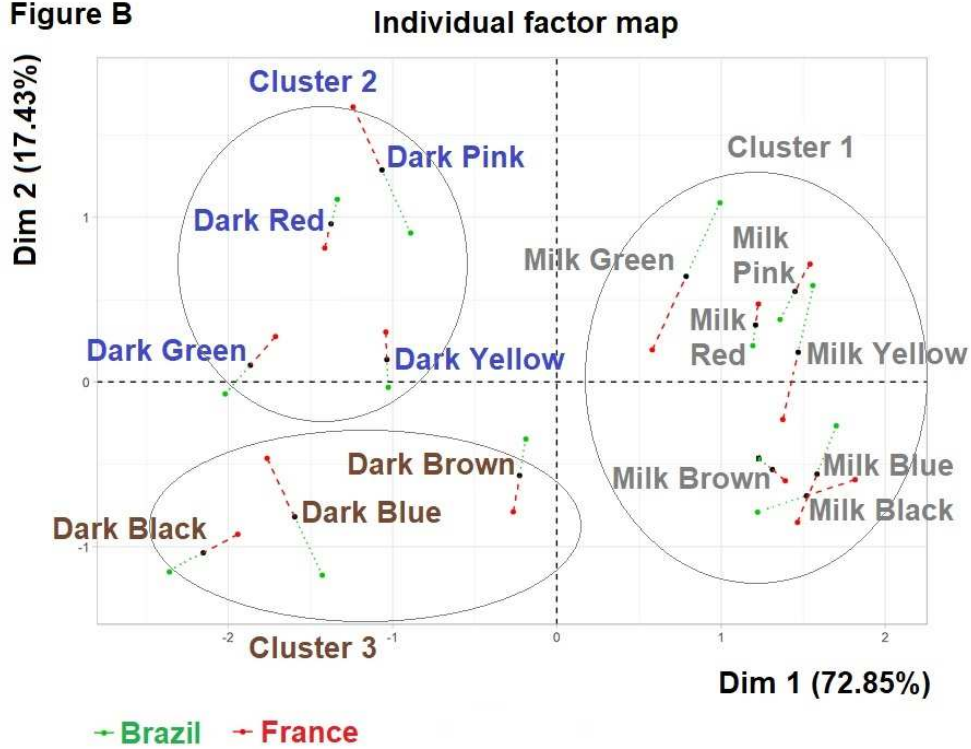
271

Figure A



272

Figure B



273

274

275

**Figure 2.** Multiple factor analysis: (A) Correlation circle of variables in Brazil and France; (B) Individual factor map with HCA clusters.

## 276 **4 Discussion**

### 277 *4.1 Color*

278 The first hypothesis (H1) was confirmed, that is, packaging colors significantly  
279 affected the expectations of sweetness, bitterness, fruitiness, melting and liking. A review of  
280 Spence and Velasco (2018) showed significant effects of packaging colors on other food and  
281 beverage products, but the only previous research on chocolate (van Lith, 2015) with 23  
282 participants in Netherlands reported no significant effect of seven different colors of  
283 packaging on tastiness and attractiveness. Reasons why the present study found significant  
284 differences in liking, while the previous did not on tastiness and attractiveness, might be: the  
285 colors used, a cultural difference, the lack of other information (i.e., logo, label, illustrative  
286 picture) and/or just a greater number of participants.

287 As dark and milk chocolate were shown interleaved to make the aim of the study less  
288 obvious to participants, the sample effect accounted for the influence of chocolate type and of  
289 packaging color at the same time. All attributes were significantly affected by sample, but  
290 sweetness, bitterness and melting were more strongly than fruitiness and liking. On one hand,  
291 it is evident that type of chocolate was more relevant for sweetness, bitterness and melting,  
292 because all milk chocolate samples were significantly different from all dark chocolate  
293 samples in these attributes, regardless of packaging color. On the other hand, color was more  
294 relevant for fruitiness than type of chocolate, because none of the samples were rated  
295 significantly fruitier than the other type packed in the same color, while there were some  
296 significant effects between samples with different colors. On liking, effects of type and  
297 packaging color were dependent and can not be separated.

298 ANOVA revealed that black packaging is correlated to bitterness, while pink and  
299 yellow packaging are correlated to sweetness. Spence et al. (2015) indicated that the  
300 associations black-bitter and pink-sweet are commonly reported in different cultures, but not  
301 the yellow-sweet association, as this color is generally correlated to sourness. Yet, the  
302 yellow-sweet association is somehow coherent with the findings that Uruguayan consumers  
303 expected milk dessert in black packaging to be more bitter than in yellow or white (Ares &  
304 Deliza, 2010); that Spanish consumers expected chewing gum in grayscale (black to white)  
305 packaging to be less sweet than in warm (red to yellow) or cool (blue and green) colors  
306 (Rebollar et al., 2012); and that Brazilians expected and perceived two coffees as sweeter  
307 when in a yellow cup (Carvalho & Spence, 2019).

308 Previous studies (Rebollar et al., 2012; Spence et al., 2015; Huang & Lu, 2015;  
309 Tijssen et al., 2017) reported that red packaging consistently increases expectations of  
310 sweetness, creaminess, and fruitiness in food products, but both chocolate samples in red  
311 packaging in this study received intermediary rates. Red was only significantly different from  
312 black on bitterness among dark chocolate and from pink on sweetness among milk chocolate.  
313 The faible effect might be due to the brightness and/or saturation used in this experiment, but  
314 van Lith (2015) also did not find significant effects for red packaging. Spence and Velasco's  
315 (2018) argued that it could be due to the Dutch association between red packaging and dark  
316 chocolate, the finding of the same result in France and Brazil indicates the lack of effect is  
317 more general in Western cultures.

318 Brightness and/or saturation could also be relevant to understand why samples in  
319 green packaging were rated significantly more bitter than in brown, pink, and yellow among

320 dark chocolate, and blue and pink among milk chocolate. Two out of five studies reviewed by  
321 Spence et al. (2015) reported an association between green and bitterness, while four reported  
322 association with sourness. This ambivalence is not rarely explained by the prevalence of  
323 limes or lemons in the participants' culture (Carvalho & Spence, 2019), but in this study  
324 Brazilians distinctly associated green to bitterness. So, it is possible that the use of a brighter  
325 or darker shade of green might also play a role in the ambiguity, as a same culture might  
326 associate the first with the color of lime and the second with the color of dark green  
327 vegetables like broccoli and spinach.

328 The dark chocolate in brown packaging received the most ambivalent ratings, being  
329 the sweetest and the least bitter among dark chocolates, while it got the highest rating for  
330 bitterness and the lowest for sweetness among milk chocolate. This might be due to a dual  
331 effect of packaging color depending on chocolate type or, more likely, a miscalibration of the  
332 lighting by the camera used in this study, as the dark chocolate seems slightly brighter in the  
333 brown packaging than the other dark chocolate samples. This unbalanced lighting was  
334 unnoticed by the researchers before the conclusion of the data collection. Other samples  
335 might also have lighter differences, but these differences varied according to the device used  
336 by the participant and are, at least in part, an effect of the contrast with the packaging color.

337 As the stimuli showed both chocolate and packaging, the samples were combinations  
338 of two colors. It has been shown that the combination of two congruent colors can be more  
339 strongly associated to a taste than the colors alone, especially when one is dominant and the  
340 other is auxiliary (Woods & Spence, 2016; Woods et al., 2016). In the present study, stronger  
341 effects of chocolate type indicate that the color of the chocolate was more important than the  
342 color of the packaging, suggesting that the former was perceived as foreground and the latter  
343 as background. That is understandable, since participants were asked to rate their  
344 expectations for the chocolate, not for the packaging. Thus, the results in this study are the  
345 effects of the combination of the packaging color with the color of chocolate and they might  
346 not be replicable in packaging that do not show the chocolate by transparency or illustration.

347

#### 348 *4.2 Warm and cold colors*

349 The hypothesis that cold colors would increase bitterness ratings (H2a) and warm-  
350 colored packaging would increase sweetness (H2b) and fruitiness (H2c) ratings was not  
351 confirmed. First, MFA separated almost perfectly between cold and warm colors, except for  
352 both samples in green, that are together with pink, red and yellow on the upper part of the  
353 individual map (Figure 2B). Then, the milk chocolate in red packaging received much closer  
354 ratings to black, blue, green, and brown than to pink and yellow in sweetness and bitterness,  
355 being rated significantly more bitter than pink. In the other direction, the milk chocolate in  
356 blue packaging, a cold color, was rated the second most sweet and the second less bitter,  
357 being expected significantly less bitter than brown and green. Among dark chocolate the  
358 distinction was stronger, as all warm colors were rated-although not always significantly-as  
359 sweeter and less bitter than all cold colors, except brown, whose results are questionable.

360 Based on the cold and warm distinction, most studies compare and find significant  
361 effects on expectation and perception of food and drinks in red and blue packaging (Rebollar  
362 et al., 2012; Huang & Lu, 2015; Tijssen et al., 2017; van Esch et al., 2019; Rosa et al., 2019).  
363 This study found no significant difference between these two packaging colors in any

364 attribute of any chocolate type. These unusual results might be particular to chocolate  
365 packaging, to Brazilian and French cultures, or to the brightness and saturation used by this  
366 experiment, but they resemble the results on single colors reported by Woods & Spence  
367 (2016). Thus, researchers, industries, artisans, chefs, baristas, mixologists, packaging  
368 designers, food bloggers and photographers might consider contrasting black to pink or  
369 yellow, instead of red to blue when willing to influence the consumer's expectations.

370

### 371 *4.3 Chocolate type*

372 The third hypothesis (H3) was confirmed: packaging colors affected milk and dark  
373 chocolate differently. The greater standard deviation of the mean ratings and the greater  
374 number of significant differences indicate that packaging color affected more the  
375 expectations for dark chocolate than for milk chocolate. HCA also evidences that, as dark  
376 chocolate samples were separated in two clusters, while the milk chocolate samples were all  
377 grouped in one single cluster. This difference might be a consequence of a stronger and wider  
378 flavor and texture profile found in chocolates with higher cocoa content, and/or of the adding  
379 effect of shape and color congruency (de Sousa et al., 2020). As dark chocolate is related to  
380 squared-shapes and milk chocolate to round-shapes (Ngo et al., 2011), results could be  
381 different if the chocolate samples were rounded.

382 Regarding liking, packaging colors influenced the types of chocolate differently, even  
383 in opposite directions. Table 2 shows that while the black packaging made the milk chocolate  
384 the most liked of all samples, the same packaging made the dark chocolate the least liked.  
385 The pink packaging had an opposite effect, making the dark chocolate the second most liked-  
386 only behind the one packed in brown, whose results are questionable as mentioned on the  
387 previous item-and the milk chocolate the second least liked among its type. Other colors,  
388 except brown, had similar ambivalent effects, increasing liking in one of the types and  
389 decreasing on the other.

390 If at first it would be intuitive and congruent to use dark packaging colors for dark  
391 chocolates and light colors for milk chocolates, this study shows that contrasting the  
392 chocolate type and the packaging color might make it more appealing for consumers. This  
393 might be an explanation for why some industries in Europe use red packaging for dark  
394 chocolate, as mentioned before. Perhaps the incongruity between packaging color and  
395 chocolate type increases liking by making the product look more balanced, that is, "sweet  
396 colors" make dark chocolate look not too bitter, and "bitter colors" make milk chocolate look  
397 not too sweet.

398 This result does not necessarily mean that consumers individually prefer balanced  
399 chocolates, but that the group preference converges on balanced chocolates, something  
400 natural if we expect to have individuals with preferences normally distributed through all the  
401 spectrum of bitterness to sweetness. Therefore, food industries and services that use visual  
402 cues to sell their products to a broad public, such as chocolate bars in a supermarket or a  
403 chocolate-based pastry on a shop window, could improve their overall expected liking by  
404 using the right packaging or background color to the right type of chocolate. This resource  
405 should be used with care, though, since great disconfirmation of expectation may lead to a  
406 penalty on post-consumption liking (Cardello & Sawyer, 1992).

407



#### 408 4.4 Cross-cultural effects

409 The hypothesis that packaging color would affect Brazilian and French consumers  
410 differently (H4) was not confirmed. ANOVA combining the effects of country and sample  
411 showed no significant difference between groups, indicating that packaging colors affected  
412 ratings in the same general way in both groups. This understanding is also supported by the  
413 proximity between groups of the angles on the correlation circle (Figure 2A) and of the  
414 projections on the individual map (Figure 2B). For practical applications, it evidences that no  
415 **change** in packaging or context colors might be necessary for exporting chocolate products or  
416 offering a chocolate pastry dish in Brazil, France, and possibly many other Western cultures.

417 It is interesting to add that ANOVA found significant effects of country alone in all  
418 attributes except sweetness. These results show that the overall rating of bitterness, fruitiness,  
419 melting, and liking was different between groups, but not that packaging colors had different  
420 effects. For example, the Brazilian mean rating for bitterness of all samples was significantly  
421 higher than the French, probably a consequence of the smaller percentage of Brazilians that  
422 reported eating chocolate with more than 60% cocoa. As they are less familiar to bitter  
423 chocolates, they rated bitterness higher than the French.

424 In the other direction, it is unexpected that there was no significant difference for  
425 sweetness between countries with such different relationships with sugar, as Brazilian  
426 desserts are known for being distinctly sweet and sugar being part of the cultural, economic  
427 and political history of the country (Freyre, 2007). But the lack of difference does not  
428 necessarily indicate that they perceive sweetness equally, it only shows that both groups had  
429 similar expectations of sweetness when seeing images of chocolate samples. What Brazilian  
430 consumers would rate as a moderately sweet chocolate when tasted might still be too sweet  
431 for French consumers.

#### 432 433 4.5 Limitations

434 As recent studies showed that the lightning and chroma may affect emotions more  
435 than the hue alone (Schloss et al., 2020) and, as color-taste effects might occur via emotions  
436 correspondences (Palmer et al., 2013), they were a relevant uncontrolled factor in this study.  
437 Further studies should investigate the effects of colors in more complex and realistic  
438 packaging, including more than one hue, brightness and/or saturation. As the aim of this  
439 study was to explore the color effect, no other detail was included in the packaging, such as  
440 brand, weight, claims, product description **or illustration**. Participants of both groups were  
441 recruited from institutions that teach and research Food, Biology and Agriculture, therefore  
442 their background knowledge of scientific methods and/or food likely influenced the results.  
443 This study also did not check participants for color blindness, nor controlled the final  
444 resolution and color balance of the pictures since participants used their own devices to  
445 answer the questionnaire. To make the goal of the experiment less obvious to participants,  
446 this study chose to collect and analyze data on milk and dark chocolate samples together.  
447 This might have led to a smaller number of significant differences, particularly among milk  
448 chocolate samples, because the effects of packaging color on dark chocolate were stronger.  
449 Another step forward on the subject would be testing if these effects on expectation affect  
450 consumers' actual perception, because that is not always the case (Zellner et al., 2018).

451

452 **5. Conclusion**

453 This study was the first to find significant effects of several packaging colors on  
454 expected taste, flavor, texture and liking of chocolate. It was also the first to evaluate that for  
455 two types of the same food product with opposing sensory qualities (bitter x sweet) among  
456 two different cultures. Another difference was showing both the product (chocolate) and the  
457 packaging on the picture. Significant interactions between chocolate type, packaging color  
458 and culture showed that effects are co-dependent, making it important to consider and control  
459 all these variables together. It is possible to conclude that black packaging induces greater  
460 expectation of bitterness and yellow and pink packaging induce greater expectation of  
461 sweetness and melting in chocolate. Also, that the effects of a packaging color on expected  
462 liking might take opposite directions for milk and dark chocolate. The effects of context color  
463 on food must be further investigated to understand how industries, artisans, chefs, baristas,  
464 mixologists, packaging designers, food bloggers and photographers may use it to influence  
465 the consumers' expectations for its products and services.

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