Potential use of naturally colored antioxidants in the food industry - A study of consumers' perception and acceptance

Perception of naturally colored antioxidants

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Abstract

In the present study, the influences of color and awareness of the presence of three different naturally colored antioxidants, were studied using the projective consumer method Word Association. *Moringa*, propolis and red grape pomace extracts were added to three different food products categories (bread, yogurt and pate) as case studies. To explore the influence of the presence of natural antioxidants in the colored products, two conditions were applied: *blind condition* (unawareness) and *informed condition* (awareness). Hedonic scores were concurrently collected using a facial scale with seven points. Results exposed that an unfamiliar color, in food products with added naturally colored antioxidants, did not have a strong impact on consumers' perception of the appearance. The awareness of the presence of natural antioxidants, positively influenced consumers' perception and acceptance. Results also demonstrated that a naturally colored antioxidant from propolis could not be used in all food categories. The problem highlighted by consumers was not attributed to the color, but to the off-flavor presented by the propolis extract.

Practical applications: To increase natural antioxidant use by the food industry, consumers' perception emerge as important tools. The addition of a natural antioxidant in the color of the final product is important information for consumers and for future industrial applications, especially if they provide unfamiliar colors to the products.

Keywords: Food Industry, consumers acceptance, antioxidant, bread, pate, yogurt, Moringa, propolis, red grape pomace, Word Association.

1. INTRODUCTION

Food antioxidants are a core topic of food science and are among the most studied topics in the areas of food science and nutrition (Cömert & Gökmen, 2018). This is mainly due to the high consumption of ultra-processed foods, which are characterized by convenience as well as long shelf life (Ribeiro et al., 2019), and represent a demand of modern society (Shim et al., 2011). Increasingly, food antioxidants have gained the spotlight, not merely as a food preservative but also as inhibitors of the oxidation processes in humans metabolism (Cömert & Gökmen, 2018).

Consequently, natural food antioxidants have been gaining great attention in several studies recently. They are important healthy alternatives to replace synthetic antioxidants that have been identified as toxicological and/or carcinogenic (Kumar et al., 2015). A number of antioxidants were discovered and isolated from natural sources such as herbs, spices, vegetables, fruits and even food residues (Brewer, 2011; Cömert & Gökmen, 2018). Among the natural matrices studied which showed biological activity, it is possible to highlight the resin propolis (Tiveron et al., 2016), red grape pomace (Rockenbach et al., 2011) and leaves of the *Moringa oleifera* plant (Oldoni et al., 2019).

The limited use of natural antioxidants, despite the European Union allowing the use of rosemary extract, for example, is probably due to their stability (Carocho et al., 2018). The presence of bitterness, astringency and intense flavor could also limit their incorporation in foods and beverages (Ares et al., 2009). Natural antioxidants from fruits and vegetables present an overall concentration of bioactive compounds that are known to be pigmented and provide a specific color (Cömert, Ezgi Doğan et al., 2020). Pigments that provide color in products could be a challenge for their use. The coloring potential could be desirable or not, depending on consumer perception, or could limit their use by some sectors of the food industry.

Food appearance is of unquestionable importance to consumers. Among other attributes, color is considered one of the most significant in food product appearance (Cömert, Ezgi Doğan et al., 2020; König & Renner, 2018; Paakki, Sandell, & Hopia, 2016; Schifferstein, Wehrle, & Carbon, 2019; Spence, Levitan, Shankar, & Zampini, 2010; Wadhera & Capaldi-Phillips, 2014). Studies have confirmed the relationship between colorful foods and healthy foods (Cömert, Ezgi Doğan et al., 2020; König & Renner, 2018) and consequently the effect of food color when deciding what and how much to eat (König & Renner, 2018; Wadhera & Capaldi-Phillips, 2014). Other studies have tried to understand the influence of food color in flavor and odor perception, revealing that color clearly influences perceived flavor identity (Spence et al., 2010) and strongly affects participants' self-reports on odors qualities (Stevenson & Oaten, 2008).

In the studies of Paakki et al.(2016) and Schifferstein et al. (2019) the authors explored consumer reaction to atypically colored foods and concluded that an atypical color in an ordinary food product affects consumer perception and choices. In addition, although atypical colors produce more available types of food products, commercial success may be limited until consumers integrate them into their routines and habits (Schifferstein et al., 2019).

Thus, in the present study, the influence of color and the presence of three different naturally colored antioxidants (from *Moringa*, propolis and red grape pomace), was studied in three different products categories (bread, pâté and yogurt) through Word Association. To explore the influence of consumers' awareness of the presence of natural antioxidants in colored products, two conditions were applied: *blind condition* (unawareness of presence) and *informed condition* (awareness of presence).

Considering the objectives, three hypotheses were formulated:

i) Unfamiliar colored food products influence consumer perception of food appearance;

ii) The awareness of the presence of natural antioxidants in colored food products positively influence consumer perception and acceptance;

iii)Not all naturally colored antioxidant have the same acceptance in all food products.

2. MATERIAL AND METHODS

2.1 Naturally colored antioxidants and food products

Naturally colored lyophilized extract antioxidants were added to three products from different sectors of food industry: yogurt, chicken pâté and bread. The extracts were from *Moringa* (NAM-green) (*Moringa oleífera* Lam, grown at Itajaí, SC - Brazil), propolis (NAP-yellow) (donation Breyer & Cia Ltda, União da Vitória, PR -Brazil) and red grape pomace (NAG-purple) (*Vitis labrusca*, grown at Mariópolis, PR - Brazil). The extracts were obtained according to methodologies proposed by Oldoni et al. (2019) for *Moringa*, Calegari et al. (2020) for propolis and Karling et al. (2017) for red grape pomace. Figure 1 shows the three lyophilized extracts of natural antioxidants.

Fig. 1

Natural antioxidants were used in the 0.5% dosage according to studies already carried out by Terra, N.N.; Fries, L.L.M.; Milani, L.G.; Kubota, E.H.; Terra, A. M.; Urnau, (2005) (*c.f.* see formulations in supplementary material). *Moringa* extract was added with a greenish color expected, propolis a yellowish color and grape a purple/pink color in the products. Figure 2 presents photos of the three products with the proposed three natural antioxidants added.

Fig. 2

2.2 Sensory tests

In order to assess the holistic and hedonic perception of food products with naturally colored antioxidants added, a Word Association (WA) task and a hedonic evaluation using a facial 'smiley' scale were used. Participants were provided with an informed consent form at the beginning of the questionnaire. The Ethics Committee for Human Research of Federal University of Technology - Paraná approved the study (CAAE number 15220019.4.0000.5547).

2.2.1 Participants

The participants in the test were students and lecturers that were randomly selected at the Federal Technological University of Paraná with no relation to food sciences. The participants (n = 476) aged between 20 and 55 years old. Each consumer participated in the evaluation of only one of the products with one of the naturally colored antioxidants added, in order to get the most spontaneous answers and avoid biased responses caused by previous contact with the samples and technique. All participants were consumers of the tested products categories. The data related to the numbers of participants are shown in Table 1.

Table 1

2.2.2 Sample preparation

The tests were performed in a sensory analysis laboratory according to ISO 8589 (ISO, 2007). Yogurt samples were prepared the day before and refrigerated at 4 °C. Each yogurt sample (10 mL) was served at 15 °C in a plastic cup coded with a 3-digit random number

(Miele et al., 2019). Pâté samples were prepared the day before and refrigerated at 4 °C in glass containers. 10 g of pâté with cream crackers were served on plastic dishes coded with a 3-digit random number at 10 °C (Siret & Issanchou, 2000). Bread samples were prepared 24 hours before, packed in plastic bags and kept at room temperature (25 ± 1 ºC). Before analysis, the samples were sliced into equally sized pieces (2 cm thick) and served on plastic dishes coded with 3-digit random number (Dhen et al., 2018).

2.2.3 Word Association

Word association was applied according to Ares, Giménez, & Gámbaro (2008) and Mitterer-Daltoé, Carrillo, Queiroz, Fiszman, & Varela, (2013). Two stimuli were applied to each consumer. For the first stimulus, called *blind condition*, the instruction was: "Write the first four words, sensations or feelings that come to your mind when you taste the sample (yogurt, bread or pâté)". For the second stimulus, called *informed condition* the instruction was: "Write the first four words, sensations or feelings that come to your mind when you taste the (yogurt, bread or pâté)" with natural antioxidant added (from *Moringa*, propolis or red grape pomace)". No prior explanation of natural antioxidants was given to the participants.

2.2.4 Hedonic test

Nowadays, emojis have grown in popularity in all age-groups, becoming a must in digital communication. Previous studies (Deubler et al., 2020; Swaney-Stueve et al., 2018) have compared emoji scales to the P&K scale and found it to be an alternative to traditional hedonic methods.

The test was applied using a facial 'smiley' scale with seven points. Each consumer was asked to mark with an X over the emoji that identified their level of acceptance of the tested product (Deubler et al., 2020; Swaney-Stueve et al., 2018).

2.3 Data analysis

Word Association data analysis was based on Antmann, Ares, Salvador, Varela, & Fiszman (2011). Associations were grouped into different categories, which were then grouped into different dimensions. Four researchers performed the grouping independently. The final categories and their names were determined by consensus among the researchers. Categories mentioned by more than 5% of the participants were included in the analysis. The bilateral Z-test was performed to study differences between the associations for the *blind* and *informed conditions* (Mitterer-Daltoé et al., 2013). To better understand and visualize the categories that represented each product with natural antioxidant added (in *blind* and *informed conditions*), Correspondence Analysis (CA) was applied.

The means of hedonic scores for each product were evaluated by the Tukey test ($p \leq 0.05$). T-test was used to verify significant differences between *conditions* for each product. Data were analyzed using Statistica® software 12.7.

3. RESULTS

3.1. Consumer perception of the products

The Tables from 2 to 4 show the dimensions and categories obtained from the results of the WA. Six common dimensions among samples were built by consensus among the

four researchers' participants in the data analysis process. Words with similar meanings were grouped in the same category. The common dimensions were: **Hedonic**, **Texture**, **Flavor**, **Appearance**, **Habits** and **Ingredients**. Other dimensions such as **Odor** and **Health** appeared for some of the products.

3.2.1 Yogurt

Table 2 shows the dimensions and categories obtained from *blind condition* and *informed condition* for yogurts with the three naturally colored antioxidants added. **Hedonic** was one of the dimensions most mentioned for the three yogurts in both conditions. The most mentioned category of this dimension was *Tasty*, showing good acceptance of the yogurts.

Table 2

Significant differences between conditions for this dimension were verified for yogurts NAM-green and NAG-purple-added. In the NAM-green-added category, *Bad* had no mentions on *informed condition*, meaning, the awareness of the presence of a natural antioxidant provided a more positive perception, and a consequently decrease in rejection. Similarly, in the NAG-purple-added yogurt, the category *Tasty* was significantly more mentioned, and the category *Bad* was significantly less cited in the *informed condition.*

The number of mentions in the **Flavor** dimension revealed the importance of this sensory attribute in dairy products such as yogurts. *Sour* was the category most mentioned, an expected result since this basic taste is typical in yoghurt as a consequence of the fermentation process (Shepard et al., 2013). It is worth noting that the difference in mentions of *Sour* between conditions for the three yogurts, even though significant, it only appeared for yogurt NAG-purple-added. This does not imply that participants did

not perceive sour taste in the *informed condition*. What may have happened, was that due to the additional information the associations in focus changed.

Yogurt formulations contained 11.5% sugar, a fact that justified the mention of *Sweet* in all samples. Specific **Flavor** categories were cited for the three yogurts with naturally colored antioxidants added. Furthermore, the mention of *Tea* category for the NAM-green-added yogurt revealed a flavor connected to plants or leaves provided by the natural antioxidant from *Moringa*. *Honey* was the flavor that appeared in the *blind condition* for the NAP-yellow-added yogurt. Consequently, in the *informed condition*, the awareness of the natural antioxidant from propolis converted *Propolis* as the flavor most elicited.

The yogurt NAG-purple-added was the only product with a correct flavor identification, since the term *Grape* was mentioned not only in the *informed condition* but also in the *blind condition*. This may have happened due to the regular consumption of this fruit. The opposite can be said regarding *Moringa* and propolis.

It is noteworthy the *Natural* **Appearance** perception of consumers, led by NAM-green and NAP-yellow-added yogurts, was only in the *informed condition* in the NAM-green case and was equally mentioned in both conditions for NAP-yellow yogurt. The natural appearance could indicate a potential for a healthy appeal for the products with naturally colored antioxidants added (Dickson-Spillmann et al., 2011).

The yogurts were moreover associated to *Memories*, revealing the influence of past experiences in the perception of yogurts. This *Memories* may also indicate a potential market use of these naturally colored antioxidants in yogurts, since it is known that memory has a positive effect on the perception of foods (Morin-Audebrand et al., 2012). Furthermore, past experiences (Ajzen, 1991; Verbeke & Vackier, 2005) and familiarity can influence the food buying behavior (Fotopoulos et al., 2009). Spontaneous mention of any color was observed only in the yogurt NAM-green-added. This was probably due

241 to green color being an atypical color for commercial yogurts. The results also showed
242 that consumers related the *Green* color with avocado.
243
244 **3.2.2 Pâtés**
245 The dimensions and categories obtained from *blind condition* and *informed condition* for
246 the pâtés with the three added naturally colored antioxidants are shown in Table 3.
247 **Hedonic** was the dimension most mentioned for pâtés with naturally colored antioxidants.
248 The frequency of mentions of the category *Tasty* demonstrated that the three natural
249 antioxidants used in pâtés pleased consumers. Likewise, the good acceptance as *Tasty*
250 mentions for pâtés was equally ($p \geq 0.05$) observed in *blind* and *informed conditions*.
251 **Table 3**
252 The dimensions **Texture** and **Flavor** revealed the sensory attributes most relevant
253 for pâtés by consumers. According to Antmann, Ares, Salvador, Varela, & Fiszman
254 (2011) the most frequently mentioned terms could be related to the most relevant for
255 consumers, and more commonly used by them to describe the characteristics of food
256 products.
257 Some results corroborated the findings for yogurts: A change of focus with the
258 provided information about the presence of natural antioxidants in the *informed condition*
259 stimulus. Among sensory attributes, *Seasoned* was one of the most cited for all
260 formulations. In NAM-green-added pâté for *blind condition* 38.46% of participants cited
261 this term. The number of mentions dropped to 3.8% of participants in the *informed*
262 *condition*. This influence could also be visualized by the *Garlic* category. For NAP-
263 yellow-added pâté, the i*nformed condition* resulted in the occurrence of the terms
264 *Propolis/Honey* to describe the product and the absence of the term *Garlic*.

The *informed condition* also produced significant differences in other categories, such as the *Healthy* category in NAG-purple-added pâté. Awareness of the presence of the red grape pomace natural antioxidant provided a positive healthy perception. Another positive perception for all pâté samples was the category *Memory* represented by the terms *family* and *home.* Once more, few mentions about color were reported. *Weird/ugly* was mentioned for NAG-purple-added pâtés, most probably related to the unusual purple color. No mentions related to color were registered to NAP-yellow-added pâtés.

3.2.3 Bread

Table 4 exhibits the dimensions and categories obtained from *blind a*nd *informed condition* for breads with NAM-green, NAP-yellow and NAG-purple added.

Table 4

Similarly, the dimension **Hedonic**, specifically the category *Tasty*, was the most mentioned for all bread samples. As with NAG-purple-added yogurts, NAG-purple-added bread in the *informed condition* exhibited significant differences ($p \leq 0.05$) from *blind condition*. The awareness of the natural antioxidant presence provided a more positive hedonic perception.

To the NAM-green-added bread, an interesting result is the occurrence of the category *Surprise* when the stimulus offered the information about the presence of a natural antioxidant from *Moringa*. The category *Surprise* appeared for all breads samples, indicating a perception of innovation (Mazon et al., 2020) for these colored breads. However it is important to note that not all mentions about innovation point to a good acceptance (Tuorila et al., 2008). Instead, it often indicates a behavior known as food neophobia, which can be defined as a fear of eating novel foods.

A key find in the present study was the category *Bitter* appearing to describe the NAM-green-added bread in *informed condition* ($p \leq 0.05$), revealing a relationship between plants and the bitter taste perceived. *Bitter* was an important category to describe the NAP-yellow-added bread and this category was mentioned in *blind condition* and *informed condition*, for 53.57% and 42.86% of consumers, respectively. The number of mentions for this category clearly showed the relevance of this attribute for the NAP-yellow-added bread. The category *Bitter residual* corroborated the presence of this undesirable taste.

Although cited, mentions about **Appearance** and color were few. For the bread with NAP-yellow, *Weird/ugly* was cited for 10.71% of consumers in *blind condition* and for 5.35% of consumers in *informed condition*. The appearance of NAG-purple-added breads was described as *Old/mold* and *Weird/ugly*. No mentions about appearance were registered to the NAM-green-added breads.

Once more, *Memories* appeared as a positive category cognitively related to the colored breads. Significant differences were registered between conditions. Less mentions were noted in the *informed condition* probably due to a change in focus caused by the awareness already discussed. This suggested the absence of a link between products with natural antioxidants and the memories of consumers, indicating the newness of the subject.

3.2.4 Correspondence analysis

Combining the terms elicited by the WA task and the products with natural antioxidants added led to better understanding of the perceptions of consumers, Correspondence Analysis for each product category was applied (Figures 3, 4 and 5). It is a technique of interdependence whose main benefit is the ability to represent rows and columns on a perceptual map (Hair et al., 2009).

The primary result revealed by bi-plots was the visual association for each product with different natural colored antioxidant added. Moreover, bi-plots highlighted the different perceptions from each natural antioxidant added. It became clear from the analysis of the sample (Fig. 3) the NAM-green-added yogurts were linked to *Sour*, *Bitter*, *Green*, *Avocado*, *Tea* and *Healthy* terms. While, NAP-yellow-added yogurts were associated with *Memories*, *Happiness*, *Smooth*, *Medicine* and *Honey*. In addition, NAG-purple-added yogurts were associated with *Natural*, *Creamy*, *Milk, Consistent* and *Grape* categories.

Fig. 3

For the NAM-green-added pâtés the (Fig. 4) linked associations were *Garlic*, *Memories* and *Salty*. The NAP-yellow-added pâtés were associated with *Consistent*, *Soft*, *Bad*, *Residual*, *Cold*, *Humid* and *Honey* categories. It is important to note that the NAG-purple-added pâtés became more distant on the perceptual map, indicating a stronger influence of the *blind* and *informed*. NAG-purple-added paté in *blind condition* was associated with *Creamy, Satiety, Good Smell, Weird-Ugly, Snack, Strong* and *Chicken.* While NAG-purple-added pâté in *informed condition* was associated with *Light, Homogenous, Herbs, Good color, Fear, Sweet, Weird texture* and healthier associations such as *Natural* and *Healthy*.

Fig. 4

Finally, the findings showed that NAM-green-added breads (Fig. 5) were associated with *Salty, Porous, Market, Good smell, Dry, Breakfast* and *Light.* NAP-yellow-added breads were associated with *Bitter, Herbs, Medicine, Honey, Bitter residual* and *Bad.* As can be seen *Bad* appeared as an important category to understand the negative hedonic effect of the sensory characteristics of NAP-yellow-added breads by consumers. Thus, it can be stated that for consumers, NAM-green-added bread samples had a bad taste due to the bitter and residual bitter taste. For NAG-purple-added bread, the related categories were *Yeast, Flour, Surprise, Dense, Good texture, Satiety, Humid, Grape. Healthy* was again noted for a NAG-purple-added product. Moreover, negative categories related to appearance were also associated with *Weird/Ugly* and *Old/mold.*

Fig. 5

3.5. Acceptance of products with naturally colored antioxidants added

Results showed no significant difference in acceptance between both conditions for NAM-green, NAP-yellow and NAG-purple added pâté and bread (Table 5), meaning that for consumers awareness of natural antioxidants did not influence acceptance rates. Among yogurts, only the formulation NAG-purple-added showed significant difference between conditions. This indicates that the information about the presence of a natural antioxidant of red grape pomace produced a higher acceptance of the yogurt.

Combining the results from CA and acceptance rate helps to confirm the suitability of emoji scales to get likability or emotional response to consumer products. Samples with positive word associations were given the highest scores and those with negative the lowest. This situation can be clearly seen by analyzing natural coloring antioxidant-added breads. NAP-yellow-added breads, in both conditions, showed the lowest acceptance rate

and based on CA bi-plots were better related to the negative words: *Bad, Bitter* and *Bitter residual*.

Table 5

4. DISCUSSION

The present work was based on three hypotheses regarding the use of naturally colored antioxidants in different food products. In order to verify the hypotheses, the present article used a projective technique Word Association and a hedonic test in two conditions: *Blind* and *informed*, generating two scenarios for consumers to distinguish the information regarding the presence of natural antioxidants.

The data from WA and hedonic tests confirmed or partially confirmed these hypotheses. The technique proved to be an important tool to display terminologies that better describe products by consumers. In this sense, it can be said that the terminologies related to **Hedonic**, **Texture** and **Flavor** dimensions, which were the most noted, and the ones related to sensory aspects demonstrated that sensory attributes are imperative for consumers.

Accordingly, it is important to point out that low importance (few mentions) was given to appearance cues. For the objectives of this work, this is a positive result, since the resulting color from the application of natural antioxidants did not create strong negative associations. According to Roininen, Arvola, & Lahhteenmaki (2006), the associations that first come to the consumers' minds are considered the most important for consumption decisions. This finding is aligned with the assessment of the first hypothesis.

4.1 Hypothesis 1

The analysis of the first hypothesis derived from the stimulus *blind condition*. In the Brazilian market, green yogurts, purple, or green breads and purple, green, or yellow pâtés are considered products with atypical color. According to the present results, Hypothesis 1 could not be confirmed, since the unusual color of products from this study did not have a major (negative) impact on the perception of their appearance. The unusual green yogurt drew attention from few consumers (9.8%) that mentioned the category *Avocado* relative to the visual appearance of the yogurt. This connection is due to the Brazilian habit of consuming an emulsified dessert from milk, avocado and sugar.

Surprisingly, there were few mentions related to the appearance of the colored pâtés. In Brazil the common color of a commercial pâté is light pink caused by the addition of a dye called cochinel carmine, which makes green, purple or yellow pâtés to be considered atypical or unusual. Among colored pâtés, the purple one (NAG-purple) produced more associations relative to appearance, as 3.8% of consumers mentioned the category *Good Color* and 11.5% mentioned *Weird/Ugly* to appearance. For green pâtés (NAM-green) only one consumer mentioned *Weird/Ugly* to describe appearance. For yellow pâté (NAP-yellow), no mentions about appearance were registered.

Among colored breads, with some mentions, the NAG-purple-added bread produced more mentions among the samples about appearance. It is noteworthy that the two categories that emerged were of a negative nature: *Old/Mold* and *Weird/Ugly*. The same effect was noted for NAP-yellow bread, while for green (NAM-green) bread no mentions about appearance were recorded. Therefore, based on the low number of associations related to appearance, and suitable acceptance rates discovered, we can consider that

unusual color of food products from this study had little influence on consumers' perception of appearance.

Hypothesis 1 was developed based on the studies of Paakki et al. (2016) and Schifferstein et al. (2019). In both papers, they demonstrated that an atypical color in an ordinary food product affected participants' perception. What is common between these two studies is the application in a vegetable *in natura* (potatoes and carrots), which contrast with the processed foods from this study (yogurt, bread and pâté). The current findings suggested that consumers are probably more receptive (less neophobia) to unusual color in processed foods. To the food industry, it is indicative of great potential to use natural antioxidants, even if they have color.

Two differences that cannot be overlooked between the present study and the research developed by Paakki et al. (2016) and Schifferstein et al. (2019) were the methodologies applied for atypical colored food evaluations. In Schifferstein et al. (2019) the methodology applied was to explore the atypical color of carrots when directed to appearance through the question: "I find that this carrot looks like…" and assessed on 7-point un-numbered Likert scale. The methodology, therefore, forced the evaluation of visual cues. Paakki et al. (2016) for instance, used a Likert scale with defined attributes for potato evaluation, which also drove consumer perception, after participants were asked to imagine an occasion where both typical colored potatoes (yellow) and atypical colored potatoes (blue) were served, asking them to choose between them, and to explain their choice. This second part generated a free association list and appearance and color were noted to be important aspects when explaining their choice, especially among those choosing atypical colored potatoes. Although the assessment was less targeted, the cognitions of the second methodology were the result of a comparison between two

conditions in which the only difference was color (typical and atypical), leading to a directed assessment.

Word association is a technique where the main characteristic is the possibility of holistic product evaluation. This methodology is based on the assumption that providing a stimulus to respondents and asking them to free associate the ideas that come to mind, could give relatively unrestricted access to the respondents mental representations of the stimulus (Antmann et al., 2011; Ares et al., 2008). Therefore, what could be indicative of the studies of atypical colored food perceptions is that, when the stimulus has a direction to the visual aspects, they gain greater importance. When the stimulus is associated with a holistic, undirected technique and healthy ingredient information, visual cues do not appear as the main association of conditions. This particular fact could be used by the research and development sector, especially the label one.

Besides that, the hue of an atypically colored food product could have an important influence on consumer perception of food appearance. Blue, the atypical color used in the study of potatoes, was described by consumers as “looks odd”. As discussed by the authors, blue is an unfamiliar color in food, and for this reason, blue in potatoes was related to food neophobia (Paakki et al., 2016). In this way, purple/pink, green and yellow are colors naturally found in foods (vegetables, fruits) (Cömert, Ezgi Doğan et al., 2020) and possibly, for that reason, did not cause much impact on consumers, reinforcing the potential of *Moringa*, propolis and grape pomace extracts.

4.2 Hypothesis 2

The analysis of Hypothesis 2 was derived from the comparison between conditions of the categories from WA and acceptance rates from the hedonic test. As can be seen in the results section, awareness of the presence of natural antioxidants in colored food

products influenced consumers' perceptions and acceptance, *i.e.*. Hypothesis 2 was confirmed.

The results also suggested that the influence of awareness of the presence of natural antioxidants in colored products had different effects for each product and for each naturally colored antioxidant. Regarding yogurts, the results revealed differences between conditions in the categories of the dimensions **Hedonic**, **Texture**, **Appearance**, and **Flavor**. For pâtés the differences were in the dimensions **Flavor**, **Ingredient** and **Health**. Bread presented differences in the categories of **Hedonic**, **Flavor**, **Habits** and **Ingredient**.

Based on general analysis, which involves all products with all three antioxidants added, a significant positive effect could be extracted from the perception of the products in the *informed condition*. This positive effect is clearer in the analysis of the **Hedonic** dimension of the NAM-green and NAG-purple added yogurts; the three pâtés; and the NAG-purple-added bread. In the NAG-purple yogurt the number of mentions of the category *Tasty* was significantly higher in the *informed condition*, and this behavior was also reflected in its acceptances. Indeed, it is noteworthy that NAG-purple-added yogurt was the only one that presented significant differences both in acceptance and *Tasty* category between *blind* and *informed condition*.

The hypothesis that the acceptance would be impacted by the awareness of the presence of natural antioxidants in the colored food products is based on studies which reported the importance given by consumers to food safety issues (Wongprawmas & Canavari, 2017), and healthy eating (Carrillo et al., 2011). This could determine the future potential of any food ingredient (Varela & Fiszman, 2013). As mentioned by Grunert (2005), quality and safety perception by consumers is highly related to food choice, consumer demand, and may be connected to price perception and willingness to

pay. In the present study, health issues represented by the category *Healthy* were just related to NAG-purple-added pâté ($p \leq 0.05$ between conditions), and to NAM-green-added yogurt and bread ($p \geq 0.05$ between conditions).

Another category that has a direct connection to health issues is *Natural*. This category was significantly more mentioned relative to the NAM-green yogurt in *informed condition*. The occurrence of this category when the presence of natural antioxidants was acknowledged, may be linked to the lack of mentions of *Bad* category for this product in *informed condition*. This was also the case for NAG-purple-added bread, that presented significantly more mentions of *Tasty* in the *informed condition*. The opposite was noted with the NAM-green and NAP-yellow breads with *Surprise* category appearing in the *informed condition* ($p \leq 0.05$).

Flavor was a dimension that reflected significant differences between conditions in all products. An interesting result was the emergence of the *Bitter* category in the *informed condition* ($p \leq 0.05$) for the NAM-green bread. This behavior showed the relationship between the awareness of *Moringa* and bitter taste. As is well known, color influences taste and flavor perception (Spence et al., 2010), and the awareness of the presence of a green leaf may have influenced perceptions as well. Furthermore, for green vegetables the relation to bitter and sour tastes is common (Schifferstein et al., 2019).

Memories was another category that called attention in breads. It was clear that in the *blind condition* an influence of past experiences in the associations of the breads occurred and in informed condition there was a significant reduction in these associations. This behavior could be explained by a change in focus or an indication that there were no associations between the word antioxidant, even natural antioxidant, and past experiences.

4.3 Hypothesis 3

Hypothesis 3 was also confirmed. Analysis of acceptance results demonstrated that a naturally colored antioxidant cannot be applied in all categories of products. It was the acceptance rates of the NAP-yellow-added breads that confirmed this hypothesis. This natural antioxidant when added to bread indicated the lowest acceptance for both conditions, revealing a slight difficulty that the industry could face using NAP-yellow in the baked products sector. Interestingly, this hypothesis was based on coloring action, which natural antioxidants could offer. In fact, the rejection of the product was not caused by the color provided by the NAP-yellow, but by another drawback of this antioxidant: The bitter taste produced in food.

The category *Bitter* in NAP-yellow-added bread could not be overlooked. No differences between the two conditions were identified, showing the bitter taste was clearly perceived and unaltered by the information received. *Bitter* obtained a large number of mentions and revealed more than an important attribute with which to describe bread, indicating a disadvantage in the use of this antioxidant in breads and similar products.

Nowadays, it is well established that the chemical composition of propolis varies according to climatic and phyto-geographic conditions (Bankova, 2005; Bankova et al., 2016). The propolis used in this study was produced in the South of Brazil (Paraná and Santa Catarina states) and its chemical composition was previously determined by Calegari et al., (2017) and Oldoni et al., (2015). The results indicated a high content of phenolic acids such as caffeic, coumaric, ferulic, gallic and derivative of cinnamic (artepillin C), all low-molecular-weight compounds. The bitter taste is related to phenolic compounds with low-molecular-weight (Drewnowski & Gomez-carneros, 2000). To further explain, it is worth noting that with the other NAP-yellow-added products (yogurt

and pâté), the bitter taste was not associated, possibly as a consequence of the presence of a high amount of sugar, salt and condiments in these products, since the interaction of basic tastes mixed in high concentrations is known. Sweet and salty suppress bitter taste (Keast & Breslin, 2002).

This behavior brought to light two important insights: the potential for applying the same naturally colored antioxidants in various sectors of the food industry, even if causing some type of atypical color; and the emergence of another drawback in the use of natural antioxidants in food, the unintended taste or flavor. Regardless of the cause, the results of the present study showed a wide possibility for application in different sectors of the food industry of naturally colored antioxidants.

Despite the fact that this work covers only three specific food categories, and give that results point out to the fact that consumers reaction to naturally colored antioxidant is category dependent, it is important to study the effect in further product categories. Also, it is necessary to expand the number of consumers to the tests if the aim is launching these naturally colored antioxidants to the market. Besides further studies need to assess the effectiveness of these natural antioxidants preserving food when compared to the synthetic ones.

5. CONCLUSION

The results showed that the unfamiliar color of foods with added naturally colored antioxidants, did not have a strong impact on consumers' perception of appearance. This behavior was probably linked to consumers being more receptive to unusual colors in processed foods. Being aware of the presence of natural antioxidants in colored foods positively influenced consumers' perception and acceptance. The categories *Tasty, Healthy, Natural* and *Surprise* were most mentioned in the *informed condition*.

Acceptance rates revealed the potential use of naturally colored antioxidants of *Moringa* and red grape pomace in the three categories of tested products (dairy, baked and meat). Naturally colored antioxidants of propolis in bread presented a significant drawback for consumers, because of the presence of an intense bitter taste. Therefore, this sector of the food industry may face a struggle in its use, not caused by the color, but by the off flavor.

Finally, in answer to the hypotheses that guided this research, this study brought an important insight into the use of a holistic approach to the evaluation of unusually colored food products by consumers. The Word Association technique proved to be a useful tool in understanding consumers' perception of atypical colored foods with added natural antioxidants, revealing the most important barriers and opportunities to their addition. Hedonics, flavor, and texture attributes were the most important ascpects for consumers, regardless of the awareness of a natural antioxidant present in the product.

Ackowledgements

The authors thank UTFPR- Pato Branco and CAPES and acknowledge the technical support provided. Thanks also to Robert Lee for his assistance with the English manuscript. Author P. Varela thanks the Norwegian Fund for Research Fees for Agricultural Products (FFL) through the project "FoodForFuture" (project number 314318).

Conflict of interest

The authors declare no conflict of interest.

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746 **Table 1**- Number of participants.

	Yogurt	Pâté	Bread
NAM-green-added	51 consumers (25 female and 26 male)	52 consumers (30 female, 22 male)	57 consumers (37 female, 20 male)
NAP-yellow-added	50 consumers (28 female and 22 male)	51 consumers (27 female, 24 male)	56 consumers (26 female, 30 male)
NAG-purple-added	52 consumers (23 female and 29 male)	52 consumers (28 female, 24 male)	55 consumers (30 female, 25 male)

747 NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally
748 colored antioxidant propolis added. NAG-purple: Naturally colored antioxidant red
749 grape pomace added.

750 **Table 2** - Frequency of mention of dimensions and categories for yogurt added with extracts in blind and informed conditions.

	NAM-green			NAP-yellow			NAG-purple		
Dimensions and categories	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test
Hedonic									
Tasty	35	37	0.4346	39	41	0.5000	40	49	2.6722
Happiness (Pleasure)	3	1	1.0202	8	8	0	5	8	0.8907
Bad	4	0	2.0404	0	0	-	4	0	2.0404
Fear	6	5	0.3192	4	3	0.3919	0	0	-
Texture									
Creamy	4	7	0.9576	5	6	0.3196	5	7	0.6146
Smooth	0	0	-	2	7	1.7471	3	0	1.7580
Good texture	6	1	1.9582	3	0	1.7586	0	0	-
Liquid	6	3	1.0472	0	0	-	3	5	0.7365
Consistent	0	4	2.0404	0	0	-	1	4	1.3757
Flavor									
Sour	26	19	1.3959	15	8	1.6633	26	13	2.6487
Sweet	14	15	0.2195	19	17	0.4166	16	25	1.8175
Bitter	9	7	0.5445	6	4	0.6666	5	2	1.1749
Light	2	3	0.4585	3	3	0	0	0	-
Honey	0	0	-	10	3	2.0786	0	0	-
Propolis	0	0	-	0	6	2.5264	0	0	-
Medicine	0	0	-	3	2	0.4588	0	0	-
Tea	3	1	1.0202	0	0	-	0	0	-
Grape	0	0	-	0	0	-	9	12	0.7346
Habits/Daily life									
Memories (childhood, family)	7	4	0.9576	10	9	0.2549	8	6	0.5754
Appearance									
Green	0	3	1.7581	0	0	-	0	0	-
Avocado	5	5	0	0	0	-	0	0	-
Natural/Fresh	0	6	2.5248	6	4	0.6666	7	6	0.2969
Health									
Healthy	3	1	1.0202	0	0	-	0	0	-
Ingredients/Production									

	NAM-green			NAP-yellow			NAG-purple		
Dimensions and categories	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test
Milk	5	2	1.1749	0	0	-	5	1	1.6832
Fruits	15	9	1.4005	8	3	1.5980	6	5	0.3192

NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally colored antioxidant propolis added. NAG-purple: Naturally colored antioxidant red grape pomace added.

Show significant difference ($\alpha = 0.05$; $Z\alpha = 1.96$).

754

755 **Table 3 -** Frequency of mention of dimensions and categories for pâté added with extracts in blind and informed conditions.

	NAM-green			NAP-yellow			NAG-purple		
Dimensions and categories	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test
Hedonic									
Tasty	82	69	1.5736	54	51	1.7192	56	57	0.3190
Satiety	0	0	-	0	0	-	3	0	1.7575
Indifferent	5	4	0.3487	7	7	0	7	4	0.9565
Fear	0	0	-	0	0	-	4	6	0.6652
Cold	0	0	-	3	2	0.4585	0	0	-
Bad	0	0	-	3	1	1.0202	0	0	-
Texture									
Soft	0	0	-	10	5	1.3978	5	5	0
Creamy	12	8	0.9952	10	13	0.7108	9	8	0.2651
Consistent	3	2	0.4583	8	8	0	6	5	0.3188
Weird texture	0	0	-	0	0	-	1	4	1.3751
Humid	0	0	-	3	5	0.7365	0	0	-
Flavor									
Strong	5	11	1.6306	8	6	0.5754	7	5	0.6138
Salty	15	16	0.2143	10	9	0.2543	11	7	1.0367
Sweet	0	0	-	0	0	-	1	3	1.0198
Seasoned	20	2	4.3218	10	15	1.1509	8	8	0
Light	4	11	1.9537	6	12	1.5584	10	17	1.5656
Bitter	0	0	-	8	5	0.8907	0	0	-
Residual	0	0	-	4	2	0.8416	0	0	-
Propolis/honey	0	0	-	0	8	2.9463	0	0	-
Odor									
Good smell	3	5	0.7359	4	4	0	7	4	0.9565
Appearance									
Homogeneous	0	0	-	0	0	-	4	2	0.8411
Good color	0	0	-	0	0	-	2	4	0.8411
Fresh	0	0	-	0	0	-	2	3	0.4584
Weird/ugly	1	3	1.0198	0	0	-	6	3	1.0463
Habits/Daily life									

	NAM-green			NAP-yellow			NAG-purple		
Dimensions and categories	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test
Snack (picnic, afternoon)	3	2	0.4583	0	0	-	3	5	0.7360
Appetite	0	0	-	0	0	-	6	7	0.2965
Memories (family, home)	10	4	1.7237	4	1	1.3757	4	2	0.8411
Appetizer (toast, crackers)	3	5	0.7359	4	5	0.3490	4	1	1.3751
Health									
Healthy	0	0	-	0	0	-	0	5	2.2918
Ingredients/Production									
Herbs	0	0	-	0	0	-	3	1	1.0198
Garlic	9	2	2.2319	5	0	2.2929	3	1	1.0198
Chicken	5	4	0.3487	5	4	0.3490	5	3	0.7360

NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally colored antioxidant propolis added. NAG-purple: Naturally colored antioxidant red grape pomace added.

Show significant difference ($\alpha = 0.05$; $Z\alpha = 1.96$).

759 **Table 4 -** Frequency of mention of dimensions and categories for bread added with extracts in blind and informed conditions.

	NAM-green			NAP-yellow			NAG-purple		
Dimensions and categories	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test
Hedonic									
Tasty	52	49	0.8839	38	37	0.2008	34	45	2.3312
Hunger	3	1	1.0180	3	2	0.4575	3	0	1.7561
Warmth	4	4	0	0	0	-	6	2	1.4686
Bad	4	2	0.8388	10	6	1.0801	2	6	1.4686
Indifferent	2	5	1.1704	1	8	2.4331	1	7	2.2029
Surprise	0	5	2.2867	3	1	1.0183	1	4	1.3732
Satiety	0	0	-	0	0	-	2	3	0.4577
Texture									
Soft	38	28	1.8969	32	27	0.9462	22	28	1.1489
Porous	3	2	0.4573	0	0	-	0	0	-
Dense	4	6	0.6621	5	10	1.3872	6	10	1.0817
Dry	2	6	1.4666	3	1	1.0183	0	0	-
Humid	0	0	-	0	0	-	1	4	1.3732
Good texture	0	0	-	0	0	-	3	4	0.3906
Flavor									
Strong	3	5	0.7333	6	5	0.3175	0	0	-
Bitter	0	6	2.5166	30	24	1.1346	2	5	1.1717
Salty	6	5	0.3172	0	0	-	0	0	-
Sweet	6	6	0	4	4	0	1	6	1.9529
Bitter residual	0	0	-	3	12	2.4970	1	4	1.3732
Light	7	11	1.0274	6	0	2.5178	6	5	0.3178
Medicine	0	0	-	3	7	1.3254	0	0	-
Propolis/Honey	0	0	-	10	21	2.3231	0	0	-
Grape	0	0	-	0	0	-	0	5	2.2887
Odor									
Good smell	3	4	0.3901	0	3	1.7557	0	0	-
Habits/Daily life									
Market	3	3	0	0	0	-	0	0	-
Breakfast	8	4	1.2207	3	2	0.4575	2	4	0.8397
Margarine/ butter	0	4	2.0360	3	2	0.4575	0	0	-

Dimensions and categories	NAM-green			NAP-yellow			NAG-purple		
	Blind condition	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test	*Blind condition*	*Informed condition*	Z test
Memories (family, home, childhood)	23	8	3.1573	13	5	2.0582	15	6	2.1834
Appearance									
Weird/Ugly	0	0	-	6	3	1.0427	3	6	1.0436
Old/Mold	0	0	-	0	0	-	3	0	1.7561
Health									
Healthy (functional food)	0	3	1.7553	0	0	-	4	5	0.3478
Ingredients/Production									
Dough	2	4	0.8388	4	4	0	3	2	0.4577
Flour	4	0	2.0360	0	0	-	5	1	1.6794
Herbs	0	0	-	3	1	1.0183	0	0	-
Yeast/ fermentation	3	0	1.7553	0	0	-	3	1	1.0187

760 NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally colored antioxidant propolis added. NAG-purple: Naturally
761 colored antioxidant red grape pomace added.
762 Show significant difference ($\alpha = 0.05$; $Z\alpha = 1.96$).

763 **Table 5 -** Hedonic test results for the products added naturally colored antioxidants

Products	Naturally antioxidant	Blind condition	Informed condition	p t-test
Yogurt	Moringa	5.14^{a}±1.41	5.37^{a}±1.27	0.38
Paté		5.50^{a}±1.01	5.58^{a}±1,13	0.72
Bread		5.47^{a}±1.08	5.53^{a}±0,96	0.78
Yogurt	Propolis	5.58^{a}±1.18	5.84^{a}±1.19	0.28
Paté		5.29^{a}±1.03	5.63^{a}±0.93	0.09
Bread		4.41^{b}±1.35	4.80^{b}±1.46	0.14
Yogurt	Grape pomace	5.63^{a}±1.08	6.08^{a}±0.95	0.03
Paté		5.36^{a}±1.18	5.77^{ab}±0.97	0.06
Bread		5.27^{a}±1.08	5.38^{b}±1.09	0.58

764 p: p-value of T-test, $p \leq 0.05$ means statistic difference between conditions for each product in rows;

765 Means of the different categories of food products added with one of the naturally colored antioxidant followed by equal

766 letters in the same column do not differ significantly by Tukey test ($p \geq 0.05$).

767

768

Supplementary material

Potential use of naturally colored antioxidants in food industries - A study of consumers' perception and acceptance

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Table S1 - Formulation of yogurts added with extracts of moringa, propolis and red grape pomace

Ingredients	Formulations (%)		
	F1	F2	F3
UHT whole milk	85.00	85.00	85.00
Whole milk powder	3.00	3.00	3.00
Industrial dairy yeast	0.30	0.30	0.30
Sugar	11.50	11.50	11.50
Moringa extract	0.50	-	-
Propolis extract	-	0.50	-
Grape pomace extract	-	-	0.50

F1: Fermented milk with natural antioxidant extract from moringa; F2: Fermented milk added with natural antioxidant extract of propolis; F3: Fermented milk added with natural antioxidant extract of red grape pomace.

Table S2 - Formulation of chicken patés with extracts of moringa, propolis and red grape pomace

Ingredients	Formulations (%)		
	F1	F2	F1
Chicken meat	39.98	39.98	39.98
Sunflower oil	25.00	25.00	25.00
Cassava starch	4.00	4.00	4.00
Ice	25.00	25.00	25.00
Soy protein	2.50	2.50	2.50
Salt	1.30	1.30	1.30
TPF	0.50	0.50	0.50
Chili	0.12	0.12	0.12
Garlic	1.00	1.00	1.00
Parsley	0.10	0.10	0.10
BHT	-	-	-
Moringa extract	0.50	-	-
Propolis extract	-	0.50	-
Grape pomace extract	-	-	0.50

TPF: Sodium tripolyphosphate stabilizer; Control: chicken paté without antioxidant; F1: chicken pate added with natural antioxidant extract from moringa; F2: chicken paté added with natural antioxidant extract of propolis; F3: chicken paté added with natural antioxidant extract of red grape pomace.

Table S1 - Formulation of bread with extracts of moringa, propolis and red grape pomace

Ingredients	Formulations (%)		
	F1	F2	F3
Wheat flour	53.87	53.87	53.87
Salt	0.80	0.80	0.80
Sugar	2.41	2.41	2.41
Whole pasteurized milk	33.56	33.56	33.56
Eggs	5.91	5.91	5.91
Soy oil	2.42	2.42	2.42
Biological yeast	0.53	0.53	0.53
Moringa extract	0.50	-	-
Propolis extract	-	0.50	-
Grape pomace extract	-	-	0.50

F1: Bread added with natural antioxidant extract from moringa; F2: Bread added with natural antioxidant extract of propolis; F3: Bread added with natural antioxidant extract of red grape pomace.

Figure 1 - Lyophilized extracts of naturally colored antioxidants. A) NAM-green: *Moringa*; B) NAP-yellow: propolis; C) NAG-purple: red grape pomace.

Figure 2 –In order; Yogurts, patés and bread samples with natural antioxidants added: (A) NAM-green (*Moringa*); (B) NAP-yellow (propolis) and (C) NAG-purple (red grape pomace).

Figure 3 - Correspondence Analysis performed on data from Word Association task for yogurts. NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally colored antioxidant propolis added. NAG-purple: Naturally colored antioxidant red grape pomace added. BC: *Blind condition*. IC: *Informed condition*.

Figure 4 - Correspondence Analysis performed on data from Word Association task for patés. NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally colored antioxidant propolis added. NAG-purple: Naturally colored antioxidant red grape pomace added. BC: *Blind condition*. IC: *Informed condition*.

Figure 5 - Correspondence Analysis performed on data from Word Association task for bread. NAM-green: Naturally colored antioxidant *Moringa* added. NAP-yellow: Naturally colored antioxidant propolis added. NAG-purple: Naturally colored antioxidant red grape pomace added. BC: *Blind condition*. IC: *Informed condition*.

Fig. 1

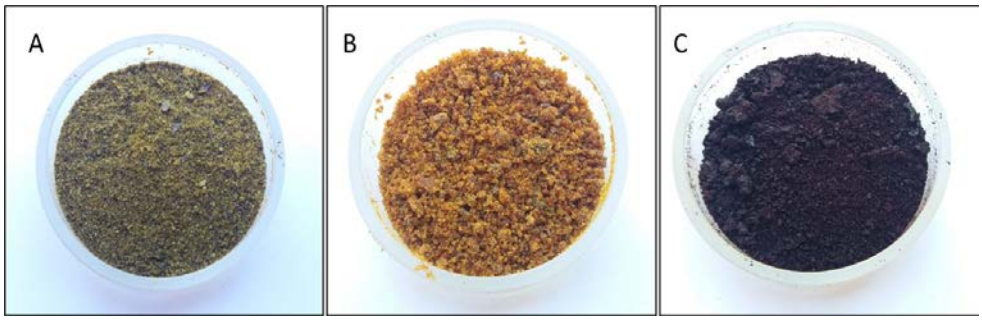


Fig. 2

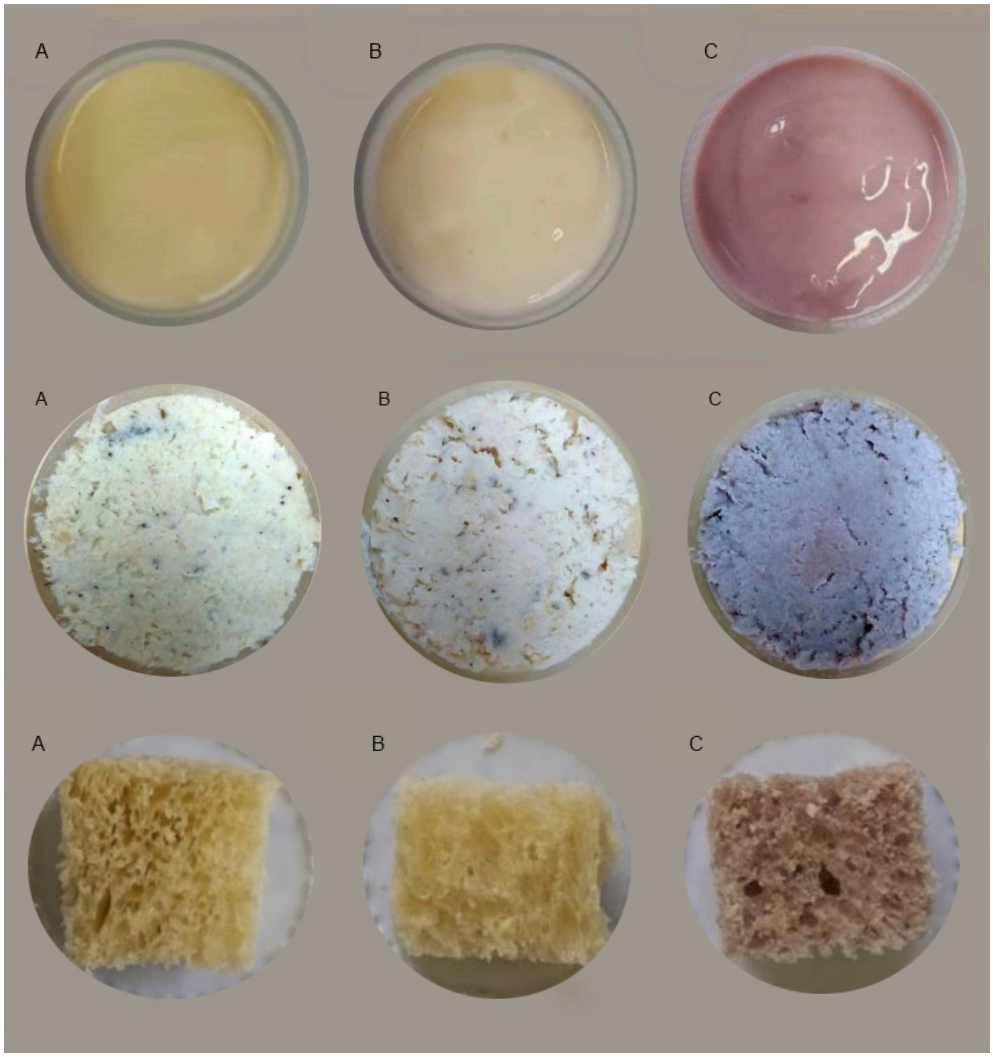


Fig. 3

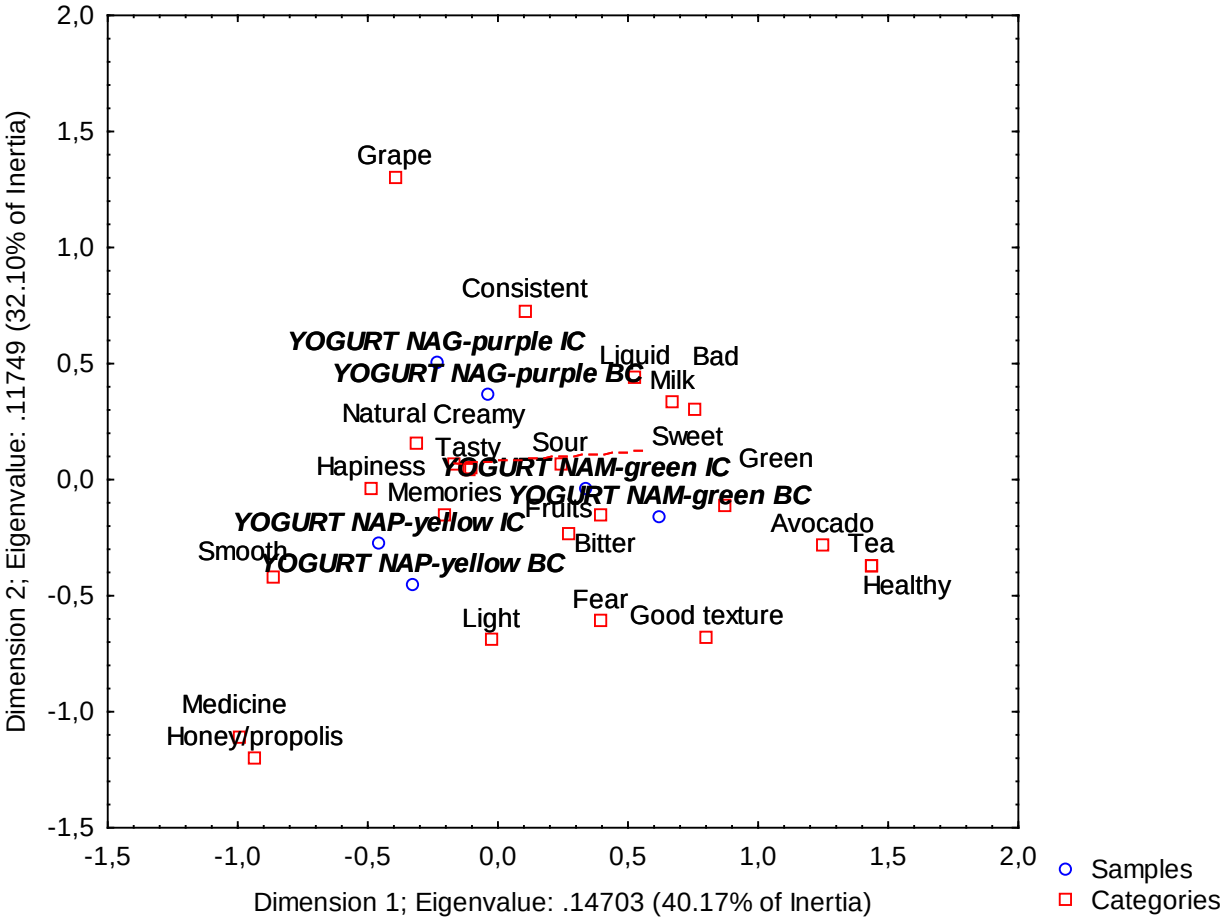

Grape
Consistent
YOGURT NAG-purple IC
YOGURT NAG-purple BC
Liquid
Bad
Milk
Natural Creamy
Tasty
Sour
Sweet
Hapiness
YOGURT NAM-green IC
Green
Memories
YOGURT NAM-green BC
Fruits
YOGURT NAP-yellow IC
Avocado
Smooth
Bitter
Tea
YOGURT NAP-yellow BC
Healthy
Fear
Light
Good texture
Medicine
Honey/propolis
2,0
1,5
1,0
0,5
0,0
-0,5
-1,0
-1,5
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
Dimension 2; Eigenvalue: .11749 (32.10% of Inertia)
Dimension 1; Eigenvalue: .14703 (40.17% of Inertia)
Samples
Categories

Fig. 4

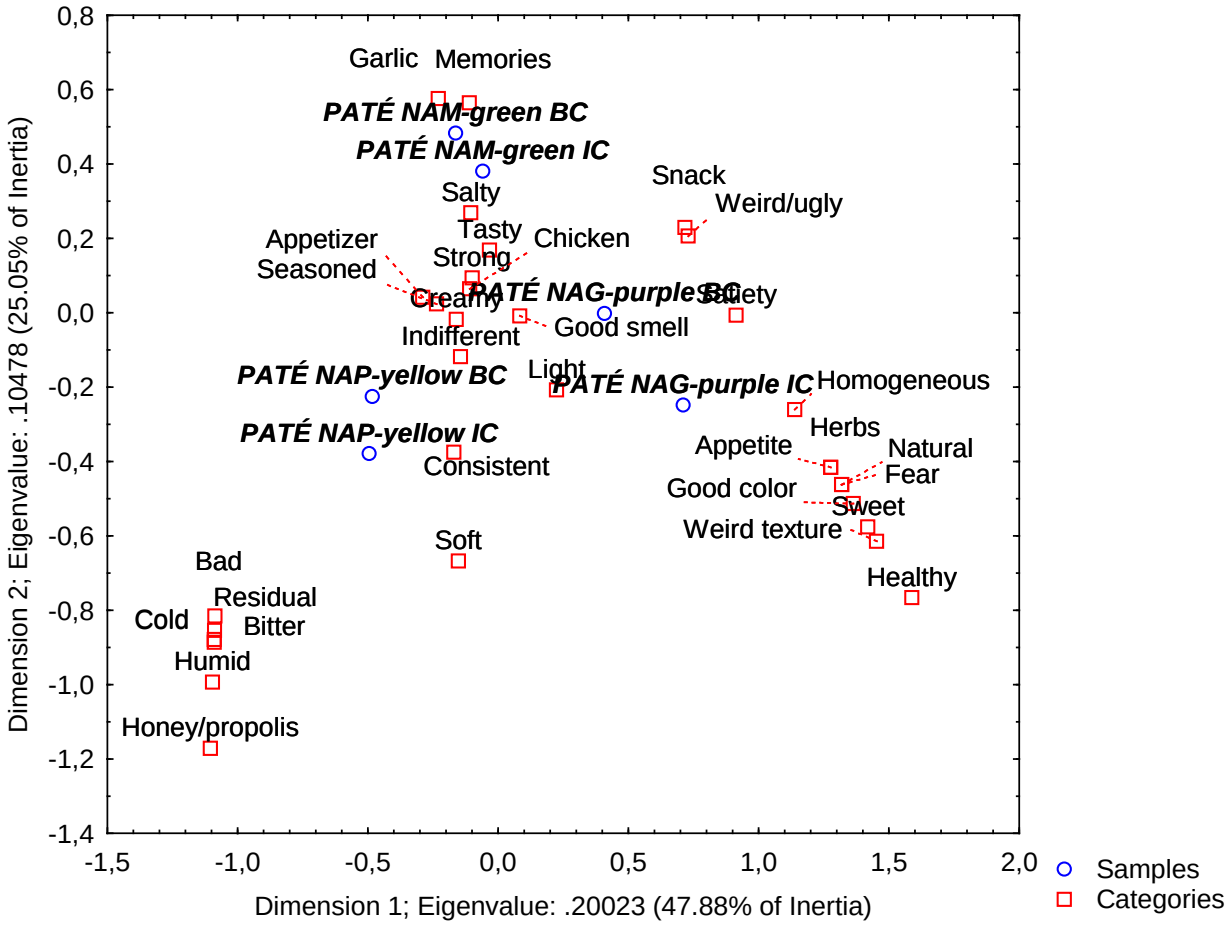
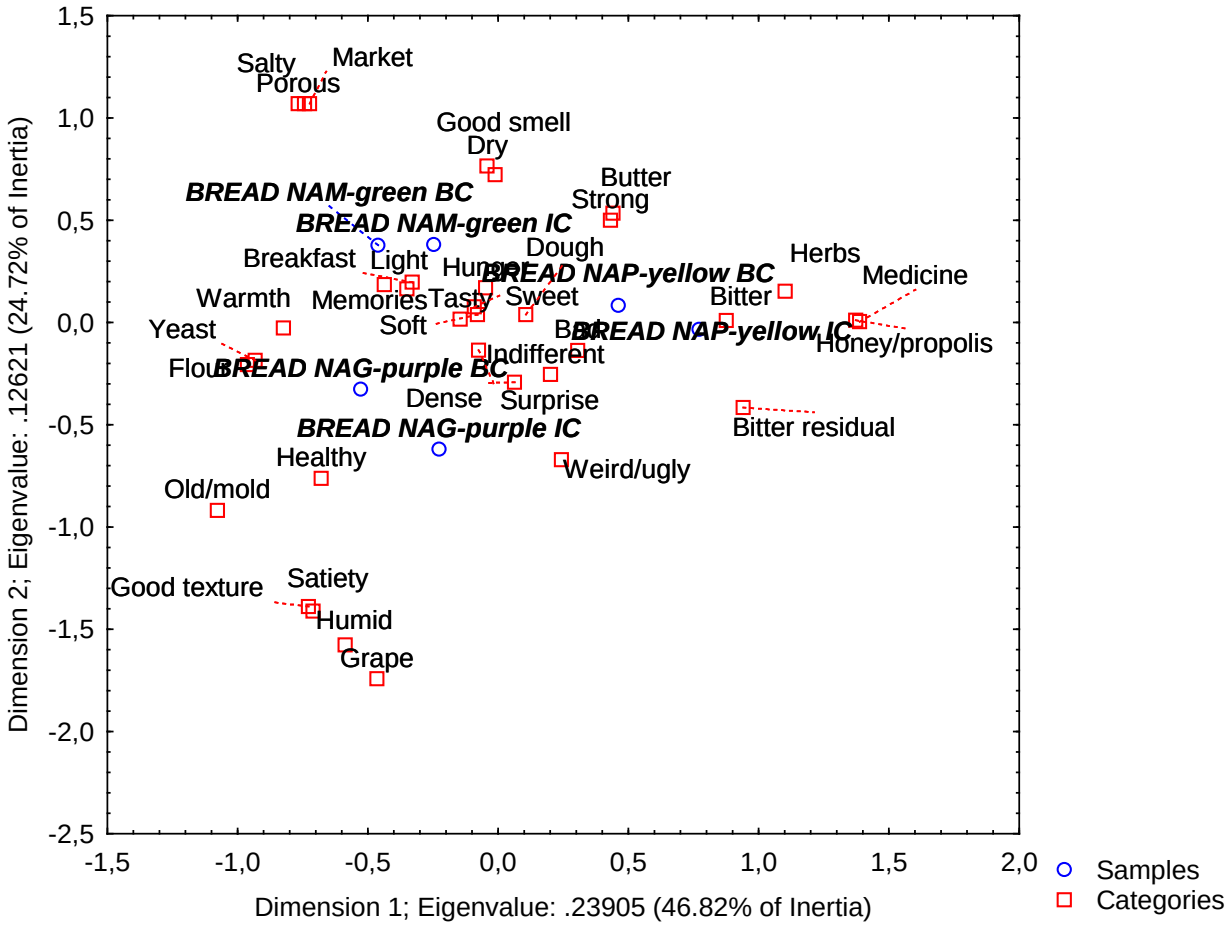

Garlic
Memories
PATÉ NAM-green BC
PATÉ NAM-green IC
Salty
Snack
Weird/ugly
Tasty
Chicken
Appetizer
Seasoned
Strong
Creamy
PATÉ NAG-purple BC
Safety
Indifferent
Good smell
PATÉ NAP-yellow BC
Light
PATÉ NAG-purple IC
Homogeneous
Herbs
PATÉ NAP-yellow IC
Appetite
Natural
Consistent
Fear
Good color
Sweet
Weird texture
Soft
Bad
Healthy
Residual
Cold
Bitter
Humid
Honey/propolis
Dimension 2; Eigenvalue: .10478 (25.05% of Inertia)
Dimension 1; Eigenvalue: .20023 (47.88% of Inertia)
0,8
0,6
0,4
0,2
0,0
-0,2
-0,4
-0,6
-0,8
-1,0
-1,2
-1,4
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
Samples
Categories

Fig. 5


Salty
Market
Porous
Good smell
Dry
Butter
Strong
BREAD NAM-green BC
BREAD NAM-green IC
Dough
Herbs
Medicine
Breakfast
Light
BREAD NAP-yellow BC
Warmth
Memories
Tasty
Sweet
Bitter
Yeast
Soft
BREAD NAP-yellow IC
Honey/propolis
Undifferent
BREAD NAG-purple BC
Dense
Surprise
Bitter residual
BREAD NAG-purple IC
Healthy
Weird/ugly
Old/mold
Good texture
Satiety
Humid
Grape
Dimension 2; Eigenvalue: .12621 (24.72% of Inertia)
Dimension 1; Eigenvalue: .23905 (46.82% of Inertia)
Samples
Categories