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Ingeniería de Alimentos

Propuesta de memoria de grado presentada como requisito parcial para la obtención del grado de Ingeniero en Alimentos

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Evaluación de la respuesta de los consumidores asociada al consumo de alimentos elaborados con subproductos de la industria alimentaria

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CHAPTER 2 - Consumers' perception and emotional response towards different BSG-enriched food products under informed conditions

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Preface

A growing and worldwide concern over environmental issues has been shown by the public in recent years (Funk, Tyson, Kennedy & Johnson, 2020). The current food system contributes to green gas emissions, climate change and food waste production for which it is not exempted from criticism (Eldesouky, Mesias & Escribano, 2020). Unless multiple innovative changes are introduced, food systems negative impact on the environment would increase to the point where Earth would no longer be "a safe operating space for humanity" (Springmann et al., 2018). It is thus urgent for the food industry to adopt new and more environmentally friendly practices.

Brewer's Spent Grains (BSG) is the most important by-product of the brewing industry representing an annual generation estimated of 38.2 million tons. Its adverse impact on the environment and the additional costs involved in its treatment can be avoided if upcycled and used as a functional ingredient due to its high fibre content.

Therefore, the aim of this study was to investigate consumers' acceptability and emotional response to different food products containing BSG as an alternative sustainable ingredient. Additionally, the impact of extrinsic information on consumers' response was also evaluated on another circumstance. Information about BSG's sustainability and nutritional credentials was presented to participants through the labels. A key objective was to understand the contribution that measuring emotional response would reveal.

While the first chapter focuses on the formulation of BSG-enriched products and consumers' blind perception of them, the second one addresses the impact of extrinsic information on its marketability.

CHAPTER I

Brewery Spent Grain as a functional ingredient

1. Introduction

Food production and processing is accompanied by high levels of waste and by-products. Over 38% of the food waste generated comes from the manufacturing process (Helkar, Sahoo & Patil, 2016). Within the considerable volume of by-products generated, a large amount is simply discarded. Two serious shortcomings stem from this: an adverse impact on the environment and the additional expenses incurred for waste final disposal. An increasing consumer awareness of environmental issues has prompted new ways to reduce industrial waste by turning it into *co-products* (Fărcaş et al., 2017).

Beer is one of the most consumed beverages around the world. Just in 2019, worldwide beer production was 1.91 billion hectolitres (Conway, 2020). During the brewing process, the crushed malted barley is mixed with water and mashed to extract the fermentable sugars from the endosperm. The resulting sweet liquid, known as the wort, is subsequently boiled together with hops. After yeast is added, fermentation starts, and the wort is slowly converted to beer. However, while the hopped wort is the raw material from which beer is produced, the remnants of barley become the waste product known as Brewery Spent Grain (BSG). BSG is the most abundant by-product of the brewing industry accounting for an estimate of 85% of the total generated waste (Nigam, 2017). Based on the BSG generation rate of about 0.2 kg/L of beer (Fărcaş et al., 2015), there is an estimated annual generation of 38.2 million tons of BSG.

One of the challenges concerning BSG is its high moisture content, ranging from 77% to 81% water, together with its fermentable sugars (Ivanova et al., 2017). This triggers its rapid degradation and pushes up the cost of transportation. Therefore, BSG is popularly used as livestock feed or fertilizer (He et al., 2019). Instead of these uses, BSG can be dried and used as a food grade industrial raw material, simultaneously decreasing transportation costs, and extending its shelf life.

BSG is mainly composed of barley grain husks (i.e., grains without most carbohydrates which were removed by saccharification and extraction in mashing). Certainly, the variety of cereals used and the characteristics of the malting, dictate the final composition of BSG. The overall composition in dry matter consists of fibre (30-50%), protein (19-30%), lipids (10%) and ash (2-5%) (Lynch, Steffen & Arendt, 2016). The high amount of fibre as well as the high protein content in BSG, justifies its use as a functional ingredient in the preparation of food for human consumption (Lynch et al., 2016). Indeed, fibre consumption has potential benefits on human health such as prevention of chronic noncommunicable diseases like obesity, diabetes and

cardiovascular diseases (Prasadi & Joye, 2020). This is especially relevant since noncommunicable diseases are the leading causes of death (World Health Organization [WHO], 2020).

Cardiovascular diseases are the most common non-communicable diseases globally, responsible for an estimated 17.8 million deaths in 2017 (WHO, 2019). Furthermore, according to research published by the World Health Organization (WHO, 2020) the prevalence of obesity tripled between 1975 and 2016. An estimated of 39% of adults were overweight in 2016 and 13% suffered from obesity. Also, over 18% of children and adolescents were overweight or obese (WHO, 2020).

Despite the inherent benefits to the consumption of this nutrient, a globally fibre deficiency is observed in both developed and underdeveloped countries. A review by Stephen et al. (2017) revealed the daily average dietary fibre intake in adults for ten countries (including USA, UK and Spain), none of which reached the recommended amount. Although this recommendation varies depending on age and lifestyle, on average it should be greater than 25 g/day according to the WHO. Thus, adding BSG in basic foods is a potential direct solution to the fibre intake deficiency and indirectly to the health hazards previously mentioned.

Due to the previously mentioned benefits of BSG as a raw material, development of new food products containing it has been investigated. To mention some of them, Cappa & Alamprese (2017) studied the valorisation of BSG trough fibre-enriched egg pasta reaching an optimized formulation of 6.2% of BSG. It has also been studied together with mushrooms as an animal protein replacer and fibre enricher of smoked sausages containing 3-6% of BSG (Nagy et al., 2017). Moreover, Garrett, Bellmer, McGlynn & Rayas-Duarte (2021) obtained promising results for snack chips containing 40% BSG inclusion.

This alternative greatly reduces the waste generated by the brewing industry and optimizes the use of its raw material inputs. In lieu of discarding BSG grains after mashing, all 100% of the malted cereals are used, strengthening the economy, and reducing environmental pollution while constituting a healthier option for consumers.

For different food product categories, consumers hold specific sensory and hedonic expectations which subsequently affect their food perception and acceptance (Cardello, 1994). In fact, previous experiences, product description and context shape expectations. Sensory attributes of the product must meet consumers' expectations for the acceptability to be high.

Fibre is considered to impart a strong flavour, coarse texture and dry mouthfeel (Mudgil, Barak & Khatkar, 2017) for which consumers are sometimes reluctant to compromise sensory quality (Grigor, Brennan, Hutchings & Rowlands, 2016). This is more so if the product is mainly consumed for hedonic pleasure (Maehle, Iversen, Hem & Otnes, 2015) as in the cases reported by Curutchet, Trias, Tárrega & Arcia (2021) and Curutchet, Cozzano, Tárrega & Arcia (2019) in which cakes and cookies, respectively, were enriched with fibre by adding fruit pomace and resulted in a reduction in the overall acceptability and purchase intention. However, owing to the multiple health benefits derived from fibre enrichment, they can also be valued and consumed for their utilitarian nutritional value (Maehle et al., 2015). For instance, fibre enrichment did not have any perceivable effect on the overall acceptability of fermented pork sausages (Ham et al, 2015) and noodles (Karthiayani, Udaya Ganga & Ashok Kumar, 2021). Motivations driving food choice and tolerance vary from one food product to another. Thus, three different ones were selected to study consumers' response to: bread, pasta and chocolate milk.

Average worldwide consumption volume for bread, pasta and milk are expected to reach 26.6 kg, 7.7 kg and 25.1 kg per person, respectively, in 2021 (Statista, 2020). Interestingly, expected volumes for Uruguayans surpass all those previously mentioned values and increase to 41.1 kg, 14.3 kg and 31.2 kg accordingly. Chocolate flavoured milk was considered more suitable for BSG addition than regular milk due to its already dark colour, fairly thick consistency and its potential at masking BSG flavour. It is also greatly consumed in the region reaching 4.3 L per person in 2018 in Uruguay (Ministerio de Agricultura, Ganadería y Pesca [MGAP-DIEA], 2019, p. 24).

Despite the multiple benefits that BSG valorisation brings when used as an ingredient, it is key to understand consumer behaviour towards it. Certainly, the multisensory perception of the product is not the only determining factor in its acceptability. Despite most of the research investigating consumer response focuses on consumer liking and purchase intention, the emotions that this product arouses in the consumer may be equal or more important than sensory perception (Gutjar et al., 2015).

The interest in measuring emotional response to foods and beverages has increased in the field of sensory and consumer science in the last decade, including studies with crackers and biscottis (Yang, Shen, Foster & Hort, 2020) and frankfurters (Polizer, Lapa-Guimarães, de Noronha & Trindade, 2018). It is believed that emotional response can disclose more accurate results regarding consumers' preference than the clinical methods (Chaya et al., 2015; Yang, et al.,

2020). As is the case with the market failure of a newly launched product despite being previously tested by a consumer panel. Thus, broadening the scope of research by investigating the emotions provoked by food products and its effect on liking is useful for predicting products future performance in the market.

Self-reporting questionnaires have been reported to successfully measure emotional response associated with food products (King, Meisleman & Carr, 2013), including beers (Chaya et al., 2015) and blackcurrant squash (Ng, Chaya & Hort, 2013). Among these, EsSense25 has gained popularity for evaluating food and beverages due to its emphasis on positive emotions: these are more closely associated with food products (Yang et al., 2020; Nestrud, Meiselman, King, Lesher & Cardello, 2016). Derived from EsSense Profile (King & Meiselman, 2010), EsSense25 contains 25 emotions, instead of the original 39. This reduction in the number of terms, makes the questionnaire easier and faster to complete as well as more suitable for product testing situations (Nestrud et al., 2016).

The aim of this first chapter was to formulate three functional food products with BSG (bread, pasta and chocolate milk) and to evaluate and compare consumers' acceptability, purchase intention and emotional response towards these under blind conditions.

2. Materials and Methods

2.1 Preparation of Brewers Spent Grains

Brewers Spent Grains (BSG) were obtained from the Uruguayan brewing company *Fábricas Nacionales de Cerveza S.A.* Immediately after collection, BSG was refrigerated (<8 °C) until drying on the following days at 55 °C for 72 hours in a convection oven (LATU, Uruguay) to reach a water content below 5 % (Stojceska & Ainsworth, 2008). Dried BSG was then milled through a 1 mm mesh screens[1] in Retsch ZM 200, packed in polyethylene bags and kept at room temperature until use.

2.2 BSG Composition

The nutritional composition of dried BSG was determined in Universidad Católica del Uruguay (UCU) Chemistry Laboratory. All components were determined based on methods proposed by the Association of Official Analytical Collaboration (AOAC, 2019). Protein content was determined by Kjeldahl method and performed according to method 981.10 of the AOAC International with a conversion factor of 6.25. Fat content was determined by Soxtec method as described in AOAC 2003.5. Quantification of moisture and ash content were performed in accordance with AOAC 925.09 and AOAC 923.02, respectively. Total dietary fibre was measured according to the enzymatic gravimetric method AOAC 985.29. Carbohydrates were calculated by difference (i.e., all other nutrients were summed and subtracted from the total weight of the sample). Sodium was estimated based on values obtained from Arcia, Curutchet, Cozzano and Rodríguez (2018).

2.3 Product selection and formulation study

As consumers' expectations and tolerance vary from one food product to another, three different ones were selected to study consumers' response to. As previously mentioned, these were: bread, pasta and chocolate milk.

For the products to bear the nutritional claim *Source of Dietary Fibre,* products formulations had to have a minimum content of 2.5 g of dietary fibre per serving size according to MERCOSUR

[1] Smaller samples of dried BSG were milled using 0.25 mm and 0.5 mm and used exclusively for chocolate milk formulation study.

resolution 01/12 of 19 April 2012. Serving sizes were taken from MERCOSUR resolution 46/03 of 1 July 2004. This resulted in a minimum content of dietary fibre of 5.0%, 2.5% and 1.25% (w/w) for bread, pasta and chocolate milk respectively, which were used as the lower limit for BSG addition in the fibre-enriched products. These products also comply with Codex Alimentarius (2013) *Source of Fibre* claim, particularly the condition which calls for a minimum of 10% of the daily reference value per serving. As a result, three product formulations with BSG as an ingredient were developed and studied: fibre-enriched bread, fibre-enriched pasta and fibre-enriched chocolate milk, with BSG flour concentrations of 8.3%, 2.8% and 0.35% (w/w), respectively.

Non-added-BSG formulations were also developed by replacing the BSG flour with regular flour or milk and used as control. These were regular bread, regular pasta and regular chocolate milk.

All formulations were developed in the pilot plant of Food Engineering in UCU.

2.3.1. Bread

Bread formulation was taken from Arcia et al. (2018) and included as ingredients wheat flour 000, water, dried-and-milled BSG, sunflower oil, granulated sugar, skim milk powder, salt and instant yeast (**Table 1**). All ingredients were bought at a local supermarket.

Table 1. *Fibre-enriched bread and regular bread formulations*

Ingredients	Fibre-enriched Bread (%)	Regular Bread (%)
Water	33.37	33.37
Wheat flour	45.00	53.30
BSG flour (<1mm)	8.30	-
Sunflower oil	4.86	4.86
Granulated sugar	3.60	3.60
Skim milk powder	3.20	3.20
Salt	1.20	1.20
Instant yeast	0.47	0.47

The dough was formed in KitchenAid using the spiral dough hook and 6.9 L bowl. For the fibre-enriched bread, water, wheat flour, granulated sugar, skim milk powder, salt and instant yeast were first mixed at low speed (speed setting n° 2) for 15 minutes. The oil was added and then mixed for 5 additional minutes at the same speed. Finally, the BSG flour was incorporated and

mixed for another 5 minutes at low speed (same speed setting). The regular bread dough was made following the same mixing steps except for the final mixing which was omitted. Once the doughs were formed, they were left to bulk ferment at 35 °C and 60% RH for 30 minutes in a proofing chamber. Subsequently, the bread doughs were shaped in 27.5x15.0x6.5 cm (LxWxH) loaves pans and left to further ferment for 50 minutes under the same conditions. The proofed breads were baked at 190 °C for 30 minutes in a convection oven. After baking, they were left to cool for 20 minutes, then packed in sealed polyethylene bags and stored refrigerated until sensory evaluation took place the following day.

2.3.2 Pasta

Ingredients for the pasta included: wheat flour 000, water, BSG flour and eggs. The pasta formula was adapted from the pasta maker machine recipe book (**Table 2**). All ingredients were bought at a local supermarket.

Table 2. *Fibre-enriched Pasta and Regular Pasta Formulations*

Ingredients	Fibre-enriched Pasta (%)	Regular Pasta (%)
Water	11.97	11.97
Wheat flour	70.06	72.86
BSG flour (<1mm)	2.80	-
Egg	15.97	15.97

Fresh pasta was made with a pasta maker machine model HR2355/08, Koninklijke Philips N.V., using the standard program and following its instructions. Spaghettis were cut at a length of approximately 25 cm and left at room temperature until the moment of cooking. Pasta was always consumed the same day it was made.

2.3.3 Chocolate milk

Chocolate milk ingredients consisted of semi-skimmed milk (1.5% fat content), granulated sugar, cacao powder (12% fat content), BSG flour with particle size 250 µm, carrageenan, carboxymethyl cellulose (CMC) and chocolate flavouring. Amounts are detailed on **Table 3**.

Table 3. *Fibre-enriched Chocolate milk and Regular Chocolate milk Formulations*

Ingredients	Fibre-enriched Chocolate milk (%)	Regular Chocolate milk (%)
Semi-skim milk	89.47	89.82
Granulated sugar	7.00	7.00
Cacao powder	3.00	3.00
BSG flour (<250µm)	0.35	-
Carrageenan	0.075	0.075
CMC	0.075	0.075
Chocolate flavouring	0.03	0.03

Regular chocolate milk formulation was inspired by a locally well-known commercial chocolate milk, to which BSG flour was then blended in to create the fibre-enriched version. Chocolate milk was made mixing together for 2 minutes in a mixer semi-skimmed milk (1.5% fat content), BSG flour with particle size 250 µm, cocoa powder (12% fat content), granulated sugar, carrageenan, carboxymethyl cellulose (CMC) and chocolate flavouring.

2.4 Consumer Sensory Evaluation

To study acceptability of the products, one session was held for each product under blind condition. A total of three sessions took place in which over one hundred consumers voluntarily participated in every single one. The panellists were of both genders, over 16 years old, residents of Uruguay and consumers of each product (See details on **Table 4**).

2.4.1 Samples

For the sensory evaluation, the participants were provided with two samples, one containing the regular product and the other one containing the fibre-enriched product. These samples were given without any information about the product.

Table 4. *Socio-demographic characteristics of the participants in the sensory evaluations*

	N	Gender		Age			
		Female (%)	Male (%)	15-25 (%)	26-40 (%)	41-55 (%)	>55 (%)
Blind condition							
Bread	110	50.9	48.2	57.3	15.45	21.8	6.5
Pasta	118	55.1	44.9	58.5	18.6	18.6	4.2
Chocolate milk	111	52.3	47.7	47.7	14.4	27.0	10.8

2.4.1.1 Bread

The breads where prepared the previous day and refrigerated in plastic bags for avoiding moisture loss. The day of evaluation, breads were removed from the refrigerator and left to warm up to room temperature. Both, fibre-enriched bread samples and regular half bread slices were served (approximately 12 g) in biodegradable plastic plates coded with a three-digit number. Water was available to consumers.

Sensory evaluation took place in Universidad Católica del Uruguay and Latitud Foundation.

2.4.1.2. Pasta

Fresh pasta was made the day of evaluation. Regular and BSG-enriched pasta were cooked in abundant salted water (2 tablespoons in 3L) for 10 and 12 minutes respectively, drained and seasoned with extra virgin olive oil (1 tablespoon). Approximately 15 g of cooked spaghettis were served in white polystyrene cups coded with a three-digit number. Pasta was made and evaluated warm. Sensory evaluation took place in Universidad Católica del Uruguay.

2.4.1.3. Chocolate milk

Chocolate milk samples were prepared, refrigerated and evaluated in less than 24 hours after making. Each consumer received two samples served in three-digit-coded, plastic cups with lids and refrigerated unless immediately evaluated. Sensory evaluation took place in Universidad Católica del Uruguay.

2.4.2 Questionnaire

Questionnaires for all three products consisted of the following stages:

1. *Product perception.*

Consumers were asked to rate overall acceptability using a nine-point hedonic scale (1-*disliked extremely* to 9-*like extremely*. Product-specific JAR questions were then asked about product characteristics: saltiness in bread and flavour, consistency and sweetness in chocolate milk. Subsequently, consumers completed a check-all-that-apply (CATA) product-specific questionnaire to describe the samples. The attributes presented had been previously determined in a preliminary study and included both sensory and non-sensory characteristics. The attributes options were randomly presented to participants to avoid order effects. Finally, purchase intention was measured by a five-point scale from 1: *would definitely not buy* to 5: *would definitely buy*, followed by the General Health Interest questionnaire proposed by Roininen, Lähteenmäki & Tuorila (1999) to uncover the reason behind their decision (**Table 5**).

Table 5. *Question of purchase intention: reasons for buying or not buying the products.*

Why would you buy it?
1. Because it is healthy
2. Because it is tasty
3. To avoid weight gain
4. Because it is high in calories
5. Because it is good for my family
6. Because I want to include fibre in my diet
7. Because my kids would like it
Why wouldn't you buy it?
1. Because it does not seem healthy
2. Because it is distasteful
3. Because it is not the one I always buy
4. Because I do not need fibre
5. To prevent weight gain
6. Because I think it is bad for my family
7. Because it seems expensive
8. Because I don't want to include fibre in my diet
9. Because my family would not like it

2. *Product-evoked emotions.*

EsSense25 was used to collect emotional response data based on method suggested by Nestrud et al. (2016) and following the advice from King et al. (2013). The twenty-five emotions were first translated into Spanish. As Spanish and Portuguese are closely related due to their Latin roots, Spanish translations were then compared to the Portuguese terms suggested by Polizer et al. (2018). Four researchers checked and adjusted when necessary. Emotions included on EsSense 25 profile are classified according to their nature in positive, negative and unclassified subgroups (Yang et al., 2020). Translation and classification are shown in **Table 6**.

Consumers were presented with a five-point intensity scale (including: 1-*Nothing*, 2-*Slightly*, 3-*Mildly*, 4-*Very* and 5-*Extremely*) and asked to select the most accurate intensity for every one of the twenty-five emotions. Both parts of the questionnaire were repeated after tasting the second sample. It should be noted that emotions were randomly presented in order to increase reliability according to King et al. (2013).

Table 6. *List of terms and classification described by EsSense profile.*

Emotion (EN)	Emotion (ES)	Classification
Active	Activo	Positive
Adventurous	Aventurero	Positive
Aggressive	Agresivo	Unclassified
Bored	Aburrido	Negative
Calm	Calmo	Positive
Disgusted	Asqueado	Negative
Enthusiastic	Entusiasmado	Positive
Free	Libre	Positive
Good	Bien	Positive
Good Natured	Bondadoso	Positive
Guilty	Culpable	Unclassified
Happy	Felíz	Positive
Interested	Interesado	Positive
Joyful	Alegre	Positive
Loving	Amoroso	Positive
Mild	Leve	Unclassified
Nostalgic	Nostálgico	Positive
Pleasant	Agradable	Positive
Satisfied	Satisfecho	Positive
Secure	Seguro	Positive
Tame	Insulso	Unclassified
Understanding	Comprensivo	Positive
Warm	Afectuoso	Positive
Wild	Salvaje	Unclassified
Worried	Preocupado	Negative

2.6 Data Analysis

Acceptability and purchase intention results obtained from sensory analysis were subjected to Student's t-test analysis at a significance level of $p=0.05$.

Raw CATA data was converted into binary data based on frequency of citation (1 - cited, 0 - non-cited). The nonparametric Cochran's Q test was then performed on the binary CATA data to detect significant differences ($p<0.05$) among fibre-enriched and regular samples for each attribute.

Based on recent research published by Yang et al. (2020), EsSense25 results for blind conditions were first subjected to t-test analyses at a significance level $p=0.05$ to investigate differences in the intensity of emotions between regular and fibre-enriched products.

All statistics analysis were performed using XLSTAT 2020.3.1 software (Addinsoft 2021, New York, NY, USA).

3. Results and Discussion

3.1 BSG flour composition

BSG flour composition is shown in **Table 7**, including the contents for protein, fat, carbohydrates, total dietary fibre, ash, sodium and moisture. As a notable feature, BSG flour content of total dietary fibre obtained is considerably high and in accordance with previous results obtained by Arcia et al. (2018) which indicated a 44.61 ± 0.29% of fibre content in BSG flour. Owing to the significant amount of this nutrient, it was possible to formulate products with the addition of BSG as a functional ingredient and for them to bear the *Source of Fibre* claim.

Table 7. *BSG flour composition per 100g*

Component	Mean Value ± SD
Proteins (g)	24.90 ± 0.02
Lipids (g)	6.28 ± 0.16
Carbohydrates (g)	16.24*
Total dietary fibre (g)	45.47 ± 0.34
Ash (g)	2.81 ± 0.25
Sodium (mg)	240
Moisture (g)	4.3 ± 0.4

* Carbohydrates were determined by difference.

3.2 Sensory Evaluations

3.2.1. Bread

3.1.1.1 Acceptability and Purchase intention

In the blind condition, means of liking differed significantly ($p<0.05$) for regular and fibre-enriched bread (**Table 8**). Similar results were obtained by Amoriello, Mellara, Galli, Amoriello and Ciccoritti (2020) and by Arcia et al. (2018), where the BSG addition to bread dropped consumers overall acceptability.

No significant ($p<0.05$) difference was found in purchase intention suggesting that consumers may have identified the health benefits from fibre-enriched bread and were willing to compromise on taste for them. According to Maehle et al. (2015), for utilitarian products such as bread, sensory quality is not as important to consumers as for hedonic products. Consumers

may have identified the health benefits due to whole grains natural darker colour, as reported by Combest and Warren (2018), and compromise on them. Moreover, for both samples JAR results indicated that the products had the right saltiness.

Table 8. *Results of sensory evaluation for Bread*

Product	Acceptability	Purchase intention
Regular Bread	7.10 ± 1.48[a]	3.93 ± 1.00[a]
Fibre-enriched Bread	6.44 ± 2.06[b]	3.75 ± 1.26[a]

Acceptability and Purchase intention expressed as (mean ± SD). Scores not sharing letters in same column are significantly different ($p < 0.05$) according to Student's T-test.

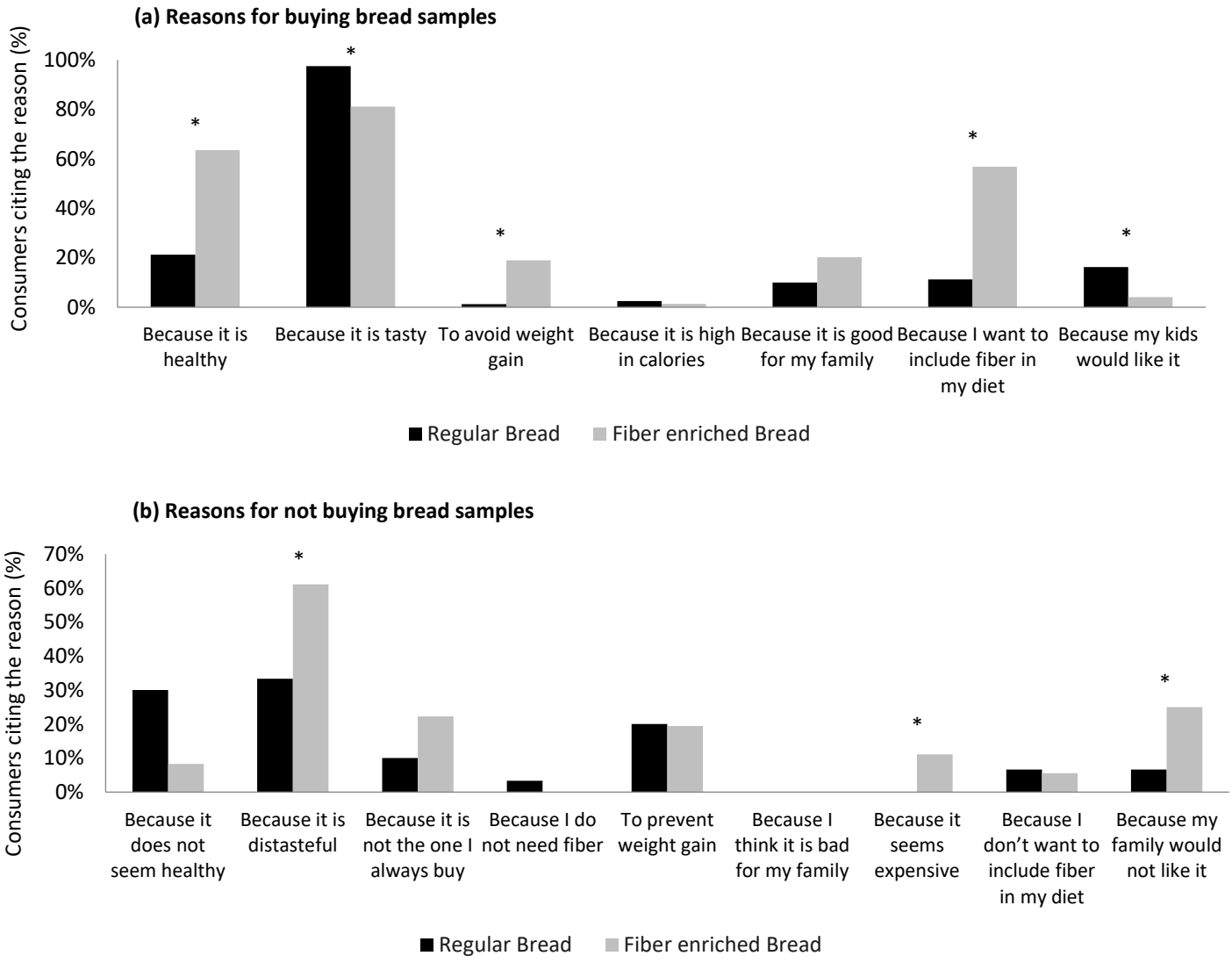


Figure 1. R*easons to buy (a) or not to buy (b) breads evaluated without information.*
(*) indicates significant difference at $p<0.05$

Among the reasons for consumers choosing to buy the fibre-enriched bread, the most frequently mentioned ones were that it is *Healthy* (64%), *Tasty (*81%), *To include fibre in their diet* (57%) and *To avoid weight gain* (19%) (**Figure 1**). Except for being *Tasty*, all the other reasons were more frequently selected for fibre-enriched bread than regular bread ($p<0.05$). Despite the high frequency of choice of *Tasty* for the fibre-enriched bread, it was more commonly selected as a reason for buying the regular bread ($p<0.05$), which accounted for a vast 98% of the consumers willing to buy the latter.

For both fibre-enriched and regular bread, the main reason for not buying the breads was related to their taste, being this reason significantly more frequently cited for the fibre-enriched bread ($p<0.05$): 61% for the former compared to 33% for the latter. Sensory properties have already been reported to be the main reason for not consuming a fibre-enriched product (Laureati, Conte, Padalino, Del Nobile & Pagliarini, 2016). Unlike for regular bread, price resulted in a relatively common reason for not buying the fibre-enriched one ($p<0.05$). This is supported by Quagliani and Felt-Gunderson (2017) which states expensiveness as a misperception consumers have towards fibre-enriched products. Furthermore, the reason related to consumers' families not liking this type of product may be due to the low popularity of fibre-enriched products in children and adolescents (Meynier, Cahnson-Rollé & Riou, 2020; Kamar, Evans & Hugh-Jones, 2016).

3.2.1.2 Check-all-that-apply (CATA) attributes

In the blind condition, 12 out of the 21 attributes detailed in the CATA questionnaire showed a significant ($p<0.05$) difference in terms of frequency of mention (**Figure 2**). Specifically, the attributes most frequently used to describe the fibre-enriched bread were *Fibrous, Natural, Soft, Compact, Fluffy* and *Dry*. For regular bread *Soft, Fluffy, Natural* and *Moist* were the attributes most frequently selected. Despite many of these attributes being recurrent in both bread samples, repeated frequent attributes except for *Natural* differed significantly ($p<0.05$) on the frequency of mention.

Table 9. *Attributes presented in CATA questionnaire for bread sensory evaluations in Spanish (ES) and English (EN).*

Attribute (ES)	**Attribute (EN)**
Fibroso	Fibrous
Suave	Soft
Natural	Natural
Compacto	Compact
Esponjoso	Fluffy
Seco	Dry
Húmedo	Moist
Sabor extraño	Strange taste
Apelmazado	Stodgy
Amargo	Bitter
Aereado	Airy
Difícil de tragar	Hard to swallow
Aroma desagradable	Unpleasant aroma
Retrogusto	Unpleasant aftertaste
Salado	Salty
Duro	Hard
Difícil de masticar	Hard to chew
Desabrido	Bland
Dulce	Sweet
Crocante	Crispy
Ácido	Acidic

Compactness is explained by the fibre-gluten interaction which prevents gluten from fully developing and reduces the gas-retention capacity of the dough (see **Appendix 1 – Product formulation study**). Fibre-enriched breads have already been reported to have a decreased specific volume compared to non-enriched (Amoriello et al., 2020; Olubunmi et al., 2015). Additionally, consumers may have described the fibre-enriched bread as *Dry* since fibre has a high-water holding capacity (Zhou et al., 2020) and free water may seem scarce in this type of bread.

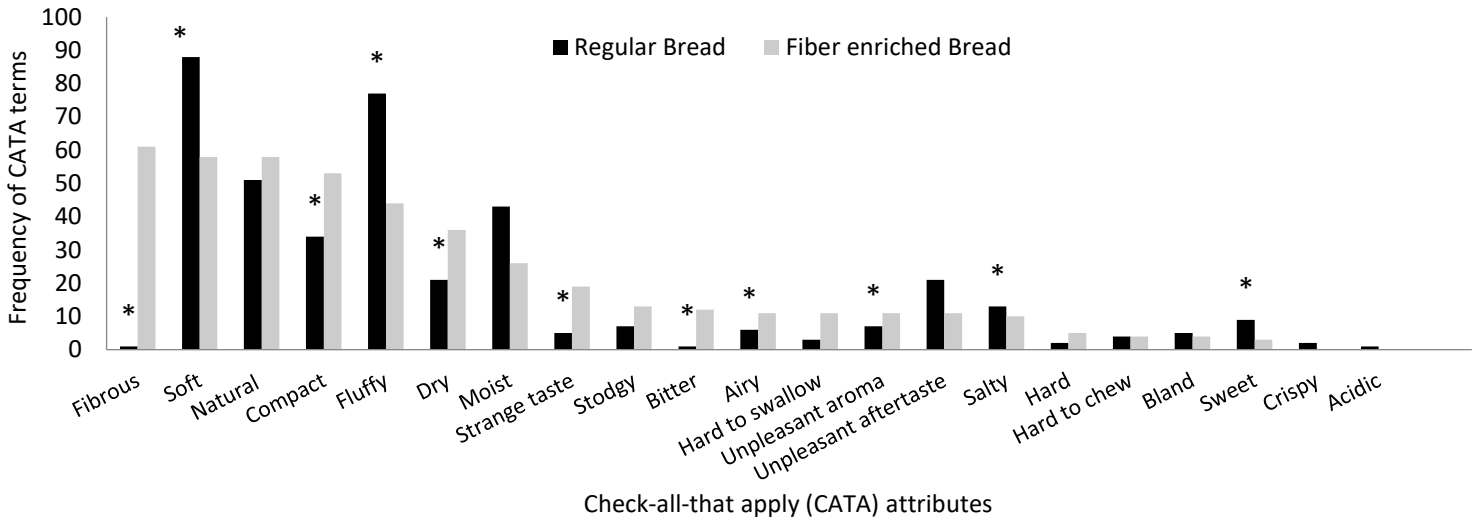


Figure 2. *Frequency of check-all-that-apply (CATA) terms for the Fibre-enriched Bread and the Regular Bread.*
(*) indicates significant difference at p<0.05.

3.2.1.3 Product-evoked emotions

In the blind condition, five emotional terms showed significant (p<0.05) difference (**Figure 3**). Regarding the two positive emotions (*Warm* and *Active*), participants felt more *Active* after testing the regular bread, but the opposite occurred with *Warm*.

Additionally, two unclassified emotional terms, *Tame* and *Guilty* showed significant (p<0.05) difference in their frequency of citation. Participants felt more *Guilty* and less *Tame* after testing regular bread.

Finally, respondents felt significantly (p<0.05) more *Bored* when consuming the fibre-enriched bread.

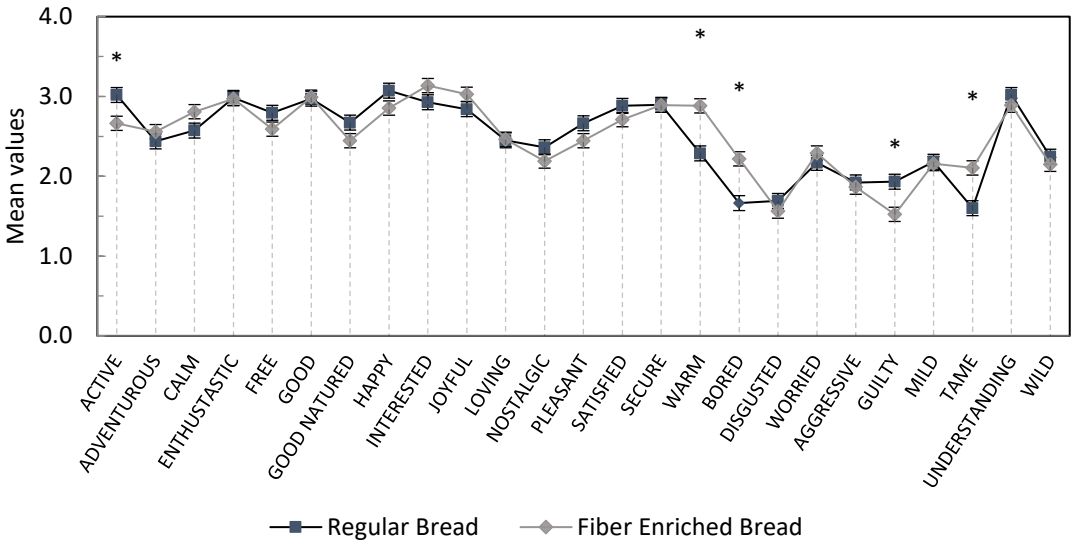


Figure 3. *Effect of product on emotional response (mean score ± SD) for Fibre-enriched Bread and Regular Bread.*
(*) indicates significant difference at p<0.05.

3.2.2. Pasta

3.2.2.1 Acceptability and Purchase intention

In the blind condition, no significant (p<0.05) differences were found in either acceptability or purchase intention for pasta (**Table 10**). This first result is in accordance with Laureati et al. (2016) who did not find a significant (p<0.05) difference between the liking of traditional pasta and the liking of 10%-wheat-bran-added pasta. The fact that consumers were equally willing to buy regular and fibre-enriched pasta is understandable based on the previous result on liking. This was an interesting finding considering that only a 15.8% of the total grains consumed on a given day are whole grains, according to the U.S. Department of Health and Human Services (Ahluwalia et al., 2019). It may thus seem that respondents were not against fibre-enriched pasta, but unaware of it as a replacement to regular pasta (Barret et al., 2020; Laureati et al., 2016). Indeed, Barret et al. (2020) reported that in their focus group participants chose whole grain breads more regularly than whole grain pasta, for which they usually opted for the refined version.

Table 10. *Results of sensory evaluations for Pasta*

Product	Acceptability	Purchase intention
Regular Pasta	6.87 ± 1.45[a]	4.14 ± 0.93[a]
Fibre-enriched Pasta	6.91 ± 1.91[a]	4.00 ± 1.20[a]

Acceptability and Purchase intention expressed as (mean ± SD). Scores not sharing letters in same column are significantly different (p <0.05) according to Student's T-test.

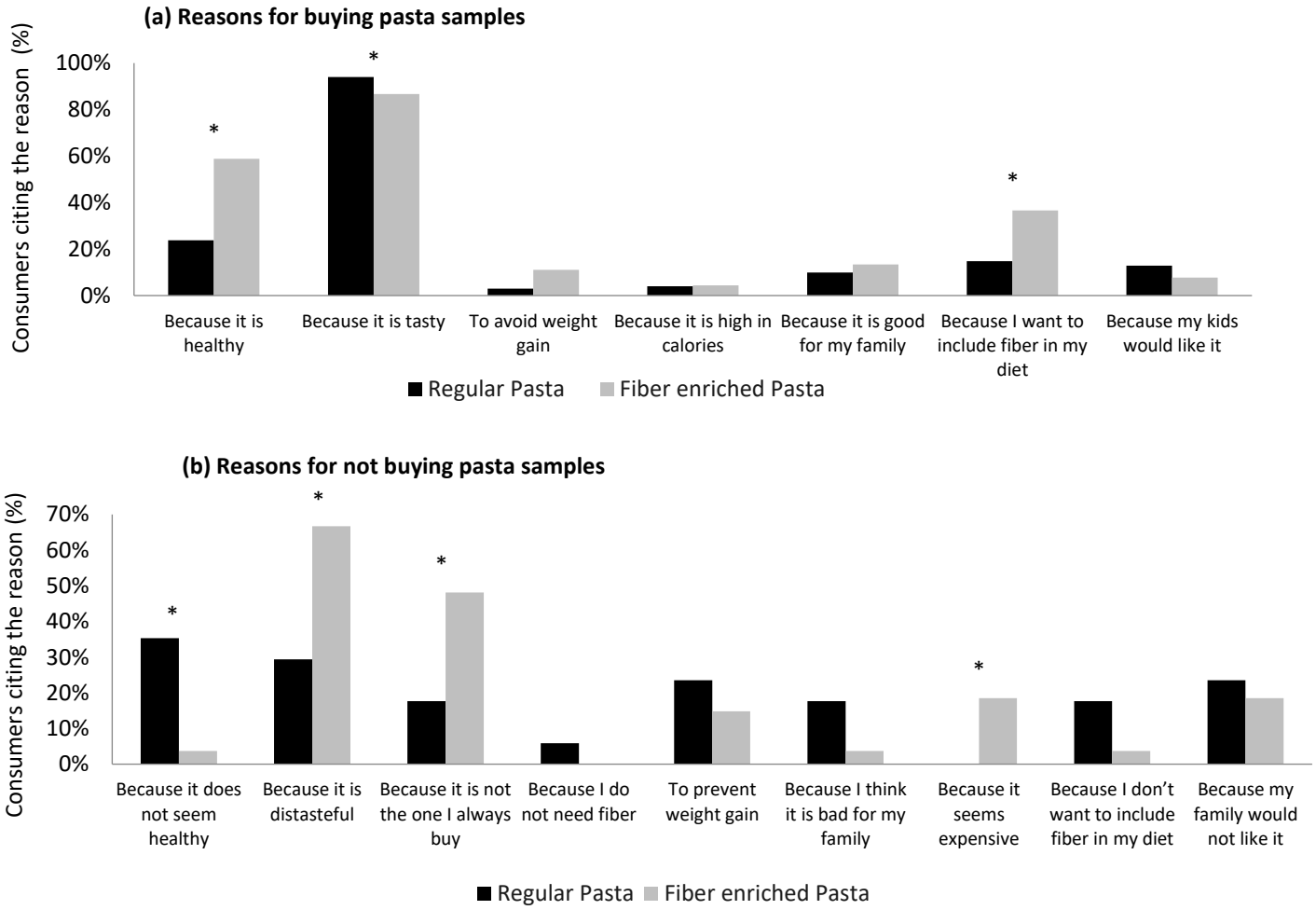


Figure 4. *Reasons to buy (a) or not to buy (b) pastas evaluated without information.*
(*) indicates significant difference at p<0.05.

The most frequently given reasons for buying fibre-enriched pasta were because it is *Tasty* (87%), *Healthy* (59%) and *Because I want to include fibre in my diet* (37%) (**Figure 4**). The main reason for buying the regular pasta was because it was *Tasty* (94,1%); while all the other reasons were negligible in terms of frequency of mention (<20%). Significant differences (p<0.05) were detected in the frequency of mention of *Healthy* and *To include fibre in my diet* between the two products. These results confirm the ability of respondents to successfully recognize fibre-

enriched products and thus infer their health benefits. Knowledge about dietary fibre and its health effects has already been reported to be substantial among the general population (Yalçın et al., 2020). Additionally, higher educational levels have been associated with a better understanding of the health benefits of dietary fibre and a higher consumption of this nutrient (Ljubicic et al., 2017). The fact that several evaluations took place at the university facilities, may be explicable of the significantly high frequency of mention of the previously mentioned arguments.

On the other hand, main reasons for not buying fibre-enriched pasta were *Because it is distasteful* (67%) and *Because it is not the one they always buy* (48%). The first one is once again related to fibre imparting a strong flavour, coarse texture and dry mouthfeel, as argued for bread samples (Mudgil et al., 2017). In addition, the last reason can be associated with food neophobia which is defined as the reluctance to eat new foods (Domjan, 2018) and has already been reported to be a barrier to novel foods consumption (Tuorila & Hartmann, 2020).

3.2.2.2 Check-all-that-apply (CATA) attributes

For 11 out of the 20 terms presented in the list, significant ($p<0.05$) differences were observed in their frequency of choice for pasta under blind condition (**Figure 5**). Participants associated the fibre-enriched pasta with the attributes: *Natural*, *Fibrous*, *Granulated*, *Coarse*, *Dark*, *Gritty* and *Strange Taste*. On the other hand, the terms *Soft*, *Uniform*, *Homogeneous*, and *Flexible* were associated with regular pasta. Moreover, both pastas were frequently described as *Tasty* with no significant ($p<0.05$) difference between them.

Table 11. *Attributes presented in CATA questionnaire for pasta sensory evaluations in Spanish (ES) and English (EN).*

Attribute (ES)	**Attribute (EN)**
Natural	Natural
Sabrosa	Tasty
Suave	Smooth
Fibrosa	Fibrous
Uniforme	Uniform
Homogénea	Homogenous
Granulada	Granulated
Áspero	Coarse
Gomosa	Rubbery
Oscuro	Dark
Arenoso	Gritty
Poco sabor	Lack of taste
Flexible	Flexible
Pegajosa	Sticky
Dura	Hard
Sabor extraño	Strange taste
Aroma desagradable	Unpleasant aroma
Insípida	Insipid
Retrogusto	Unpleasant aftertaste
Quebradiza	Brittle

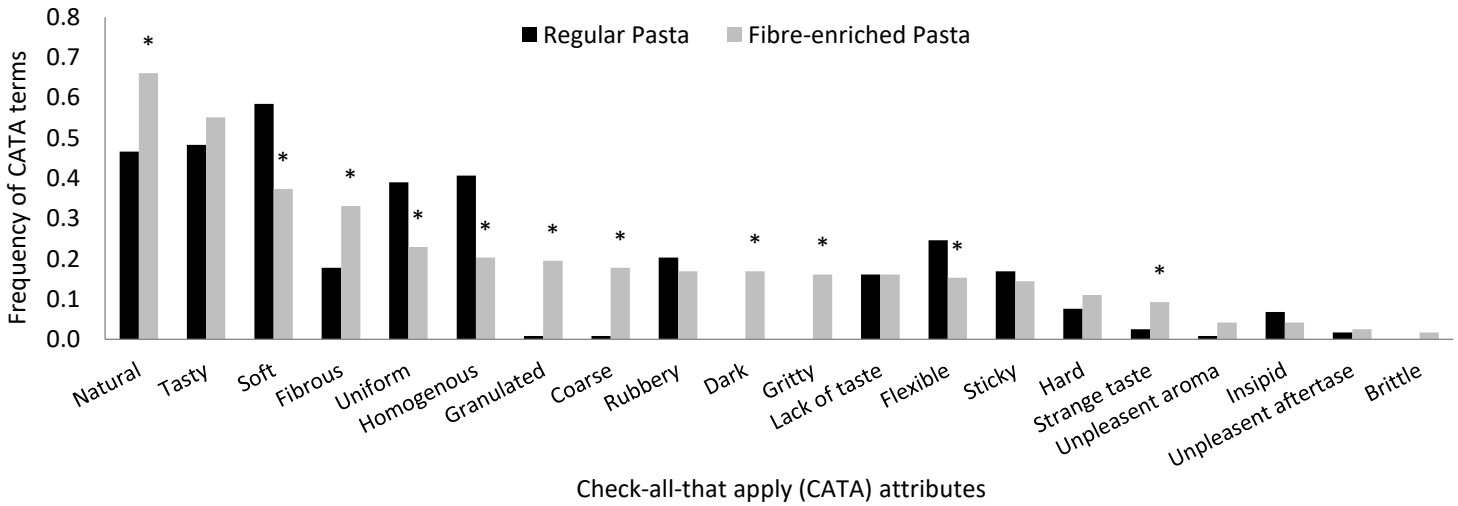


Figure 5. *Frequency of check-all-that-apply (CATA) terms for the Fibre-enriched Pasta and the Regular Pasta.*
(*) indicates significant difference at $p<0.05$.

Numerous texture attributes differed significantly ($p<0.05$) in frequency of mention between both samples, suggesting that addition of BSG to pasta produces textural and flavour changes. This is not surprising when compared to results obtained by Makhlouf et al. (2019), who studied whole barley incorporation into regular pasta for a total final dietary fibre concentration of 2.6% (w/w). Their results showed that both firmness and adhesiveness decreased with the amount of barley being added; whilst taste and overall linking ranked significantly ($p<0.05$) lower for barley-added pasta when compared to the control sample. This is apparent by the results of CATA attributes - fibre-enriched pasta was described as more *Fibrous*, *Granulated*, *Coarse* and *Gritty* and less *Soft*, *Uniform*, *Homogenous* and *Flexible* compared to regular sample. Certainly, addition of fibre interferes with gluten network and prevents cohesiveness of the dough. As a result, starch granules are more easily lost during cooking and the quality of the final product decreases (Makhlouf et al., 2019). It should be noted that a possible solution to these negative effects may be the addition of xanthan gum and vital gluten. Krawęcka, Sobota and Sykut-Domańska (2020), obtained equal texture and flavour characteristics for both 5% (w/w) β-glucans-added pasta and control sample by adding 5% xanthan gum and vital gluten.

Moreover, the colour difference detected between samples is due to BSG flour being darker than wheat flour as already observed by Nocente, Taddei, Galassi & Gazza (2019) in BSG-enriched pasta. A decrease in yellowness and increase in brownness and redness was observed for all 5%, 10% and 20% (w/w) BSG addition levels in dried pasta. This may have decreased its acceptability as the yellow colour is highly valued by consumers of durum wheat pasta (Finnie & Atwell, 2016; Nocente et al., 2019).

3.2.2.3 Product-evoked emotions

In the blind condition, 14 out of 25 emotional terms presented significant ($p<0.05$) differences in their rating when comparing fibre-enriched and regular pasta (**Figure 6**). Thus, pasta is the product whose emotional response differed the most, despite being the only one with no significant ($p<0.05$) difference neither in acceptability nor in purchase intention.

Two out of three negative emotional terms, *Bored* and *Disgusted*, presented significant difference ($p<0.05$). While the first term was significantly ($p<0.05$) more elicited for BSG-added sample, the opposite occurred for the latter.

Three unclassified emotions also presented significant difference ($p<0.05$) between samples. On the one hand, *Guilty* and *Wild* were less frequently applied to fibre-enriched pasta when compared to regular pasta. However, *Tame* rated higher for the former.

The remaining 9 terms that differed significantly ($p<0.05$) in their ratings between regular and fibre-enriched pasta were all positive emotions: *Calm, Warm, Free, Good Nature, Joyful, Happy, Loving, Active* and *Pleasant.*

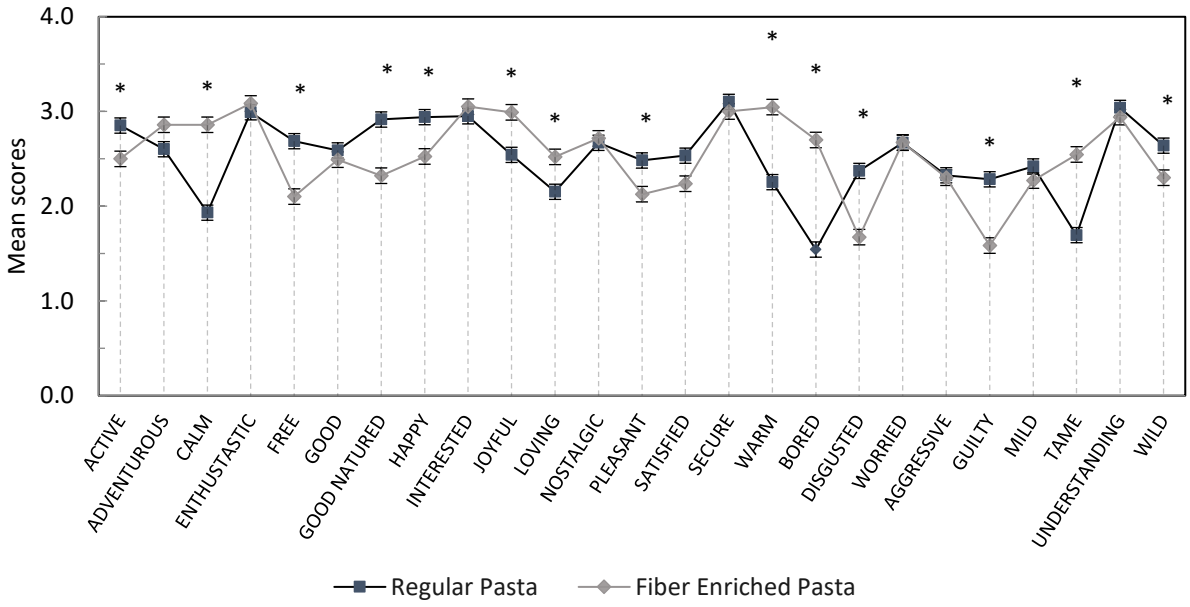


Figure 6. *Effect of product on emotional response (mean score ± SD) for Fibre-enriched Pasta and Regular Pasta.*
(*) indicates significant difference at $p<0.05$.

3.2.3. Chocolate milk

3.2.3.1 Acceptability and Purchase intention

Significant ($p<0.05$) differences were found in both acceptability and purchase intention of chocolate milk (**Table 12**). These differences are probably rooted in the fact that fibre inclusion introduces changes in the texture and flavour of the product, as evidenced by the CATA attributes and reasons for not purchasing the product.

Table 12. *Results of sensory evaluations for Chocolate milk*

Product	Acceptability	Purchase intention
Regular Chocolate milk	6.47 ± 1.86[a]	3.55 ± 1.26[a]
Fibre-enriched Chocolate milk	5.68 ± 2.13[b]	3.03 ± 1.34[b]

Acceptability and Purchase intention expressed as (mean ± SD). Scores not sharing letters in same column are significantly different ($p < 0.05$) according to Student's T-test.

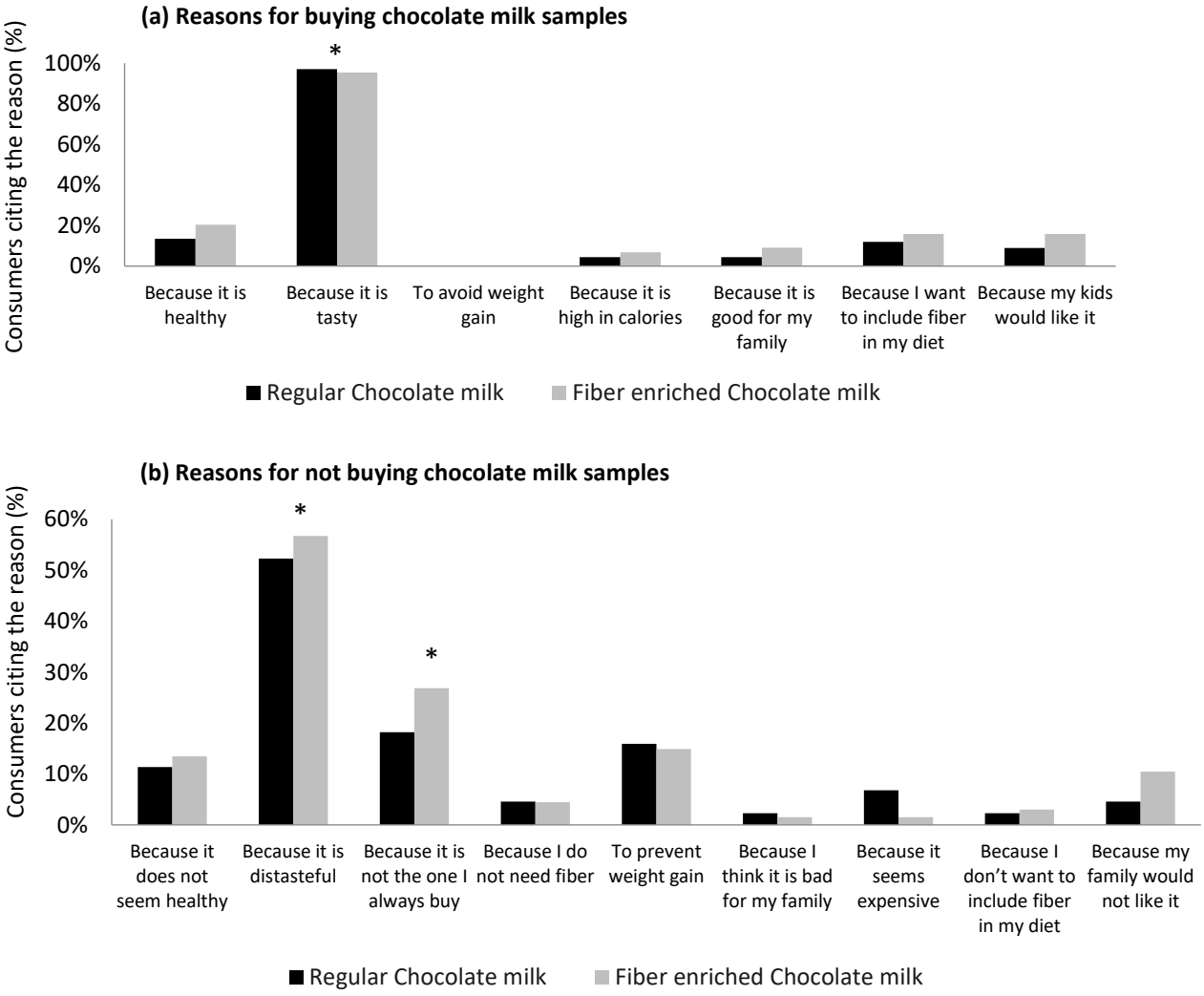


Figure 7. *Reasons to buy (a) or not to buy (b) pastas evaluated without information. (*) indicates significant difference at $p<0.05$.*

Among consumers willing to buy fibre-enriched chocolate milk (40%), most of them (96%) stated its *Taste* as the main reason for purchase (**Figure 7**). However, this was also the main cited reason for buying regular chocolate milk, scoring a significantly ($p<0.05$) higher frequency of mention compared

to the first one. This difference in frequency of choice is mostly due to the higher percentage of consumers buying the regular sample (60%).

In addition, the main reason for not buying the fibre-enriched chocolate milk was due to its taste; this being more frequently selected than for the regular product ($p<0.05$). This attribute was also chosen for bread and pasta as main reasons for not buying the products. This is probably due to the changes caused by the addition of BSG. Indeed, Ktenioudaki et al. (2013) reported that the incorporation of BSG into baked snacks altered the odour profile of the snacks, in addition to their taste and overall acceptability. Researchers associated this unpleasant odour to compounds deriving from fermentation and Maillard reaction, including 3-methyl-butanal, 2,3 butanedione and 2-methy-butanal which were present in high quantities in both BSG flour and the BSG snacks.

3.2.3.2 Check-all-that-apply (CATA) attributes

Out of the 20 terms presented in the list, 7 presented significant ($p<0.05$) differences in their frequency of choice for chocolate milk under the blind condition (**Figure 8**). Both chocolate milks were frequently associated with the attributes *Smooth*, *Strong Chocolate Flavour* and *Natural*. However, the attributes *Gritty, Artificial, Coarse, Aftertaste, Strange Taste, Unpleasant aroma* and *Greasy* distinguished the fibre-enriched chocolate milk from the regular one ($p<0.05$). Those attributes may explain the significant ($p<0.05$) lower acceptability obtained for the BSG-added product, affecting both, product texture and flavour.

Acceptability for fibre-enriched milk has not been thoroughly studied. However, its addition to other fluid dairy products, such as yoghurt, has been investigated. Particularly, Tomic et al. (2017) evaluated the sensory characteristics and consumer acceptance of fibre-enriched yoghurts, reporting a significantly ($p<0.05$) low acceptability compared to the control sample, caused primarily by a gritty or sandy texture. This conclusion is in accordance with the results obtained in this study, where fibre-enriched chocolate milk was significantly ($p<0.05$) less accepted than the regular one and the *Gritty* attribute was selected by 30% of participants for the BSG product (12% for the regular chocolate milk).

Lopez et al. (2016) studied the perceived oral grittiness of multiparticulate formulations and positively correlated it with the amount and size of particles being dispersed in the media. The product matrix has also been reported to greatly influence the particle size detection threshold, concretely particles being dispersed in liquid matrices are easier to detect than the ones in solid

matrices (Liu, Stieger, van der Linden & van de Velde, 2016; Santagiuliana et al., 2019a). Although the BSG particle size used for fibre-enriched chocolate milk was smaller than for fibre-enriched bread and pasta, it was still considerably large (>200µm) compared to detection thresholds for cellulose particles (1.5% w/w) in viscous and semi-solid high-fat processed cheese which are estimated to be 52µm and 82µm, respectively (Santagiuliana et al., 2019a). In addition, the product matrix being liquid is likely to have facilitated the perception of *Grittiness* compared to semi-solid or solid foods. For all the above, unpleasant *Roughness* and *Grittiness* was still perceived albeit BSG concentration being considerably low (0.35% w/w).

Furthermore, although *Bitterness* was relatively more frequently used to describe the fibre-enriched chocolate milk, its frequency of mention did not differ significantly ($p<0.05$) between samples. Tomic et al., (2017) reported that *Bitterness* had a negative influence in the flavour quality scores of 30 g/kg fibre-enriched yoghurts, which were significantly lower than for the 15 g/kg counterparts. This result suggests that fibre addition may have increased the bitterness of the fibre-enriched chocolate milk, yet its concentration was not high enough to exert a significant ($p<0.05$) effect.

Just as *Taste* scored significantly ($p<0.05$) higher in terms of frequency of mention among the reasons for not buying fibre-enriched chocolate milk than the regular one ($p<0.05$), significant ($p<0.05$) differences were also found in frequency of mention of the following CATA attributes describing taste: *Unpleasant aftertaste*, *Unpleasant aroma* and S*trange taste*. Again, this shows the unpleasant and negative effects of incorporating BSG into foods (Ktenioudaki et al., 2013). Nonetheless, a decrease in sensorial properties (particularly smell and taste) has also been reported after incorporating cauliflower by-products extracts to apple juice (Amofa-Diatuo, Anang, Barba, & Tiwari, 2016), becoming apparent one of the greatest struggles of by-products valorisation.

Table 13. *Attributes presented in CATA questionnaire for chocolate milk sensory evaluations in Spanish (ES) and English (EN).*

Attribute (ES)	Attribute (EN)
Suave	Smooth
Intenso sabor a chocolate	Strong chocolate flavour
Natural	Natural
Oscuro	Dark
Arenoso	Gritty
Amargo	Bitter
Intenso aroma a chocolate	Strong chocolate aroma
Artificial	Artificial
Áspero	Coarse
Cremoso	Creamy
Retrogusto	Unpleasant Aftertaste
Sabor extraño	Strange taste
Saludable	Healthy
Sabor a leche	Milk flavour
Aroma desagradable	Unpleasant aroma
Grasoso	Greasy
Poco sabor	Lacking flavour
Claro	Pale
Ácido	Acidic
Insulso	Bland

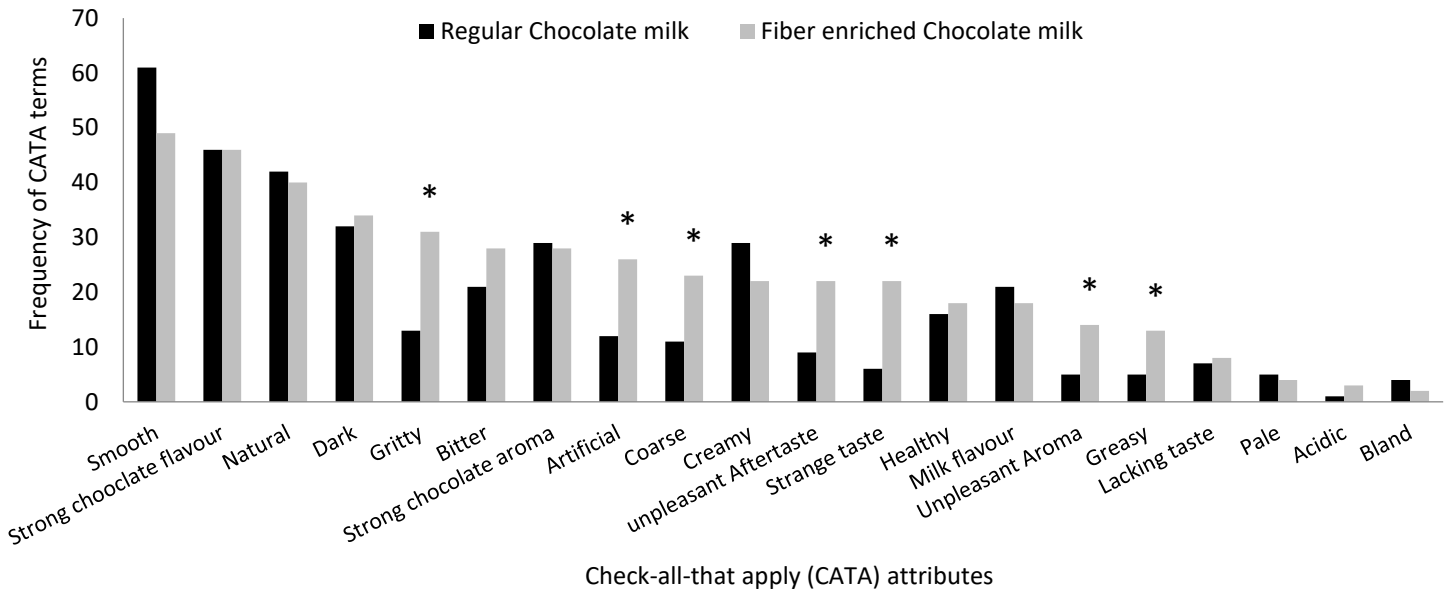


Figure 8*. Frequency of check-all-that-apply (CATA) terms for the Fibre-enriched Milk chocolate and the Regular Milk chocolate.*

(*) indicates significant difference at $p<0.05$.

3.2.3.3 Product-evoked emotions

In the case of chocolate milk, three emotional terms showed significant ($p<0.05$) differences in the blind condition (**Figure 9**). Two of them were unclassified emotions: *Mild* and *Tame*. Participants felt significantly ($p<0.05$) milder after consuming fibre-enriched chocolate milk, yet they felt tamer after testing the regular chocolate milk. *Calm*, which is a positive emotion also presented significant ($p<0.05$) difference in its rating, being more frequently elicited for the fibre-enriched chocolate milk.

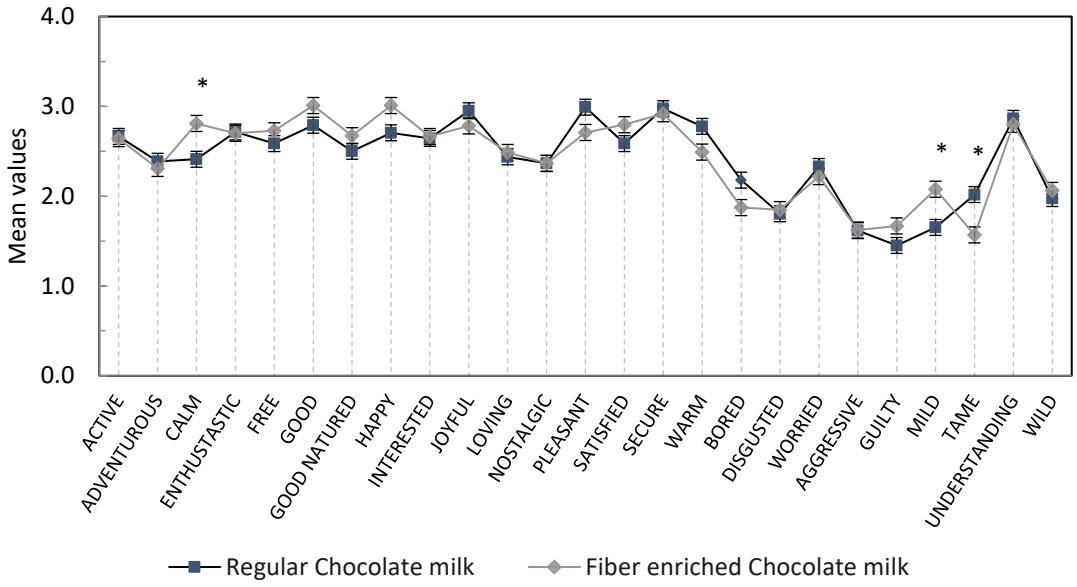


Figure 9. *Effect of product on emotional response (mean score ± SD) for Fibre-enriched Chocolate milk and Regular Chocolate milk.*

(*) indicates significant difference at $p<0.05$.

3.3. Comparison of the impact of fibre on the different food categories

Consumers responded differently to the fibre enrichment of bread, pasta and chocolate milk. Interestingly, consumer responses towards bread and pasta were remarkably similar. In neither products consumers showed a statistically significant difference in purchase intention between the regular and fibre-enriched version. Amidst the reasons for buying the fibre-enriched bread and pasta, consumers cited *Healthy* and *To include fibre in my diet*. These results confirm the ability of respondents to successfully recognize fibre-enriched products and thus infer their health benefits. Knowledge about dietary fibre and its health effects has already been reported to be substantial among the general population (Yalçın et al., 2020).

In the case of chocolate milk, consumers could not recognize the addition of fibre to the product and instead perceived a strong and unexpected flavour, coming from BSG's strong aromatic compounds, enhanced due to it being in liquid state. Lack of awareness of its nutritional benefits may have prevented the "halo" effect, which is defined as a positive influence on the perception of a product due to an unrelated impression from another attribute (Li & Dando, 2019; Biondi & Camanzi, 2019).

Indeed, communication of a product's health benefits can be a powerful marketing tool for the food sector due to its potential "halo" effect. For instance, Curutchet et al. (2021) reported an increase in liking for fibre-enriched apple pomace cake when the claim Source of Fibre was displayed, showing the impact, or "halo" effect, of health claims on hedonic liking. Thus, although fibre-enriched chocolate milk was not liked as much as the control, including the corresponding nutritional claims may bridge the gap between them.

Pasta is the product whose emotional response differed the most, despite being the only one with no significant ($p<0.05$) difference neither in acceptability nor in purchase intention. Differences in emotional response between regular and BSG enriched samples were evoked due to differences in their sensory features, as no information was provided. Five emotions were repeated in at least two categories and show significant ($p<0.05$) differences between the fibre-enriched and the regular one. *Tame, Calm, Warm, Bored, Guilty* and *Active*.

None of the emotions differed ($p<0.05$) alike – between the fibre-enriched sample and regular sample – among all the food categories. Although consumers felt more *Warm*, *Bored*, *Tame* and less *Guilty* and *Active* when tasting fibre-enriched pasta and bread, for fibre-enriched chocolate

milk this did not occur. Except for *Tame*, none of the other previously mentioned emotions differed ($p<0.05$) significantly for this last product. This seems to indicate that the knowledge or perception of fibre enrichment provokes a distinct set of emotions.

4. Conclusions

In the current chapter, the effect of BSG addition to different food product categories was analysed by sensory evaluations of both control and fibre-enriched samples. The amount of BSG flour added to the fibre-enriched products was enough for them to bear the claim *Source of fibre* according to Uruguayan legislation and Codex Alimentarius. The addition of fibre led to some changes in the acceptability and buying intention as well as in the product perception. Results showed that BSG enrichment had a significant ($p<0.05$) effect on the sensory properties of all three products, affecting both texture and taste. Although the fibre-enriched bread and fibre-enriched chocolate milk ranked lower in overall acceptability compared with their counterparts, no significant ($p<0.05$) difference was found between fibre-enriched and regular pasta.

Interestingly, purchase intention did not differ significantly ($p<0.05$) for either bread or pasta, yet the reasons for purchasing them differed significantly ($p<0.05$). It seems consumers were aware of fibre-enrichment in these two and were willing to partially compromise on sensory attributes. Fibre-enriched chocolate milk, nonetheless, scored significantly ($p<0.05$) lower in purchase intention than the regular product, probably due to the mouthfeel perception being affected by BSG particles and lack of awareness of it being a functional product.

Overall, the findings demonstrated that the effect of BSG addition is product-specific; while fibre-enriched pasta and fibre-enriched bread were approved by consumers, results for fibre-enriched chocolate milk suggested the opposite. Ambivalence was seen in the emotions generated by the different fibre-enriched products, depending on whether the fibre was perceived or not. When consumers perceived the fibre enrichment in the product, they approved of consumption, feeling in general more confident.

Further research should focus on the effect of information on consumers' perception and emotional response towards fibre-enriched products, including their effects on attention, to draw more in-depth conclusions.

CHAPTER II

Consumers' perception and emotional response towards different BSG-enriched food products under informed conditions

5. Introduction

Food waste generated by the food industry is a prominent contributor to the environmental impact (Tonini, Albizzati & Astrup, 2018). Over the years, BSG was commonly considered as another waste product, but investigation about its composition positioned it as a promising functional ingredient. BSG can be successfully incorporated to food products with numerous advantages for both the environment and human health, such as optimization of the resources, minimization of waste, and fortification of food products with dietary fibre (Mussatto, 2014; Lynch et al., 2016; Naibaho et al., 2021).

Nonetheless, the main drawback to this is the fact that adding BSG to food products produces undesirable changes in their sensory properties. BSG enrichment has already been associated with changes in texture (Nocente et al., 2019; Stojceska, 2011), colour (Petrovic et al., 2017; Nocente et al., 2019), taste (Oluseyi, Dawodu, Ajanaku & Nwinyi, 2011), aroma (Ktenioudaki et al., 2013) and rheological properties (Ktenioudak et al., 2015; Amoriello et al., 2020) in multiple products including bread, cookies, biscuits, pasta, breadsticks, pizza and baked snacks. Many of these are undesirable and make them less appetizing, presenting a technological challenge in the formulation of BSG-enriched products.

The increasing consumers' concern about the food production impact on the environment seems to support the demand for environmentally friendly food products. It is estimated that the number of sustainable products sold in the USA will reach a fourth of the total products in 2021 (Wilson, 2019). In this sense, BSG-added products may be promising provided that their environmental benefits are successfully conveyed to consumers. Indeed, new conceptual models have been recently investigated to better understand how healthier and sustainable food choices are made (Chen & Antonelli, 2020).

Extensive research has been conducted in relation to food choice. Although most of them have focused on sensory food properties, studies have found that the way the food product is perceived by the individuals is even more important (Rozin, 2007). Indeed, food choice is a complex phenomenon where multiple forces play including food-internal factors, food-external factors, personal-state factors, cognitive and sociocultural factors (Chen & Antonelli, 2020). Thus, consumers' values, traits and emotions join with visual marketing stimulus to direct their attention and eventually form a decision. Both bottom-up and top-down factors take place while decision-making (Wedel & Pieters, 2008). The former ones are largely involuntarily and stimulus based. A clear example of this is when a product pops out due to its colour, luminescence, shape,

phrase or label. On the other hand, top-down factors are effortful and slower. They arouse from consumers' search goals, like "find the cheapest milk", and memory "find the blue, cylindrical cookie package", referring to Oreo biscuits.

Research has shown the influence of front of packaging messages and sustainability claims on consumers' acceptance (Biondi & Camanzi, 2019; Fernqvist & Ekelund, 2014). For instance, Curutchet et al. (2021) showed that apple pomace cake ranked higher in overall acceptability when bearing the *Sustainable Source of Dietary Fibre* claim than under blind condition.

However, label information is not always clearly understood or paid attention to (Samant & Seo, 2016). Bearing in mind that consumers spend on average 22 seconds when choosing a product while grocery shopping (Machín et al., 2020), information should be displayed succinctly and eye-catchingly. Logos and short strong statements are excellent examples of such. Yet consumers do not always understand or even trust sustainability-related logos (Kaczorowska, Rejman, Halicka, Szczebyło, & Górska-Warsewicz, 2019). A more detailed description of the processing has proven to increase consumers linking (Samant & Seo, 2016) but, on the other hand, information overload tends to confuse consumers (Koen, Blaauw & Wentzel-Viljoen, 2016). Striking the right balance of the information being displayed appears to be of paramount importance for a successful and effective communication with consumers.

The quality of information being conveyed on the label should not be undermined either. While "*by-product*" can be related to sustainability and put forward a favourable view, it may also have a negative connotation for consumers (Lambie-Mumford & Silvasti, 2020). Indeed, recycled food products may be perceived as unsafe and risky due to them being contaminated or owing to consumers' uncertainness of the manufacture process (Calvo-Porral & Lévy-Mangin, 2020). Positioning these products in a favourable way through the appropriate communication seems fundamental to gain consumers acceptance. Baht et al. (2017) studied the effect of labelling on consumers' acceptance of VASP (Value-added surplus products) and discovered that the most preferred VASP food description was "upcycled", whereas "resorted" and "rescued" ranked the lowest. Thus, while it is plausible that the declaration of BSG on the label adds differential value to the products, the opposite case can also occur. In other words, the indication of the use of a by-product may not generate the desired acceptance by consumers (Yang et al., 2020).

Another key element when studying the impact of information on consumers' attitude is the type of product. The same nutritional and environmental claims on different products may not have the same effect on it (Hoek, Pearson, James, Lawrence, & Friel, 2021; Gracia & Barreiro-

Hurlé, 2019). The fact that consumers hold particular expectations and seek certain goals for a given product may be the reason behind it (Cardello, 1994). For instance, Gracia & Barreiro-Hurlé (2019) reported that while *"source of fibre"* was more important than "*reduced fat*" for biscuits, the opposite was found to be true for pastries. Similarly, Hoek et al. (2017) showed that although environment logos could shift consumers choice to more sustainable food products, it depended on the options under consideration. For white rice, many consumers consented to shift to the more environmentally friendly brown rice, yet for beef meat only a small number of them agreed to shift to kangaroo meat. For all the above, the present study analysed three products belonging to different food categories to account for possible discrepancies that may exist.

Among the different methods to study the effect of information on consumers' attitude, the eye-tracking technology is in the forefront. It has been widely used in the research field for predicting consumers food choices (Goyal, Miyapuram & Lahiri, 2015), discovering how to capture consumer attention to a specific location in the scene (Al-Azawi, 2019) and for identifying the most appealing label for a food product (Nemergut & Mokr, 2020). Eye-tracking technology is used to study visual attention as this is reflected in eye movements. Through data analysis, eye movements can then be interpreted to provide insight about the underlying cognitive processes and better understand the decision-making process (Zagermann, Pfeil & Reiterer, 2016). In this way, it is possible to evaluate different types of food labels and identify what attracted consumers' attention the most and what they based their decision upon. (Takahashi, Todo & Funaki, 2018). In this research study, measurements and analysis of respondent's eye movements, while looking at different food labels of fibre-enriched environmentally friendly products, is used to reveal which one produces the best perception on consumers.

On another note, research has been conducted into consumers' emotional response towards food products and its relation to the information provided. As detailed on Chapter I, some authors have studied the link between the traditional and direct methods of evaluating food products, with the ground-breaking and side-along measurements of emotional response (Yang et al., 2020; Polizer et al., 2018). It has been reported that this subconscious response discloses a more in-depth and accurate information about consumers' actual preference and enables discrimination between different samples of interest (Chaya et al., 2015; Yang et al., 2020). Nonetheless, how the information of food products impacts on the emotional response,

together with its relation to acceptability and purchase intention, has not yet been fully explored to the best of the authors' knowledge.

The aim of this study was to analyse consumers' attitudes towards sustainable and functional food products belonging to different food categories, under informed conditions. Two main different aspects were studied. Firstly, the effect of different messages displayed on the labels upon consumers' acceptability and purchase intention through eye-tracking technology. Secondly, the impact of information (i.e., awareness of BSG addition and its benefits) on consumers' sensory acceptability, willingness to buy the products and emotional response. These findings would reveal the perception consumers have towards these sustainable and functional food products and indicate its future market potential.

6. Materials and Methods

6.1. Product Labels

6.1.1 Design

Products labels were designed for exclusive use in this investigation using a graphic design platform. A study was carried out to first identify the best label for each product (i.e., the labels which produced the best perception on the consumers). Three categorical two-level factors were studied: (1) sustainability logo, (2) brief explanation of BSG benefits to both consumers' and environment and (3) BSG appellation. Thus, this resulted in 8 different labels for each product. Factors and factor levels studied are shown in **Table 14**. Food labels included all mandatory information according to Uruguay legislation (Exec. Order No. 315/994, 1994).

***Table 14**. Factors and factor levels studied on products label design.*

Factors	Level 1	Level 2
Sustainability Logo	Present	Absent
BSG benefits declaration	Present	Absent
BSG appellation	BSG Flour	Malted Barley

6.1.6 Eye-tracking study

Eye-tracking equipment was set up in Universidad Católica del Uruguay. The study was carried out with a convenient consumer sample in which a total of 90 people participated. Each product was evaluated by 30 consumers who gave informed consent before the evaluation started. Individual appointments were made to abide by COVID-19 socially distancing recommendations.

Eye-tracking assembly included defining Areas of Interest (AOI) on the labels to enable results interpretation. As exemplified in **Figure 10**, the following AOI were defined: front brand logo (A), product name (B), product image (C), front source of fibre logo (D), front sustainability logo (E), product appellation (F), back sustainability logo (G), brief explanation of BSG benefits to both consumers' and environment (H), back source of fibre logo (I), nutrition information panel (J), ingredients (K), back brand logo (L). It should be noted that not every area appeared in all food labels as this depended on the factor levels under study (**Table 14**).

By using eye-tracker it was possible to identify how long each participant looked at an AOI (i.e., *Fixation Time* or *Total Time Viewed*) and the *Total Fixation Count*. This last term represents the

number of times a participant fixed their gaze for an AOI. The more interested participants are in an AOI, then *Total Time Viewed* and *Total Fixations* increases (Samant & Seo, 2016).

Figure 10. *Example of how AOI were defined in one of the labels for fibre-enriched bread.*
(A) BSG Logo, (B) Product Name, (C) Image, (D) Fibre Logo F, (E) Sustainability Logo F, (F) BSG Appellation, (G) Sustainability Logo B, (H) BSG Explanation, (I) Fibre Logo B, (J) NIP, (K) Ing., (L) BSG Logo B.

The eye-tracker used in this research study was Gazepoint GP3 HD eye-tracker and belonged to the optical tracking category – it radiated infrared light which was then reflected from the eye and detected by a video camara (**Figure 11**). Based on the variations of the reflected light, the pupil movement and the participant's gaze point were measured.

The study comprised of three consecutives tasks performed in a ViewSonic VA1917A 19" monitor together with the eye-tracker positioned in front of each participant at approximately 0.6 m. Before initiation, the eye-tracker was calibrated for each participant using the nine-point calibration method. Instructions were displayed on the screen. Prior to presenting every image, a fixation cross in the middle of the screen was shown for 3 seconds to ensure that participants fixed their gaze at this point.

Figure 11. *Left: Laboratory set up showing Gazepoint GP3 and participant carrying out the study. Right: Gazepoint GP3 setup screen showing a user correctly positioned in the camera's view.*

For the first task, participants were briefly showed the eight different labels of one of the products. Each label was displayed for 5 seconds in a randomized order. No specific task was given to expose what caught respondents' attention the most in an open scanning. The second task comprised of displaying the same eight labels in randomized order, but unlimited time was provided for them to explore the labels freely. After each label, a question regarding purchase intention (Question A) or perceived healthiness (Question B) was asked to detect what participants focused on. Half of the participants were first asked Question A and the other half Question B. A seven-point discrete scale (Question A: 1- *would definitely not buy* / 7- *would definitely buy*; Question B: 1- *not healthy at all* / 7-*extremely healthy)* was displayed on screen and answers were orally communicated to researchers who recorded them. Task 3 was identical to Task 2 but with Question B (if previously asked Question A) or Question A (if previously asked Question B).

6.2. Consumer Sensory Evaluation

Informed tests were the focus of this research stage, building upon the results obtained from the blind tests (Chapter I). Bread, pasta and chocolate milk were prepared in the same way as for the blind condition (Chapter I) but this time participants were provided with each products' label to assess the impact of information on consumers' response.

The panellists were of both genders, over 15 years old, Uruguay residents and consumers of each product. Socio-demographic information about the participants of the informed evaluations is shown in **Table 15**.

Questionnaires presented on the informed sensory evaluations were the same as in the blind condition (Chapter I). The first part consisted of the evaluation of the samples on overall liking, purchase intention and sensory description, which was followed by EsSense 25 questionnaire.

***Table 15**. Socio-demographic characteristics of the participants in the informed sensory evaluations*

	N	Gender		Age (years old)			
		Female (%)	Male (%)	15-25 (%)	26-40 (%)	41-55 (%)	>55 (%)
Informed condition							
Bread	101	34.7	65.4	52.5	38.6	7.9	0.0
Pasta	101	68.3	30.7	70.3	14.9	8.9	5.9
Chocolate milk	100	61.0	39.0	78.0	16.0	6.0	0.0

6.3. Data Analysis

Shapiro-Wilk test was performed to test the normality of the data obtained from the eye-tracker questionnaires and measurements. As the data was not normally distributed, non-parametric Kruskal-Wallis test was performed at a significance level of 5% with Bonferroni correction. Results from eye-tracker tests were subjected to Spearman correlation test ($p<0.05$) and Principal Component Analysis.

Results from informed sensory analysis were analysed the same as for the blind test (Chapter I). Student t-test analysis were performed to determine significant differences ($p<0.05$) between samples' acceptability and purchase intentions. Cochran's Q test was then performed on frequency of choice of CATA attributes to detect significant differences ($p<0.05$) between fibre-enriched and regular samples for each attribute.

In view of better understanding the consumer behaviour with the fibre-enriched products, hierarchical cluster analysis (HCA) considering Euclidean distances and Ward's aggregation method were performed for each testing condition and product category (i.e., two HCA per product). Non-parametric Mann-Whitney was performed to compare acceptability between samples within clusters. Chi-square test was used to detect difference in frequencies of consumption between and within clusters.

Additionally, Multiple Factor Analysis was performed to graphically evaluate the associations between the emotions evoked by the different products under both settings. A two-way ANOVA

was carried out for each food category to examine the impact of extrinsic information and BSG enrichment on the emotional response and overall liking, followed post-hoc Tukey's Test HSD.

All statistics analysis were performed using XLSTAT 2020.3.1 software (Addinsoft 2020, New York, NY, USA).

7. Results and Discussion

7.1. Eye-tracking

7.1.1. Questionnaire

Results from the eye-tracking questionnaire are shown on **Table 16**.

Table 16. *Mean value of purchase intention and perceived healthiness for labels of bread, pasta and chocolate milk.*

Labels***	Bread		Pasta		Chocolate milk	
	PI*	PH**	PI	PH	PI	PH
111	5.67^{a}	5.53^{a}	5.60^{a}	5.63^{a}	5.75^{a}	5.56^{a}
101	5.63^{ab}	5.50^{a}	5.87^{a}	5.77^{a}	5.78^{a}	5.50^{a}
011	5.27^{abc}	5.27^{ab}	5.27^{ab}	5.40^{ab}	5.28^{ab}	4.91^{ab}
100	4.73^{abc}	4.70^{abc}	4.77^{ab}	4.97^{ab}	5.00^{ab}	4.84^{ab}
110	4.70^{abcd}	4.77^{abc}	4.90^{ab}	5.00^{ab}	5.00^{abc}	4.81^{abc}
010	4.43^{bcd}	4.47^{abc}	4.13^{ab}	4.53^{ab}	4.50^{abc}	4.06^{abc}
001	5.20^{cd}	5.10^{bc}	5.30^{b}	5.60^{b}	5.25^{bc}	4.88^{bc}
000	4.13^{d}	4.30^{c}	4.40^{b}	4.50^{b}	4.13^{c}	4.31^{c}

* Purchase Intention

** Perceived Healthiness

***Label 111 – Sustainability logo present, *Malted barley* as BSG appellation and BSG explanation. Label 101 – Sustainability logo, *BSG flour* as BSG appellation and BSG explanation. Label 011 – *Malted barley* as BSG appellation and BSG explanation. Label 001 – *BSG flour* as BSG appellation and BSG explanation. Label 110 – Sustainability logo and *Malted barley* as BSG appellation. Label 100 – Sustainability logo and *BSG flour* as BSG appellation. Label 010 – *Malted barley* as BSG appellation. Label 000 – BSG flour as BSG appellation.

Lower case letters differ in the same column to indicate significant differences ($p < 0.05$) according to Kruskal-Wallis test.

Questionnaire results on Perceived Healthiness (PH) and Purchase Intention (PI) differed significantly according to Kruskal-Wallis test at a level of $p=0.05$. Labels whose scores were significantly ($p<0.05$) lower were discarded in favour of the others, although their information was included in the correlation analysis. For pasta and chocolate milk, labels 001 and 000 were discarded and, for the bread, label 100 summed into this.

7.1.2 Eye-tracker data

Total time viewed the label, *Total fixations* on the label and *Total time viewed* the AOIs did not differ ($p<0.05$) among the labels according to Kruskall-Wallis test for the *Purchase Intention Task* and for the *5s Task* in any product.

For the bread labels, Spearman correlation test indicated that the score given for *Purchase Intention* was positively correlated with the average *Total Fixations* calculated based on the *Purchase Intention Task* data (i.e., *Total Fixations - PI*) and the score given for *Perceived*

Healthiness ($p<0.05$). It was also negatively associated with the *Time Viewed BSG appellation* calculated from the *Purchase Intention* data (i.e., *Time viewed BSG ap. - PI*). It should be noted that *Total Time Viewed - PI* was also positively correlated with *Purchase Intention* at a significance level of $p=0.05$. Similar results were reported by Samant & Seo (2016) who studied different sustainability claims on chicken labels. They also found a positive Spearman correlation ($p<0.05$) between *Purchase Intention* and *Fixation Time* but only for the consumers with prior food label education (i.e., those with high knowledge of label claims).

The before mentioned correlations are clearly seen on **Figure 12**, where the first two dimensions explained a total of 76.5% of the data variability. As reported by other authors, the longer consumers fixed their gaze and the higher the number of fixations, the more likelihood of the product being chosen (Schotter, Gerety & Rayner, 2012; Bialkova et al., 2014). A 1-second increase in visual attention has been shown to increase the likelihood of purchasing certified Forest Coffee (Takahashi, et al., 2018). Essentially, attention plays a constructive role in decision making, which is a result of both bottom-up and top-down factors including heuristics, preference, working memory and attention (Orquin & Mueller Loose, 2013). Thereby, although no significant difference ($p<0.05$) was found among the labels, it seems that Labels 101 and 111 would be the most suitable owing to their closeness to *Total Time Viewed* and *Total Fixations* in **Figure 12**.

Between these two, Label 111 was ultimately selected as the best since consumers prefer sustainable food products being named as the product it derives from (i.e., *Malted Barley*) rather than to the by-product it contains (i.e., *BSG*). This is in line with results obtained in a complementary study that is being carried out (Data not shown). Additionally, *Malted Barley* was more familiar to consumers than the alternative, who did not fully comprehend the meaning of *BSG* until after reading the BSG description. Similar results where find by Monteiro Barbosa et al., (2021) who reported a decrease in acceptability when lacking knowledge of the UFP term (standing for *Unconventional Food Plants*) displayed on the food products labels.

The same occurred with the chocolate milk labels, where *Total Time Viewed - PI, Total fixations - PI and Healthiness Perception* were also significantly ($p<0.05$) and positively correlated with *Purchase Intention* (**Figure 13**). The same reasoning was used, and Label 111 was selected to further continue the study.

For pasta, the ranking given by consumers on *Perceived Healthiness*, correlated significantly ($p<0.05$) with *Purchase Intention*. Moreover, 65.5% of the data variability was explained by the

first and second dimension and, consequently, Label 111 was chosen to match those selected for the other two products.

In conclusion, Label 111 (Sustainability logo, *Malted barley* as BSG appellation and BSG explanation) was the one selected to further continue the investigation for all three products. It should be noted that this label was one of the two that included more information. It seems that both, explanation about BSG's origin and benefits and the Sustainability Logo had a positive effect on consumers' perception of the products in study. Although providing too much information on the label may confuse consumers (Koen et al., 2016), in this case no information overload seems to have taken place. Thus, information is necessary to help understand and make consumers aware of the benefits associated with BSG-enriched products.

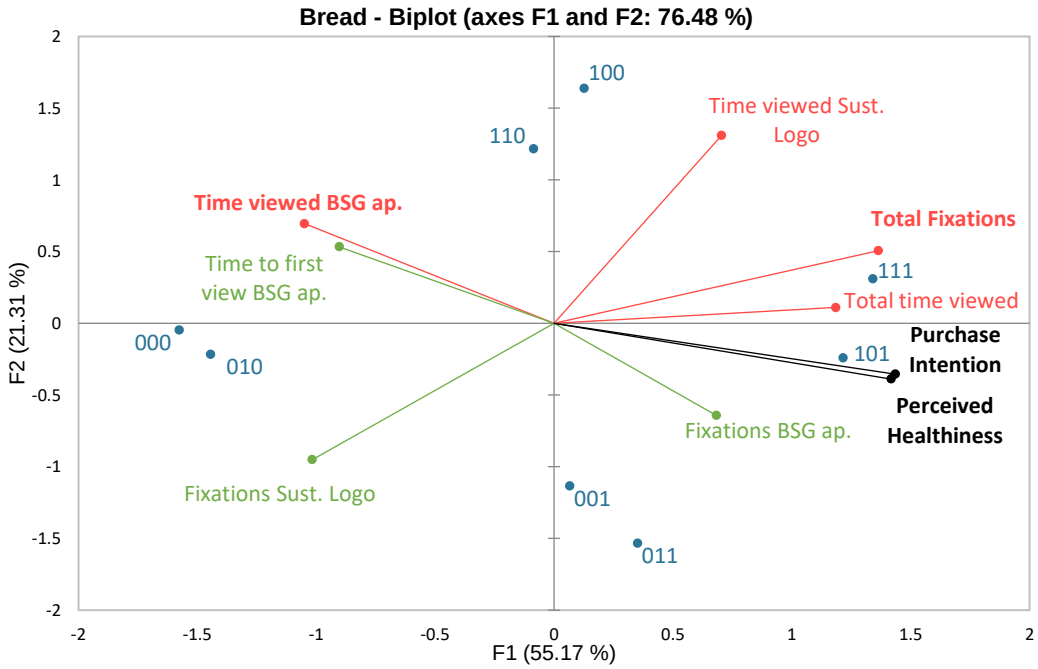


Figure 12. *Graphic representation of principal components analysis (PCA) of eye-tracker measurements and questionnaire results for bread labels.*

Variables in red correspond to data obtained from Purchase Intention task; in green data from 5s task and in black data from questionnaires. Variables in bold present significant ($p<0.05$) Spearman correlations with Purchase Intention. Labels in blue.

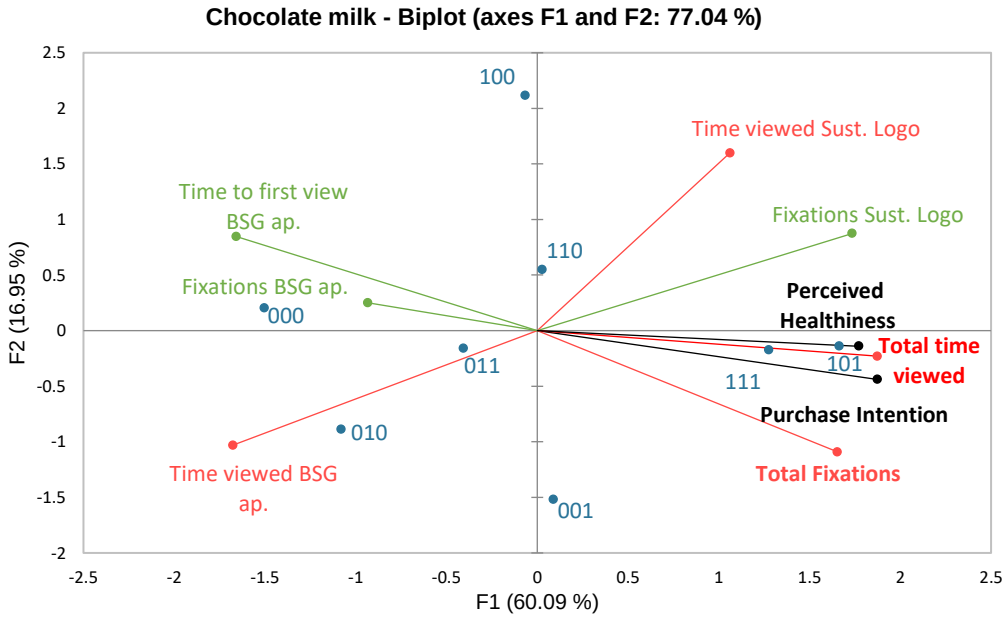


Figure 13. *Graphic representation of principal components analysis (PCA) of eye-tracker measurements and questionnaire results for chocolate milk labels.*
Variables in red correspond to data obtained from Purchase Intention task; in green data from 5s task and in black data from questionnaires. Variables in bold present significant ($p<0.05$) Spearman correlations with Purchase Intention. Labels in blue.

7.2. Sensory evaluation

7.2.1. Bread

7.2.1.1 Acceptability and Purchase intention

No significant differences ($p<0.05$) were found in acceptability and purchase intention between the bread samples (**Table 17**). This does not match results obtained under the blind conditions (Chapter I), where consumers preferred the regular bread in terms of overall liking. It seems information about BSG enrichment was strong enough to increase the fibre-enriched bread's liking, either because of the health or the environmental benefits associated with it. For instance, Baixauli, Salvador, Hough and Fiszman (2008) confirmed that the fibre information provided on the labels was well understood by the consumers and led to higher scores in wholemeal muffins. Similarly, the sustainability credence may have had a positive effect on product perception in accordance with Biondi and Camanzi (2020) and Eldesouky et al. (2020). However, neither the health nor the environmental claims could increase the acceptability and purchase intention significantly ($p<0.05$) compared with the blind condition as reported by Curutchet et al. (2021) and Silva, Bioto, Efraim and Queiroz (2017). This may be explained due to the significant difference ($p<0.05$) in acceptability found between the regular samples under both conditions, which in turn may derive from differences between the groups of respondents.

Certainly, respondents of the informed condition were mainly young men (mean age 27, SD=9 years old, 66% male) while the ones of the blind condition covered a wider age range and no gender was predominant (mean age 32, SD=14 years old, 48% male), results given by Chi-Square test at a significant level of p=0.05. This is consistent with Arganini, Sabaa, Comitato, Virgili and Turrini (2012) who reported healthier food behaviours with increased age and female gender.

Regarding purchase intention, consumers were equally willing to buy both samples ($p<0.05$), suggesting that information had no significant effect in their decision for this product. This could be due to their ability to recognize fibre with or without information as reported by Yalçın et al. (2020).

Table 17. *Results of sensory evaluations for Bread.*

Product	Acceptability	Purchase intention
Blind condition		
Regular Bread	$7.10 \pm 1.48^{a,*}$	3.93 ± 1.00^{a}
Fibre-enriched Bread	$6.44 \pm 2.06^{b,A}$	$3.75 \pm 1.26^{a,A}$
Informed condition		
Regular Bread	$6.52 \pm 1.55^{a,*}$	3.61 ± 1.09^{a}
Fibre-enriched Bread	$6.22 \pm 1.97^{a,A}$	$3.60 \pm 1.24^{a,A}$

Acceptability and Purchase intention expressed as (mean ± SD). Lower case letters differ in the same column*condition to indicate significant differences ($p<0.05$) according to Student's T-test. Upper case letters differ in same column to indicate significant differences ($p<0.05$) according to Student-s T-test. * indicates significant difference ($p<0.05$) in same column according to Student-s T-test.

The reasons given for and against buying the bread samples are shown in **Table 18**. Among reasons for buying both breads, in contrast with the result obtained on the blind condition where the regular bread scored higher, *Because it is tasty* was as frequently cited for the regular bread (93%) as for the fibre-enriched bread (85%). However, *Because it is healthy*, *To avoid weight gain* and *Because I want to include fibre in my diet*, presented significant differences ($p<0.05$) in frequencies between samples in the same way as in the blind testing (Chapter I).

Contrary to the blind condition (Chapter I), the frequency of mention of *Because it is good for my family* was significantly ($p<0.05$) higher for the fibre-enriched sample during the informed condition. Thereby, the information provided on the label seems to have brought out the potential benefits of this product, uplifting its perception of healthiness. This is supported by several authors who have studied the positive effect of information in perceived healthiness,

including health claims (i.e., *fibre source*) and symbolic information (i.e., sustainability logo) (Abrams, Evans & Duff, 2014; Sütterlin & Siegrist, 2015; Machín, Aschemann-Witzel, Curutchet, Giménez & Ares, 2018).

Simultaneously, just as in the blind condition, the main reason for not buying the bread samples was *Because of its taste*. Yet, in this case, this applied equally to both bread samples, with no significant difference ($p<0.05$) between them. In comparison with the blind testing (Chapter I), the only two statistically different ($p<0.05$) reasons against buying one of the breads, were related to the regular bread's negative impact on health. The information conveyed on the label convinced consumers to buy the fibre-enriched bread as it was seen *healthier* and better for *avoiding weight gain* ($p<0.05$). This did not occur under blind conditions which confirms the importance of good communication with consumers and their interest toward healthy food products (Moreira, García-Díez, de Almeida, & Saraiva, 2019; Ali & Ali, 2020; Saha, Vemula & Gavaravarapu, 2021). This was also evidenced by the fact that the reason *Because my family would not like it* did not present a significant difference ($p<0.05$) between the samples as it did on the blind condition, showing that consumers weighed healthiness in favour of taste. Finally, consumers previous misconception of fibre-enriched products being more *Expensive* vanished, probably due to associating BSG with a waste product. Information, thus, seemed to have created a "halo" effect which disguised the negative consequences of adding BSG (Li & Dando, 2019; Biondi & Camanzi, 2019).

Table 18. *Reasons to buy (a) or not to buy (b) breads evaluated with information.*

	Regular bread	**Fibre-enriched bread**
Reasons for buying	**N=61**	**N=68**
Because it is healthy *	27.8%	51.5%
Because it is tasty	93.4%	85.3%
To avoid weight gain *	6.6%	19.2%
Because it is high in calories	3.3%	3.0%
Because it is good for my family *	3.3%	16.2%
Because I want to include fibre in my diet *	9.8%	38.2%
Because my kids would like it	9.8%	4.5%
Reasons for not buying	**N=40**	**N=33**
Because it does not seem healthy *	19.9%	0.0%
Because it is distasteful	37.6%	66.7%
Because it is not the one I always buy	22.5%	21.1%
Because I do not need fibre	0.0%	6.1%
To prevent weight gain *	30.0%	6.1%
Because I think it is bad for my family	7.6%	3.1%
Because it seems expensive	2.5%	0.0%
Because I don't want to include fibre in my diet	2.5%	6.1%
Because my family would not like it	2.5%	18.2%

* Indicates significant difference in reasons to buy between samples at p=0.05.
Relatives percentages, where 100% corresponds to the subtotal of consumers buying the bread (a) or not buying the bread (b).

7.2.1.2 CATA attributes

Consumers described the bread samples through a CATA questionnaire. As with the blind condition, the attributes most frequently cited by consumers to describe the fibre-enriched bread were *Soft, Fluffy* and *Fibrous.* Their frequency of choice differed significantly ($p<0.05$) from the ones given for regular bread in the same manner as in the blind condition (Chapter I).

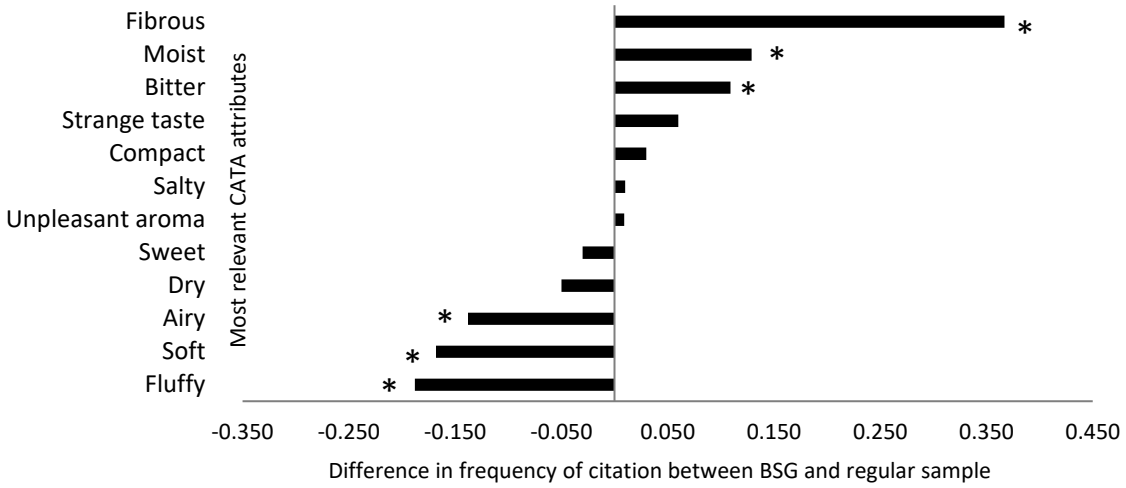


Figure 14. *Difference in frequency of citation between BSG and regular sample for CATA attributes under informed condition.*
* Indicates significant difference in frequency of citation between samples at p=0.05.

The differences in frequency of citation (i.e., subtraction of frequencies) between the BSG and regular sample under informed condition are shown in **Figure 14**.

No statistical difference was found in the frequency of mention of *Strange Taste, Compact, Salty, Unpleasant Aroma, Sweet* and *Dry* between the fibre-enriched and regular sample, contrary to the previous findings when no information was provided. It seems information positively contributed to an improved perception of the sensory features of the fibre-enriched bread. Indeed, *Unpleasant Aroma, Compact, Dry* and *Strange Taste* have a negative connotation which did not become apparent on the informed condition. Although fibre has been broadly described as unpalatable (Quagliani & Felt-Gunderson, 2017) and nutrition claims have been associated with products being healthier and less tasty, opposite results have also been reported (Dubé, Fatemi, Lu & Hertzer, 2016; Jo & Lusk, 2018). For instance, Jo and Lusk (2018) stated a positive relationship between tastiness and health when evaluating 60 products, which supports present findings. Similarly, environmental claims, have also been reported to increase tastiness (Sörqvist et al., 2015).

7.2.1.3 Cluster Analysis

Cluster analysis was performed to identify segments of consumers with different patterns of preference for fibre-enriched and regular bread under both blind (BN) and informed (IN)

conditions (**Table 19**). Its aim was to identify the promising market segments and to evaluate the impact of information on them. Three clusters were identified in each scenario (i.e., blind and informed). Regarding the bread samples, consumers belonging to BN-Cluster 3 (14%) and IN-Cluster 2 (40%) showed a significant ($p<0.05$) preference for the regular bread. Although access to product information increased the number of consumers with preference for the regular bread, the mean acceptability score in BN-Cluster 3 was considerably lower ($p<0.05$) according to Mann-Whitney test than for IN-Cluster 2. Furthermore, when the product information was available to consumers, a significant preference ($p<0.05$) for fibre-enriched bread was identified in consumers belonging to IN-Cluster 3 (19%). No such preference was present under blind conditions, where equal liking scores were awarded to the bread samples by consumers belonging in BN-Cluster 2 (28%) and BN-Cluster 1 (58%). It could be, thereby, hypothesised that BSG had a positive effect on some consumers, either due to its health and/or environmental benefits which were conveyed on the label (Bhatt et al., 2017). Interestingly, consumers with a clear preference for regular bread in both conditions (i.e., BN-Cluster 3 and IN-Cluster 2), were more used to eating white bread compared to whole-wheat bread ($p<0.05$). Similar results were found by Laureati et al. (2016) and De Leon et al. (2020) who reported familiarity to fibre as a key element for higher acceptability.

Table 19. *Clusters*' composition according to bread acceptability for the blind and informed condition.

	Blind condition (BN)			**Informed condition (IN)**		
	Cluster 1 58%	**Cluster 2 28%**	**Cluster 3 14%**	**Cluster 1 42%**	**Cluster 2 39%**	**Cluster 3 19%**
I. Age	32	35	25	28.5	26	29
II. Product acceptability						
Regular bread	7.6[a]	5.9[a]	7.5[a]	7.8[a]	6.0[a]	5.1[b]
Fibre-enriched bread	7.8[a]	5.5[a]	2.7[b]	7.6[a]	4.2[b]	7.5[a]
III. Frequency of consumption						
i. White bread						
Low users	18	14	11	**14**	**13**	6
High users	46	17	9	**28**	**27**	13
ii. Whole-wheat bread						
Low users	23	17	10	**28**	**24**	10
High users	41	14	6	**14**	**16**	9

(II.) Mean acceptability scores of consumers (Clusters 1–3). Scores not sharing letters within each cluster are significantly different ($p< 0.05$) according to Mann-Whitney test.
(III.) Frequency of consumption was grouped in: High users (More than once a week) and Low users (Less than once a week). Results in bold within a cluster show significant difference ($p<0.05$) between i and ii according to chi-square test. i and ii were non-significant ($p<0.05$) among clusters belonging to same condition (BN or IN) according to chi-square test.

7.2.1.3 Product-evoked emotions

No significant differences ($p<0.05$) were found in the emotions mean scores between the fibre-enriched and the regular bread during the informed condition, in comparison with the blind testing where five emotions presented significant differences ($p<0.05$) between the samples. Similar results were obtained by Yang et al. (2020) who reported that at least some emotions ceased to present significant differences ($p<0.05$) between the standard and sustainable sample when extrinsic information was provided. For instance, information about the sustainable Bambara biscotti, increased the mean scores for *Active,* equalling ($p<0.05$) those of the standard biscotti. Interestingly, the same occurred for this emotion in this study, probably indicating a higher degree of engagement in cognitive process when the label is provided (Smith & Kelly, 2015). Nonetheless, in comparison with Yang et al. (2020) findings, no new emotion started presenting significant difference ($p<0.05$) in their mean scores under the informed testing compared with the blind one.

Results of two-way ANOVA and post-hoc Tukey HSD are shown in **Figure 16**, where the effect of information and fibre-enrichment are studied.

MFA was used to study the relations among the emotions evoked by the food samples during the two settings (**Figure 15**). The two main dimensions accounted for 92.68% (F1=68.40% and F2=24.27%) of the experimental data variability, indicating that the model fits the data properly. It should be noted that each sample was situated in a different quadrant: BSG-enriched samples were positively correlated with F2, while the opposite occurred with the regular samples. Additionally, samples evaluated blindly positively correlated with F1 and those under informed conditions, negatively.

The variability of F1 is negatively correlated with positive emotions: 11 out of the 16 positive emotions were positioned on the left side of the axis and 9 out of these also correlated negatively with F2. The informed samples are located on the left side of the x-axis indicating that when information is provided consumers are more likely to experience positive emotions (Yang et al., 2020). Results of two-way ANOVA and Tukey post-hoc test support this finding as 7 emotions shifted ($p<0.05$) to a generally more positive emotional state.

Additionally, all negative and unclassified emotions were positively correlated with F2. Most of them were positioned in the first quadrant, where the BSG sample under blind condition was situated. This is consistent with previous results which showed a clear preference for all three other samples and rated this one the worst. Information, however, pivoted the fibre-enriched

sample towards negative values of F1 and down the vertical axis of the plot, reducing its correlation with the negative and unclassified emotions. It is unclear which element of information or combination of elements may have produced this shift. The sustainability claim and its explanation may have been responsible for its increase in *Boredom* ($p<0.05$) as a result of processing the information and becoming aware of its ingredients.

It is interesting to see that BSG-enrichment significantly decreased the feeling of *Guilt* ($p<0.05$) as shown in **Figure 16**. Eating high-containing-carbohydrates foods, such as bread, has already been shown to elicit guilt perceptions (Yu et al., 2020). Yet this could be eradicated or diminished when eating a more sustainable and healthier alternative, like fibre-enriched bread (Yu et al., 2020; Yang et al., 2021). Indeed, guilt perceptions can be strong enough to shift consumers to healthier and more sustainable food choices and eating behaviours and thus its paramount importance. Furthermore, fibre-enriched bread also made consumers feel *Tamer* and *Warmer* ($p<0.05$), showing an overall submissive and embracing attitude to this product.

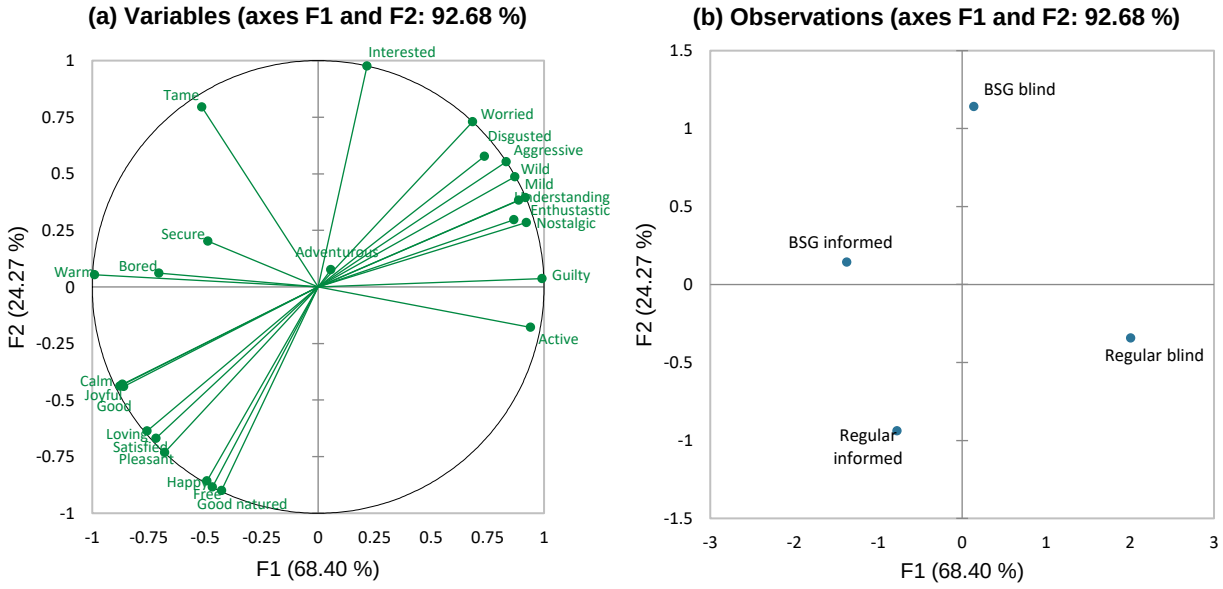


Figure 15. *Graphic representation of multiple factor analysis (MFA). (a) Representation of emotions. (b) Representation of informed and blind condition results obtained for regular and BSG-enriched bread.*

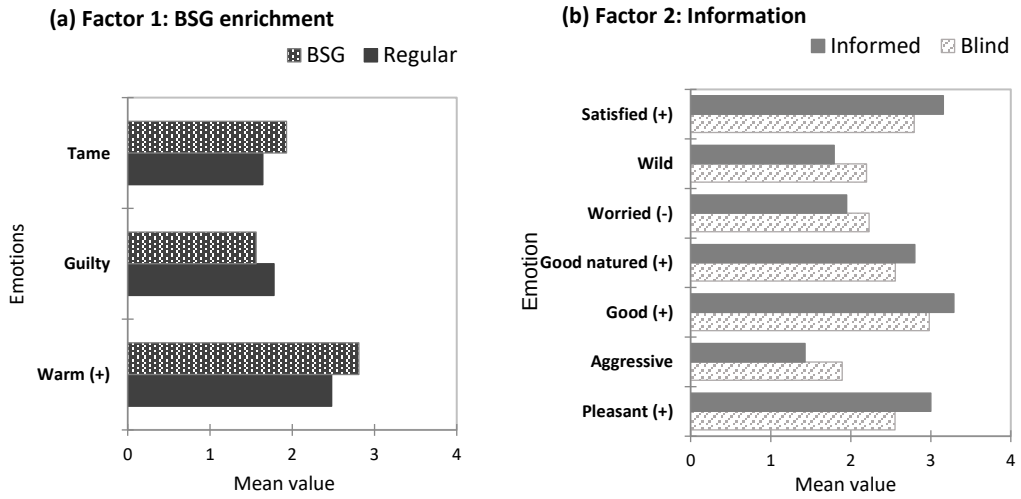


***Figure 16**. (a) Results from two-way ANOVA presenting significant difference (p<0.05) related to the effect of BSG enrichment of bread in emotions. (b) Results from two-way ANOVA presenting significant difference (p<0.05) related to the effect of blind and informed condition in emotions.*

7.2.2. Pasta

7.2.2.1 Acceptability and Purchase intention

Contrary to the results obtained during the blind testing (Chapter I), when information was provided to participants significant differences ($p<0.05$) were identified for both acceptability and purchase intention, between the fibre-enriched and the regular pasta (**Table 20**). In both cases, consumers preferred the fibre-enriched version ($p<0.05$). This differs from previous findings by Nocente et al. (2019) who reported that 5%-BSG-enriched pasta had a lower global sensorial judgement in comparison with the control sample. Nonetheless, it should be noted that these results were obtained by a trained panel based only on its textural properties without a hedonic aim. Laureati et al. (2016), on the other hand, did a sensory analysis with consumers providing information and found no differences in the liking of regular and 5%-bran-added pasta.

Table 20. *Results of sensory evaluations for Pasta.*

Product	Acceptability	Purchase intention
Blind condition		
Regular Pasta	6.87 ± 1.45[a]	4.14 ± 0.93[a]
Fibre-enriched Pasta	6.91 ± 1.91[a]	4.00 ± 1.20[a]
Informed condition		
Regular Pasta	6.07 ± 1.54[b]	3.53 ± 1.00[b]
Fibre-enriched Pasta	6.78 ± 1.84[a]	3.97 ± 1.10[a]

Acceptability and Purchase intention expressed as (mean ± SD). Lower case letters differ in the same column*condition to indicate significant differences ($p < 0.05$) according to Student's T-test.

The main reasons for buying either sample was due to their perceived *Tastiness* and *Healthiness* (**Table 21**). However, the fibre-enriched pasta scored significantly ($p<0.05$) higher in the frequency of citation compared with the control sample. Interestingly, this differed from the blind condition, where *Because it is tasty* was more commonly cited for the latter than for the fibre-enriched one. Thereby, information about BSG and its nutritional benefits successfully persuaded consumers into buying the environmentally friendly sample. In addition, *Because it is good for my family* also varied from the blind condition (Chapter I) in the same way as it did with the bread. That is, consumers were willing to buy the pasta owing to its nutritional benefits and compromise on its taste in favour of their family health (Laureati et al., 2016).

On the other hand, none of the reasons against buying the fibre-enriched pasta differed significantly ($p<0.05$) from the regular one. This shows a great degree of similarity between the products signalling its great market potential.

Table 21. *Reasons to buy (a) pasta evaluated with information.*

Reasons for buying	Regular pasta N=58	Fibre-enriched pasta N=75
Because it is healthy *	31.0%	77.3%
Because it is tasty *	86.2%	87.9%
To avoid weight gain	5.2%	12.0%
Because it is high in calories	7.0%	5.4%
Because it is good for my family *	10.3%	16.0%
Because I want to include fibre in my diet *	10.7%	38.6%
Because my kids would like it	3.5%	5.4%

* Indicates significant difference at $p<0.05$.
Relative percentages, where 100% corresponds to the subtotal of consumers buying the pasta (a) or not buying the pasta(b).

7.2.2.2 CATA attributes

Consistently with the results obtained with the blind condition, the BSG sample was more *Natural, Fibrous* and *Coarse* but less *Homogenous* than the regular sample ($p<0.05$). Nonetheless, there was an overall improvement on the perception of the fibre-enriched pasta. Contrary to the blind condition (Chapter I), in this case, the BSG sample was described as equally *Soft, Uniform, Flexible, Gritty, Granulated, Dark* and with *Strange Taste* than the regular sample. It should be noted that all these attributes were previously negatively used to describe the BSG sample. Moreover, four other attributes also differed in their citation frequency with the fibre-enriched sample being described less *Insipid*, *Hard* and with *Lack of Taste*, as well as more *Tasty*. It is clear from these results that information had a positive effect on the perception of this product which supports results obtained for acceptability.

7.2.2.3 Cluster analysis

Cluster analysis results for pasta under both blind (BN) and informed (IN) conditions are shown on **Table 22**.

For each condition, three clusters were identified where most consumers were classified as high users of pasta. Consumers belonging to IN-Cluster 1 (27%) and BN-Cluster 1 (29%) had a similar behaviour and strongly preferred the fibre-enriched pasta ($p<0.05$). Additionally, those belonging to BN-Cluster 3 (36%) and IN-Cluster 2 (24%) also presented a high acceptability for the fibre-enriched sample but so they did with the regular ($p<0.05$). Finally, participants classified as members of BN-Cluster 2 (36%) and IN-Cluster 3 (48%) had a general low acceptability for both samples. Those of the former group preferred the regular pasta, yet its liking was still considerably low. Members of IN-Cluster 3 (48%) simply disliked both samples with no particular preference for anyone. This cluster had a greater proportion of men compared with the other clusters from the informed condition ($p<0.05$). Literature supports this finding as women have been reported to be more interested in healthy habits and environmental issues (Arganini et al., 2012).

Table 22. *Cluster composition according to pasta acceptability for the blind and informed condition.*

	Blind condition (BN)			Informed condition (IN)		
	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 1**	**Cluster 2**	**Cluster 3**
	27%	**36%**	**36%**	**29%**	**24%**	**48%**
I. Age$^{n.s.}$	30.5	29.8	30.5	30.0	27.6	27.1
II. Gender						
Female	13^{A}	22^{A}	18^{A}	24^{A}	20^{A}	25^{B}
Male	19^{A}	21^{A}	25^{A}	5^{A}	4^{A}	23^{B}
III. Product Acceptability						
Regular pasta	5.8^{b}	6.6^{a}	8.0^{a}	5.3^{b}	7.8^{a}	5.7^{a}
Fibre-enriched pasta	8.6^{a}	4.8^{b}	7.7^{a}	8.4^{a}	7.9^{a}	5.3^{a}
IV. Frequency of consumption						
Low users	4	11	3	3	4	1
High users	28	32	40	26	20	47

(II.) Scores not sharing capital letters are significantly different among clusters belonging to same condition (BN or IN) according to chi-square test ($p<0.05$).

(III.) Mean acceptability scores of consumers (Clusters 1–3). Scores not sharing letters within each cluster are significantly different ($p< 0.05$) according to Mann-Whitney test.

(IV.) Frequency of consumption was grouped in: High users (More than once a week) and Low users (Less than once a week).

7.2.2.4 Product-evoked emotions

Consumers' emotional response is represented in **Figure 17** and **Figure 18**. A total of 80.57% of the variability was explained by the dimensions of F1 (60.18%) and F2 (20.38%). The variability of the first dimension (F1) was positively associated with 2 out of the 3 negative emotions (*Worried* and *Disgusted*). F2, on the other hand, was positively correlated with *Active* and *Free*, whereas negatively correlated with *Bored* and *Calm*, representing a measure of the level of stimulation of the participant. As with the bread samples, each product*condition was in a different quadrant and F1 was heavily loaded with the samples evaluated blindly. Informed evaluations were significantly ($p<0.05$) correlated with more positive scores for 18 out of the 25 emotions based on the two-way ANOVA and Tukey post-hoc HSD (Yang et al., 2020). Additionally, it is interesting to note that both the Regular sample under blind condition and the BSG-enriched sample under informed condition were positively correlated with F2. Although the control sample may have attracted consumers' attention due to its popularity (Nocente et al., 2019), BSG-enriched sample may have captured their attention owing to its originality (Pieters, Warlop & Wedel, 2002). Conversely, the other two sample*condition were positively associated with *Boredom* and *Calmness*. This may have been due to the lack of interest in the label of the Regular version or due to the BSG sample being less appetizing and tempting compared to the regular one under the same condition (Lancelot Miltgen, Pantin Sohier & Grohmann, 2016).

Both *Disgust* and *Worry* were more closely correlated with the samples evaluated without information. Feelings of *Disgust* are detrimental to liking scores (Waehrens, Grønbeck, Olsen & Byrne, 2018; Randler, 2017, Gutjar et al., 2015), supporting the positive effect information has on the emotional response.

Results of the two-way ANOVA showed, nonetheless, that the factor BSG enrichment is overall significantly correlated ($p<0.05$) with 8 emotions, including *Boredom* and *Calmness* (**Figure 18**). In addition, likewise with the bread samples, participants felt less *Guilty, Tamer* and *Warmer* when consuming the fibre-enriched sample. A higher degree of positivity was yet detected for the pasta in comparison with the bread, as evidenced by the higher scores for *Joyful, Loving* and *Disgusted*. Overall, the fibre-enriched pasta fostered a receiving and welcoming attitude on consumers towards the BSG-enriched pasta samples.

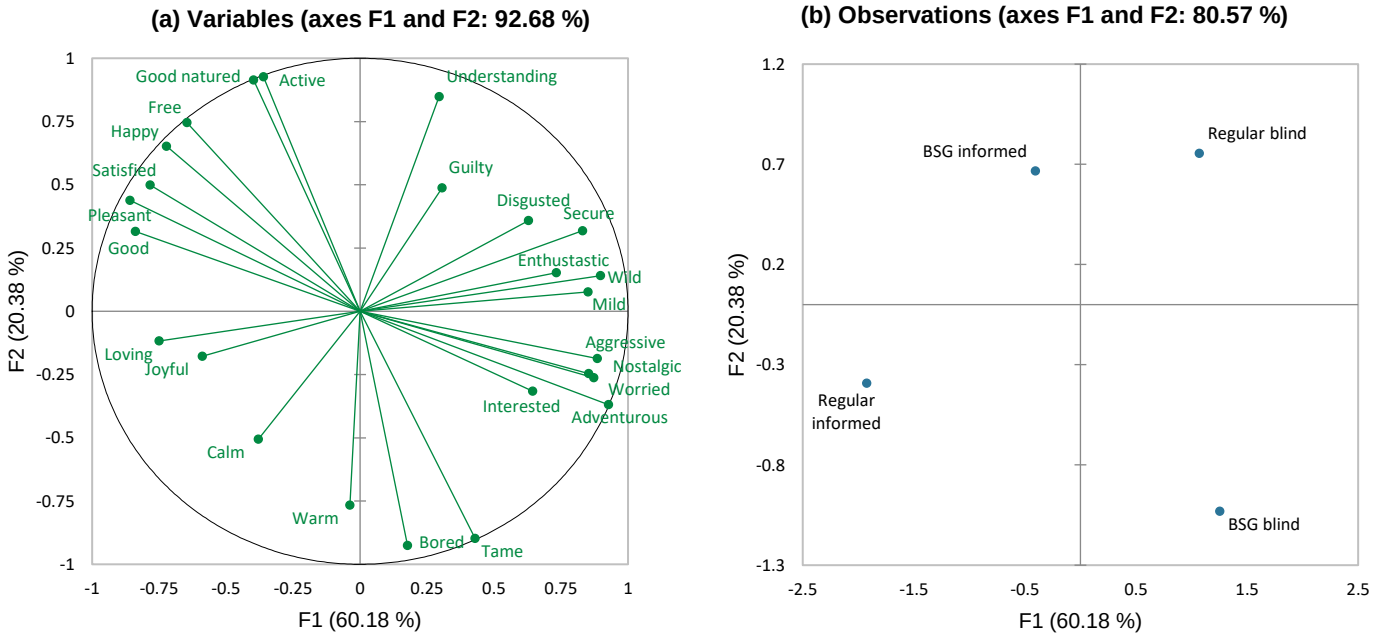
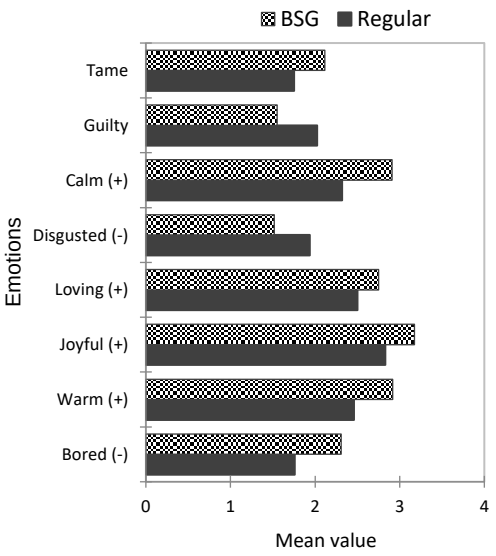


Figure 17. *Graphic representation of multiple factor analysis (MFA). (a) Representation of emotions. (b) Representation of informed and blind condition results obtained for regular and BSG-enriched pasta.*

(a) Factor 1: BSG enrichment



(b) Factor 2: Information

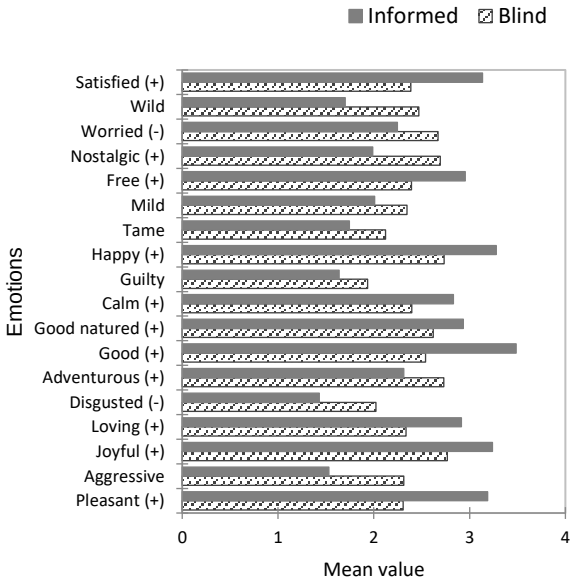


Figure 18. *(a) Results from two-way ANOVA presenting significant difference (p<0.05) related to the effect of BSG enrichment of pasta in emotions. (b) Results from two-way ANOVA presenting significant difference (p<0.05) related to the effect of blind and informed condition in emotions.*

7.2.3. Chocolate milk

7.2.3.1 Acceptability and Purchase intention

In contrast with the results obtained during the blind condition (Chapter I), no significant difference (p<0.05) was obtained between the chocolate milk samples in either acceptability or purchase intention during the informed test (**Table 23**).

However, the fibre-enriched samples did not present significant difference (p<0.05) in acceptability and purchase intention between the blind and the informed testing. Awareness of BSG enrichment in the chocolate milk, nonetheless, seems to have a positive impact on its liking and purchase intention, although slight and insignificant (p<0.05) (Curutchet et al., 2021; Silva et al., 2017). This is in accordance with the results obtained for the fibre-enriched bread. Indeed, in both cases consumers preferred the non-enriched version when no information was provided and had no preference for any of them in the second testing. Overall, there was no significant difference (p<0.05) in the acceptability for the fibre-enriched chocolate milk samples evaluated under blind and informed conditions.

Table 23. *Results of sensory evaluations for Chocolate milk.*

Product	Acceptability	Purchase intention
Blind condition		
Regular Chocolate milk	6.47 ± 1.86[a]	3.55 ± 1.26[a]
Fibre-enriched Chocolate milk	5.68 ± 2.13[b, A]	3.03 ± 1.34[b, A]
Informed condition		
Regular Chocolate milk	6.61 ± 1.73[a]	3.40 ± 1.29[a]
Fibre-enriched Chocolate milk	6.09 ± 2.27[a, A]	3.30 ± 1.37[a, A]

Acceptability and Purchase intention expressed as (mean ± SD). Lower case letters differ in the same column indicate significant differences ($p < 0.05$) according to Student's T-test. Upper case letters differ in the same column to indicate significant differences ($p<0.05$) according to Student-s T-test.

Reasons for buying and not buying the samples during the informed condition are shown in **Figure 19**.

Among reasons for buying the chocolate milk samples during the informed evaluation, the most frequently given reason was due to its *Taste*, with a score of 87% and 98% for the regular and fibre-enriched chocolate milk, respectively. However, contrary to the result obtained during the blind test (Chapter I), no significant difference was detected between them ($p<0.05$), showing the effect of nutritional and/or environmental claims (Biondi & Camanzi, 2019; Sörqvist et al., 2015).

Additionally, just as in the blind condition, the main reason for not buying either sample was due to its taste, this being mentioned by 72% of participants for the fibre-enriched sample and by 56% for the regular one. Nevertheless, that difference was also not significant in this case ($p<0.05$). In addition, the *Healthy* and *Because it is good for my family* reasons presented significant differences in terms of frequency of citation among samples ($p<0.05$). They both were more frequently chosen for the fibre-enriched sample (43% and 11%, respectively) than for the regular chocolate milk (20% and 4%, respectively). It should be noted that during the blind condition no significant difference ($p<0.05$) was detected in either reason between the samples. Thus, information positively influenced the perception of healthiness of this product.

It is highly likely that the sensory characteristics of the chocolate milk (particularly, colour and texture) made it difficult to detect its nutritional advantage easily. This hypothesis is supported with the results of reasons against buying, where the attribute *Because it does not seem healthy* was significantly more selected ($p<0.05$) for the regular chocolate milk than for the fibre-enriched one in the informed test.

It is clear from these results that provision of information increased its marketing potential by creating a "halo" over its nutritional and/or environmental claims and disguising its unpleasant taste (Li & Dando, 2019; Biondi & Camanzi, 2019).

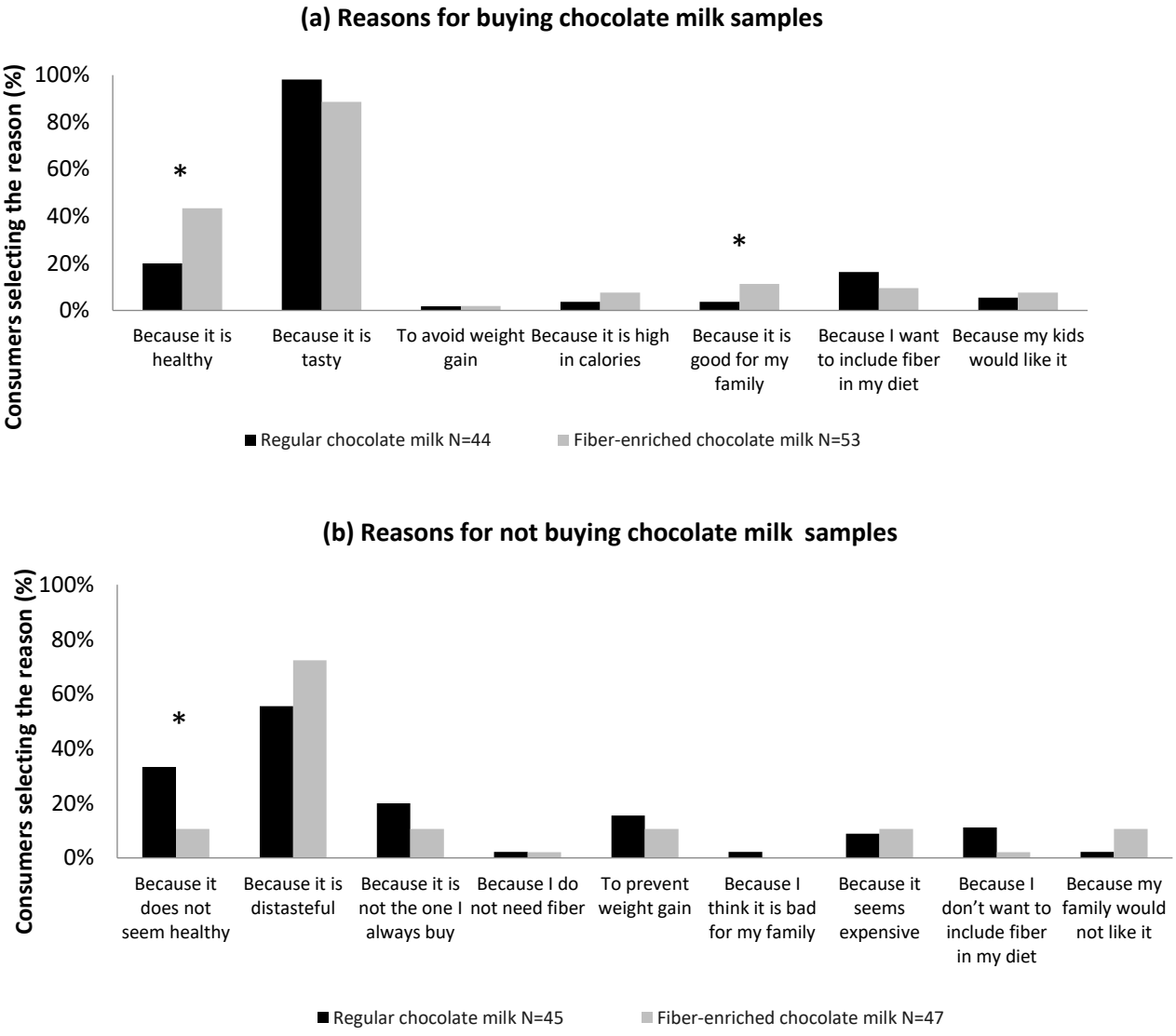


Figure 19. *Reasons to buy (a) or not to buy (b) chocolate milks evaluated with information.*
(*) Indicates significant difference at p<0.05.

7.2.3.2 CATA attributes

The attributes more frequently associated with both chocolate milks were the same as in the blind condition (Chapter I). The *Gritty* attribute was still significantly more frequently mentioned for the fibre-enriched sample (p<0.05), which was selected by 35% of participants as shown in **Table 24**. However, *Unpleasant Aroma*, *Artificial* and *Greasy* showed no significant difference

(p<0.05) in this test. As with the bread evaluations, these attributes have a negative connotation which was eradicated when information about BSG benefits was conveyed.

Additionally, the frequency of mention of the *Creamy* attribute was significantly (p<0.05) higher for the regular chocolate milk during the informed condition (p<0.05). Indeed, *Creamy* had a citation frequency of 48% for the regular sample and of 31% for the fibre-enriched one. This differed from the blind condition, where no difference was found between the samples in this regard.

Smooth and *Strong chocolate flavour* were selected with high frequency for both samples: 47% and 44% of the participants used *Smooth* and *Strong chocolate flavour*, respectively, to describe the fibre-enriched chocolate milk, while 57% and 48% where the frequencies of those attributes for the regular sample.

Table 24. *Frequencies of mention of most selected Check-all-that-apply (CATA) attributes for chocolate milk samples with information.*

Attributes	Fibre-enriched chocolate milk	Regular chocolate milk
Smooth	47%	57%
Strong chocolate flavour	44%	48%
Natural	36%	27%
Gritty *	35%	15%
Creamy *	31%	48%
Strong chocolate aroma	29%	34%
Dark	29%	25%
Unpleasant Aftertaste *	29%	12%

* Indicates significant difference at p<0.05.

7.2.3.3 Cluster analysis

Consumers belonging to BN-Cluster 1 (38%) and IN-Cluster 3 (21%) showed a significant (p<0.05) preference for regular chocolate milk (**Table 25**). High liking scores for fibre-enriched chocolate milk were seen in IN-Cluster 1 (57%) and BN-Cluster 2 (34%). However, no significant (p<0.05) preference was found for this product in these clusters. Likewise, equally low liking scores for both chocolate milks were found in IN-Cluster 2 (22%) and BN-Cluster 3 (28%).

Thus, it seemed that information could not create a clear preference for the fibre-enriched chocolate milk over the regular one. Nonetheless, the number of consumers showing high liking scores for the fibre-enriched chocolate milk increased considerably from 34% (BN-Cluster 2) to

57% (IN-Cluster 1). Although liking scores were considerably high, all clusters had a low percentage of High-users, defined as those who consumed chocolate milk *at least once a week*. Subsequently, chocolate milk could be seen as a hedonic product which would be consumed for the "Feel Good" factor and not so much for its nutritional or environmental benefits (Maina, 2018; Cardello, 1994).

Table 25. *Cluster composition according to chocolate milk acceptability for the blind and informed condition.*

	Blind condition (BN)			**Informed condition (IN)**		
	Cluster 1 38%	**Cluster 2 34%**	**Cluster 3 28%**	**Cluster 1 57%**	**Cluster 2 22%**	**Cluster 3 21%**
I. Age	32	35	25	24.6	23	22
II. Product Acceptability						
Regular chocolate milk	7.3[a]	7.4[a]	4.2[a]	7.4[a]	4.3[a]	7.0[a]
Fibre-enriched chocolate milk	4.7[b]	8.0[a]	4.1[a]	7.6[a]	4.9[a]	3.1[b]
III. Frequency of consumption*						
Low users	34	32	22	53	18	16
High users	8	6	9	4	4	5

Mean acceptability scores of consumers (Clusters 1–3). Scores not sharing letters within each cluster are significantly different ($p < 0.05$) according to Mann-Whitney test.
*Frequency of consumption among clusters under BN and IN condition are non-significant ($p < 0.05$) according to chi-square test.

7.2.3.3 Product-evoked emotions

In accordance with the results obtained for bread, no significant ($p<0.05$) difference was found in the mean scores of the 25 emotions between the fibre-enriched and the regular chocolate milk during the informed condition. This did not occur under blind conditions, where 3 emotions presented significant differences ($p<0.05$) between the samples. One possible explanation to this would be that information increases the variability among observations. However, this was not the case as oppositely variability decreased. It could be thereby hypothesized that information partially buffers the emotions. Further research is needed in order to explore more this subject and draw more conclusions.

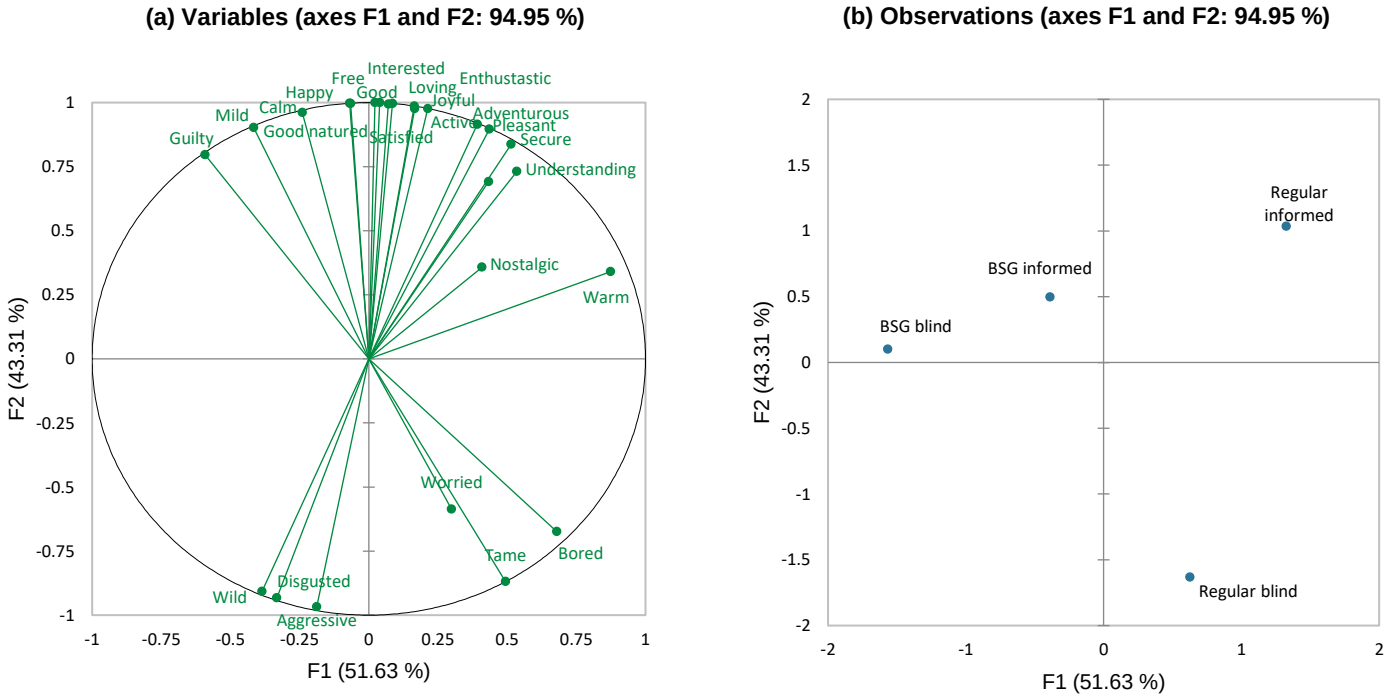


Figure 20. *Graphic representation of multiple factor analysis (MFA). (a) Representation of emotions. (b)Representation of informed and blind condition results obtained for regular and BSG-enriched chocolate milk.*

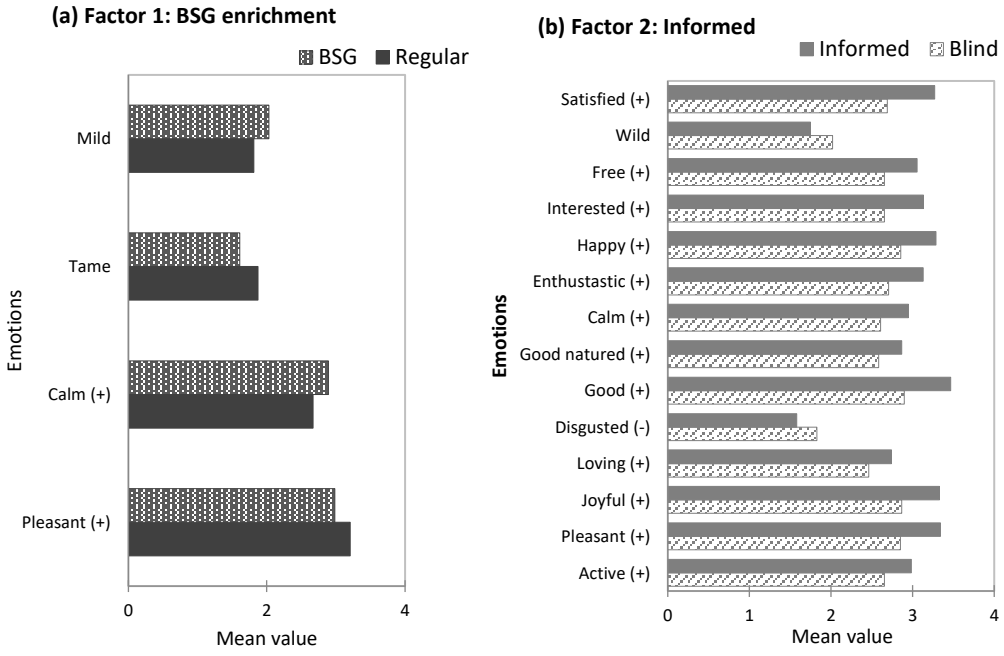


Figure 21. *(a) Results from two-way ANOVA presenting significant difference related to the effect of BSG enrichment of chocolate milk in emotions. (b) Results from two-way ANOVA presenting significant difference related to the effect of blind and informed condition in emotions.*

The graphic representation of the MFA for the chocolate milk samples is shown in **Figure 20**. The two components explained 94.95% of the total variation of the data set. The first dimension (F1) explained 51.63% of the variation and the second dimension (F2) explained 43.31%. It is clear from the correlation circle that the samples evaluated under informed conditions heavily loaded the second dimension, where all positive emotions were situated. Although the effect of information is not as strong for the BSG-enriched sample as for the regular sample, in general it made consumers feel less *Disgusted* and *Wild,* while *Calmer* and more *Comfortable.* Indeed, *Active*, *Pleasant, Joyful, Good, Loving, Enthusiastic, Good nature, Happy, Interested, Free* and *Satisfied* all presented a significant ($p<0.05$) increase in their scores when information was accessible according to results of two-way ANOVA and post-hoc Tukey HSD test (**Figure 21**). Additionally, both BSG-enriched samples correlated negatively with F1 and positively with F2. BSG informed correlated more closely with positive emotions. Indeed, while *Blind BSG* was closer to negative emotions, *Informed BSG* moved clockwise on the plot and drew closer to the positive ones.

Overall, the BSG enrichment made consumers feel *Calmer* and *Milder*, but less *Pleased* and less *Tame* ($p<0.05$) (**Figure 21**). It appears from these results that the fibre-enriched chocolate milk drew a slightly different emotional response in comparison with the bread and pasta. Although consumers also felt *Calmer* when consuming the fibre-enriched bread, only for chocolate milk did consumers feel *less Tame* and *less Pleasant*. Additionally, feelings of *Guilt* were non-significant ($p<0.05$) regarding fibre-enrichment on this product only. Essentially, craving for pleasure can make consumers less *Guilty* (Yu et al., 2020).

Taking all the above into account, together with the fact that most consumers were classified as low-users of chocolate milk, it seems that this one is mostly seen as a hedonic product (Cardello et al., 1994). The emotions elicited portrayed a more negative attitude towards it and consumers overall felt slightly more miserable and less receiving towards it. Additionally, no significant difference ($p<0.05$) was observed in acceptability. This confirms Maehle et al. (2015) findings, who reported that for hedonic products, consumers expect and prioritize the pleasure gleaned from the good taste of food, disregarding the environmental and health-related issues associated with them (Maehle et al., 2015). Such was the case for alcohol-free wine and low-fat chocolate products (Meillon, Urbano, Guillot & Schlich, 2010; Di Monaco, Ollila & Tuorila, 2005; Fernqvist & Ekelund, 2014)

7.3. Comparison of the impact of fibre on the different food categories

When information was provided, consumers continued to respond differently to these products. However, in all cases, information increased ($p<0.05$) consumers preference for the fibre-enriched sample compared with the regular one. Fibre-enriched pasta was distinguished by its significant high scores ($p<0.05$) for acceptability and purchase intention compared with the regular sample, which the other products could not match. Nonetheless, information exerted a "halo" effect on consumers for all products (Li & Dando, 2019; Biondi & Camanzi, 2019). Although consumers may have inferred the fibre-enrichment on the blind condition (Chapter I) and experienced this effect for the bread and pasta, its scope was intensified with the information. Indeed, the nutritional and environmental claims were clearly displayed on the labels which led to these improvements.

The above results were supported by the variations among the attributes used to describe the samples, especially for bread and pasta were all negative attributes ceased to present significant differences ($p<0.05$). Aligned with previous results, the fibre-enriched pasta was the only one described as more *Natural* and *Tast*ier than the regular sample, both factors being of paramount importance during food choices (Maehle et al., 2015; Román, Sánchez-Siles & Siegrist, 2017).

With respect to the emotional response, once again pasta produced the best result. In comparison with the other two products, BSG-enrichment had a significant ($p<0.05$) effect in numerous emotions, resulting in a clearly more positive emotional state. On the opposite side, chocolate milk produced a rather negative emotional response, which may be linked with the relatively rigid expectations of a hedonic product. Finally, bread was in the middle ground, with consumers approving of this product but not as much as of pasta. One possible explanation to this may be the fact that rich-in-fibre wholewheat breads are rather popular in the market, meaning that consumers are aware of alternative options; while fibre-enriched pasta is not as popular at least in Uruguay (Pieters et al., 2002). This is also supported by van Doorn, Risselada and Verhoef (2021) who reported that sustainable products do better in the market when they are innovative. Additionally, it should be noted that the pasta formulation had a significant lower content of BSG compared with the bread (Nocente et al., 2019).

8. Conclusions

Following the findings obtained on Chapter I, BSG-enriched samples were successfully evaluated by consumers under informed conditions. Tests were carried out for each product in order to identify which label captured consumers' attention the most while maximizing their purchase intention. For each label, three categorical two-level factors were studied: (1) sustainability logo or not, (2) brief explanation of BSG benefits to both consumers' and environment or not and (3) BSG appellation: *Malted barley* or *BSG flour*. All 8 resulting labels were analysed through Eye-tracking technology to measure visual attention (*Total time viewed* and *Total Fixations* on the labels and AOI). The most suitable label for all three products included (1) sustainability logo, (2) brief explanation of BSG benefits and (3) *Malted barley* as BSG appellation. The chosen labels were presented to consumers during the sensory evaluation, who evaluated the regular and fibre-enriched samples likewise the blind testing.

Results showed that information was a powerful marketing tool to increase ($p<0.05$) consumers preference for the fibre-enriched sample compared with the regular one. For both bread and chocolate milk samples no difference ($p<0.05$) was found between acceptability and purchase intention. Alternatively, for the pasta, consumers expressed a significant ($p<0.05$) preference in terms of overall liking and purchase intention towards the enriched version. In all three cases, consumers detected changes in sensory properties although they highlighted more positive attributes and less negative ones compared to the blind condition.

Each product had a strong market segment willing to consume it either due to its sustainability claims, originality, perceived healthiness, or combination of these. Indeed, 61% of consumers showed high liking scores for the BSG-enriched bread, 53% for the fibre-enriched pasta and 57% for the chocolate milk enriched sample. Thereby, confirming the existence of a potential market for these products.

Interestingly, the emotional response differed among the products, showing a more favourable attitude towards first the fibre-enriched pasta, then the bread and finally the chocolate milk. Dissimilarities across the evoked emotions were in accordance with the scores given by consumers on acceptability. Additionally, information mitigated the release of emotions and blended the effect of BSG-enrichment on the emotional response.

In summary, BSG-enriched products were more accepted when information was provided, confirming the power of nutritional and sustainability claims, together with the explanation of BSG's origin.

Overall conclusion

BSG is a widely available by-product whose high content in dietary fibre has boosted the search for alternative, more profitable and less squandering ends than cattle feed or waste disposal. This need is intensified when considering that there is a globally fibre deficiency in both developed and underdeveloped countries, which can have detrimental effects in human health.

Three different fibre-enriched functional products were formulated: bread, pasta and chocolate milk. The effect of BSG addition was analysed by sensory evaluations of both control and fibre-enriched samples under blind and informed conditions. Sensory descriptors, emotions, overall acceptability and purchase intention were all evaluated through a questionnaire. The label used for the informed condition was determined through an eye-tacking study which ended up bearing the sustainable claim, nutritional claim, BSG explanation and *Malted Barley* as appellation of BSG. This was seen as the more attractive one and received a high purchase intention score.

BSG-enrichment produced changes in the sensory properties of all three products under both conditions, particularly affecting the texture and flavour in a negative way. The effect that BSG had on the colour and appearance of the fibre-enriched bread and pasta samples, made it easier for consumers to discern the functional properties of these and led to a different emotional response and higher acceptability.

Under informed conditions, the overall liking of the products improved in comparison with control sample. It is unclear which of the following factors or combination of these may have produced this effect: sustainability claim, product originality and/or health claim. In all three products, a clear and promising market segment was identified with high acceptability scores.

A distinct inclination to more positive emotions was identified with consumers feeling more *Satisfied, Pleasant, Good* and *Good-natured* when information was provided.

Additionally, differences in emotional responses between the regular and fibre-enriched products were mitigated when information was present. The emotions generated by the enriched products were in accordance with the scores given for acceptability. A more positive emotional state was detected for pasta, followed by bread and finally the chocolate milk, suggesting that emotional responses are in line with acceptability and give a deeper insight into the food choice process.

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Appendix

Appendix 1 – Product formulation study

Fibre-enriched bread

Fibre-enriched breads are usually associated with reduced specific loaf volume, dark crumb colour and a coarse dense texture (Ortiz, Wang, He & Chen, 2020). One of the main reasons behind these detrimental effects is the gluten-dietary fibre interaction which can be summarized in (I) competitive partial dehydration of gluten and (II) physical interference of gluten (Zhou et al., 2020). The former refers to gluten incapacity to fully extend and develop due to water scarcity. The latter alleges that dietary fibre particles physically disrupt gluten network. As a result, gluten is weakened, and the gas-retention capacity of the dough is reduced.

Initially, the first bread trials were made using a Bread Maker machine and both normal and long-program were investigated using the formulation of Arcia et al., 2018. However, the resulting bread did not have a very perceivable raise in volume and its texture was extremely compact. The same formulation was then made using the Kitchen Aid Professional Bowl-Lift Stand Mixer 5KSM7990X, since its hook attachment could provide a better kneading of the dough than the one in the Bread Maker machine and thus aid to gluten formation.

Additionally, both vegetable oil and BSG were added further along in the kneading - 15 minutes and 20 minutes from the start, respectively. Vegetable oil incorporation was delayed to prevent fat from coating the flour particles which would hamper gluten development.

Fibre-enriched pasta

Pasta formulation was adapted from PHILIPS recipe book for Spelt flour pasta. Liquid content (i.e. water plus egg) was increased from 95g in the original recipe to 105g due to the perceivable heightened water absorption derived from BSG addition. An increase in water absorption has been already reported after BSG addition owing to the greater number of hydroxyl group which exists in the fibre structure and result in increased hydrogen bonding with water molecules (Haruna, Udobi, & Ndife, 2011). No further modifications were made to the formulation.

Fibre-enriched chocolate milk

As previously stated, chocolate milk base formulation was inspired by the leader chocolate milk brand in Uruguay. The amount of BSG flour added to reach the *Source of Dietary Fibre* claim -

0.35% - was relatively low compared to the ones of the other two products due to cacao powder being already naturally high in fibre.

Nonetheless, a few pressing problems arose from BSG addition to milk. Probably the most pressing one was the gritty sensation caused by the insolubility of BSG particles. BSG sedimentation and its characteristic strong aroma were also issues comprising its sensory acceptability.

Unpleasant aroma has already been reported as a limiting factor in incorporating BSG into foods (Fărcaş et al., 2017) and thus, two different chocolate flavouring powders, from different brands (*Givaudan and Duas Rodas*) were added as attempts to disguise it. *Givaudan* flavouring was preferred over *Duas Rodas* as a more intense and less artificial chocolate flavour was imparted.

In fibre-enriched chocolate milk, grittiness was rooted in the large amount of both water-insoluble dietary fibre (hemicellulose, lignin and cellulose) and proteins (mainly hordeins and glutenin) present in BSG (Ikram, Zhang, Wang & Yin, 2017). Contrary to soluble fibre, insoluble fibre has been reported to dominate the mouthfeel perception when added to beverages and make them unpalatable (Chakraborty et al, 2019). To reduce the grittiness, dryness and roughness perceived from this product, a smaller particle size was used, as suggested by Santagiuliana et al. (2020). BSG was milled using a 0.25mm mesh, resulting in a particle size relatively larger than the detection thresholds of cellulose particles of 52µm and 86µm for viscous, low-fat quark and semi-solid, high-fat processed cheese (Santagiuliana et al., 2018). Nonetheless, it should be noted that detection thresholds depend on a multiplicity of factors, including the food matrix, particle fracture stress, size, concentration and morphology (Santagiuliana et al., 2018; Santagiuliana et al., 2019b; Liu et al., 2016; López et al., 2016).

Finally, to prevent BSG from settling to the bottom of the jar, Carrageenan and CMC were used to increase liquid phase viscosity. This may also aid with the mouthfeel perception as a higher viscosity of the medium has been reported to decrease detectability of embedded particles (Santagiuliana et al., 2019b).

Appendix 2– Effects of BSG in bread volume

Although no formal measure was carried out, a rough approximation was calculated based on the midsection cut area, the loaf pans dimensions and weight of loaf breads (**Figure 22**). This was only done for comparison purposes between the two types of breads and it is not aligned with the results obtained in other studies which reported specific volume reductions of around 10% (Amoriello et al., 2020; Stojceska, 2011) with similar BSG addition. In this case fibre-enriched bread had a specific volume reduction of 27%.

In view of maximizing loaf volume, alternatives include: the use of enzymes (Stojceska, 2011), the use of BSG flour with smaller particle size (Zhou et al., 2021), the addition of sourdough starter and the use of food additives such as xanthic gum (Stojceska & Ainsworth, 2008).

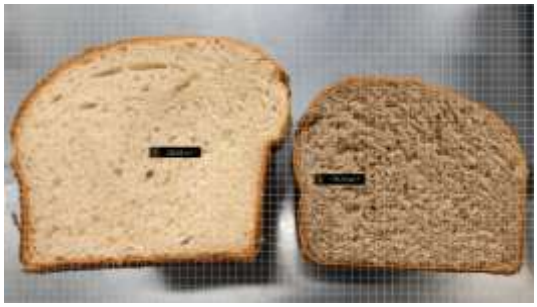

Figure 22 *Left: Midsection cut of Regular Bread with total surface area of 228.03cm^2; Right: Midsection cut of Fibre-enriched Bread with total surface area of 170.14 cm^2.*