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RECEIVED 04 September 2024

ACCEPTED 07 February 2025

PUBLISHED 03 March 2025

## CITATION

Souza A, Arias E, Arellano V, Macarin G, Vargha S and Raggio LM (2025) Revaluation of a beer industry by-product towards the development of a sustainable product: beer by-product pasta. *Front. Food. Sci. Technol.* 5:1491253. doi: 10.3389/frfst.2025.1491253

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# Revaluation of a beer industry by-product towards the development of a sustainable product: beer by-product pasta

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Brewer's Spent Grain (BSG), a byproduct of the brewing industry, presents environmental and economic challenges due to food waste. Animal feed is its primary use, but its high dietary fiber (DF) and protein content make it suitable for human consumption. BSG contains 30%–70% DF and 19%–36% protein, with essential amino acids, particularly lysine, which is scarce in cereals, making it a valuable ingredient for products like pasta and baked goods. Recent consumer trends favor foods rich in fiber and protein, aligning with increasing awareness of health benefits associated with dietary fiber. Fiber contributes to improved intestinal transit, reduced risk of cardiovascular diseases, and lower incidence of type II diabetes, among other health benefits. Additionally, for every extra 10 g of DF consumed daily, mortality risk decreases by 17%–35%. A study conducted in Uruguay in mid-2023 through an online survey with 851 participants aimed to assess interest in BSG-enriched products. Results showed 86% of respondents were willing to purchase such products, while those opposed expressed concerns about potential unpleasant taste. Participants were categorized into three groups based on their prioritization of nutritional content, fiber, and protein when making purchase decisions. Age was the most significant factor influencing the importance assigned to these nutritional components, with older individuals placing higher importance on fiber and protein content. Overall, the study indicates a favorable public interest in BSG-enriched foods, especially considering their nutritional benefits and affordability. Incorporating BSG into food products like pasta could leverage its nutritional advantages and appeal to consumers seeking healthier options.

## KEYWORDS

beer industry by-product, protein content, pasta, consumers, healthy options

## 1 Introduction

Brewer's Spent Grain (BSG) is a byproduct of the brewing industry, one of the largest industries worldwide (Farcas et al., 2021), which can cause problems due to food waste and losses, leading to significant environmental and economic impacts. The primary use of BSG is for animal feed (Farcas et al., 2021), but it would be of great interest to upcycle it and include it in foods intended for human consumption because BSG has a high dietary fiber (DF) and protein content, making it nutritionally appealing (Amoriello et al., 2020; Combest and Warren, 2019; Crofton and Scannell, 2020; Mussatto et al., 2006; Mussatto, 2014).

Beer ranks fifth in world drink consumption (Farcas et al., 2021). According to reports, the world's annual beer production is 190 billion liters, and considering that for every 100 L of beer, about 20 kg of BSG is produced, an estimated production of about 39 million tons of BSG per year is estimated (Cuomo et al., 2022).

Several factors limit the reuse of BSG in the food industry, such as microbiological instability due to high humidity (70%–80%), which makes it susceptible to microbial deterioration and makes it difficult to transfer this resource to other processing sites, as well as the presence of fermentable sugars and poor technological and sensory characteristics (uifra.org, 2023; Schettino et al., 2021). The attributes that usually affect the sensory quality of pasta with added BSG, compared to wheat pasta without added BSG, are related to aesthetic appearance, homogeneity of texture, firmness, stickiness, uniformity of color, roughness and chewiness as technological parameters, which results, due to its characteristics, in values of greater hardness and roughness, less chewiness, lower luminosity and dark color (Schettino et al., 2021; Nocente et al., 2019). For these reasons, so far, the main use of BSG has been as animal feed and partly as fertilizer (Nocente et al., 2021). However, its production exceeding demand results in waste for the brewery industry, requiring treatment methods that prevent negative environmental impacts during its final disposal (Talmón et al., 2022).

This strategy is aligned with the new concept that has emerged in the last years of Circular Economy, which has as one of its premises the recovery of materials so that they can enter new production processes and get back to consumption (Arcia Cabrera et al., 2018).

Health-conscious consumers are increasingly looking for products with health-promoting compounds, driving a rising interest in those rich in fiber and protein. The food industry is in the process of designing products to meet these need (Czubaszek et al., 2021).

BSG contains appreciable levels of minerals, polyphenols, vitamins, and lipids (Schettino et al., 2021). Among the minerals, the most abundant are silicon, phosphorus, calcium and magnesium, also containing sodium, potassium, manganese, iron and sulfur (Nocente et al., 2021; Naibaho and Korzeniowska, 2021; Waters et al., 2012). Regarding vitamins and antioxidant compounds, it contains biotin, choline, folic acid, niacin, pantothenic acid and riboflavin; tocopherols and phenolic acids, whose anticancer and antiapoptotic properties have been recognized (Nocente et al., 2021). According to the literature, the range of DF can vary between 30% and 70% of the BSG's dry weight, while proteins can constitute between 19% and 36%, with a good contribution of essential amino acids (around 30% of the total protein content) (Czubaszek et al., 2022; Ginindza et al., 2022; Lynch et al., 2016; Ikram et al., 2017; Torbica et al., 2019). The main essential amino acid in BSG is lysine, which is usually limited in cereals, making BSG an ideal complementary ingredient for products like pasta or baked goods (Farcas et al., 2021; Czubaszek et al., 2022).

It's important to consider that this type of product has gained ground in recent years, primarily due to its association with the reduction of non-communicable chronic diseases (NCDs) (Lattimer and Haub, 2010). The development of new product designs that meet nutritional needs could bring significant benefits related to reducing NCDs and better meeting the nutritional requirements of individuals needing special diets. Among the various effects of DF

are those that promote intestinal transit (increased water retention and reduced colonic pressure), helping combat constipation; protective effects against cardiovascular diseases due to a reduction in LDL cholesterol; reduced synthesis of carcinogens and decreased contact of the intestinal mucosa with toxic substances, reducing the risk of colorectal cancer; prevention of type II diabetes due to reduced postprandial hyperglycemia and lower glucose absorption; and factors that help prevent overweight and obesity (primarily through increased satiety) (Almeida-Alvarado et al., 2014; Vilcanqui-pérez and Vélchez-perales, 2017; Jones, 2014). It's worth noting that for every additional 10 g of DF in the diet, the risk of mortality is reduced by 17%–35% (Lattimer and Haub, 2010).

An alternative food product, which is likely to be enriched with DF by the industry, is the food pasta (Nocente et al., 2019), which is among the most consumed foods worldwide, is part of the Mediterranean diet, and has a high level of acceptability regardless of the social class to which the consumer belongs (Gerardi et al., 2023). Pasta's global acceptance can be attributed to its affordability, versatility, long shelf life, sensory appeal, and nutritional value. This makes pasta a viable and effective vehicle to increase consumption of DF in the population, with various formulations developed to enhance its nutritional properties (Ginindza et al., 2022).

## 2 Materials and methods

A quantitative descriptive exploratory study was carried out to evaluate the perception and appreciation of a food product (pasta) with added BSG and the differential nutritional content of fiber and protein. This study is descriptive, as it was intended to provide information and characterize the study variables.

As for the sampling, the study population was comprised of 851 people (N) resident in Uruguay, over 20 years of age, regular consumers of pasta. Only those individuals who expressed willingness to purchase the product with BSG added were selected, thus obtaining a new study population of 734 people (N1). For the selection of the sample, non-probability sampling was used for convenience.

The method chosen for the data collection was an online voluntary participation survey through the virtual platform SurveyMonkey, the technique being the self-administered questionnaire and the instrument the form.

Variables were described using absolute and relative percentage frequency tables for the target population (N) categorized by age group, gender, educational level achieved, and income level perceived.

The study examined the following relationships between variables and the intention to purchase a BSG-added food product, using graphs and tables:

- Importance of the fiber content of a food product at the time of purchase and intention of purchase of a BSG-added food product.
- Importance of the protein content of a food product at the time of purchase and intention of purchase of a BSG-added food product.

- Importance of the sustainability of a food product at the time of purchase and intention of purchase of a BSG-added food product.
- Age range and intention of purchase of a BSG-added food product.
- Gender and intention of purchase of a BSG-added food product.
- Educational level and intention to buy a BSG-added food product.
- Perceived income level and intention to purchase a BSG-added food product.

The statistical relationship between the variable “intention of purchase of a BSG-added food product” and the variables “importance of the fiber content of a food product at the time of purchase” and “intention of the protein content of a food product when purchasing” was studied by means of the Chi square statistical test, which allows to test independence and association between variables.

The ordinary qualitative variables “Importance of the sustainability of a food product at the time of purchase,” “Incidence of the fiber content of a food item at the moment of purchase,” and “Impact of the protein content of the food product when purchasing” were measured on a 5-point Likert scale, and then a group separation was carried out by applying clusters, N1, in 3 groups, using a Hierarchical Conglomerate Analysis (HAC), with Euclidean distance and Ward agglomeration method for all questionnaire responses.

Through the Shapiro-Wilks normality test, it was verified that the population willing to buy a sustainable product with BSG added does not follow a normal distribution. Once the groups were separated, the Mann-Whitney U test was applied. Relationships between clusters and variables were studied by means of the statistical test Chi square, using graphs and tables.

In all cases, a statistical significance with a probability of  $p < 0.05$  was established. The analyses were performed using XLSTAT 2021.2.2 and Jamovi 2.4.8 software.

## 3 Results

### 3.1 General characterization of the surveyed population

The study population, comprising 851 (N) individuals, was characterized by gender, age group, educational level achieved, and level of income perceived, as detailed below in [Table 1](#).

Of the total surveyed population (N = 851), 13.7% said they would not buy a BSG-added food product. The main reason was the belief that the flavor would not be pleasant (33.3%), followed by the link of the product with the brewery industry (19.7%), the belief that it would be a high-cost product (15.4%), the fact that it is an unconventional product (12.8%), and its origin as a by-product of the industry (10.3%) ([Figure 1](#)).

The option “other reasons” for which they would not buy the product (8.5%) highlights the lack of knowledge about the product and its contributions, as well as a mistrust regarding the process of obtaining the BSG and its suitability for human consumption.

TABLE 1 Characterization of the surveyed general population.

| Variable   | Total and Percentage |
|--|----------------------|
| Age  |                      |
| Between 20 and 34 years old  | 453 (53%)            |
| Between 35 and 44 years old  | 269 (32%)            |
| Over 55 years old  | 129 (15%)            |
| Gender   |                      |
| Female   | 656 (77%)            |
| Male   | 195 (23%)            |
| Level of education   |                      |
| Level 1 (Primary and Secondary Education)                                | 195 (23%)            |
| Level 2 (Incomplete University, Technical Career Students and Graduates) | 402 (47%)            |
| Level 3 (University Professionals)                                       | 254 (30%)            |
| Socioeconomic level  |                      |
| First quintile   | 168 (20%)            |
| Second quintile  | 141 (16%)            |
| Third quintile   | 180 (21%)            |
| Fourth quintile  | 235 (28%)            |
| Fifth quintile   | 127 (15%)            |

### 3.2 Characterization of the population willing to buy a food product with BSG added

Among the 851 individuals surveyed, 86% (N1 = 734) expressed a willingness to purchase a food product with added BSG. The respondents were categorized based on gender, age group, educational level, and perceived income, as detailed in [Table 2](#).

Through the clusterization process (application of ACJ), it was sought to group comparable variables among themselves, both in their logic and in their scales, trying to maximize homogeneity. Three clusters (groups with similar response patterns, different from each other) were identified with statistically significant differences in the levels of importance that, on a 5-point Likert scale, attribute to the fiber content, protein content, and sustainability of a food product at the time of purchase.

The Shapiro-Wilks normality test confirmed that the population willing to purchase a sustainable product with added BSG does not follow a normal distribution.

As a non-parametric distribution, the Mann-Whitney U statistical test was used for qualitative variables with ordinary scales, which allowed the statistically significant differences mentioned ( $p < 0.05$ ) to be tested using the medians of each variable in question.

The three identified clusters are mostly made up of people aged 20 to 34. Within the above-mentioned age group, a greater proportion of people are concentrated in cluster 2, while within

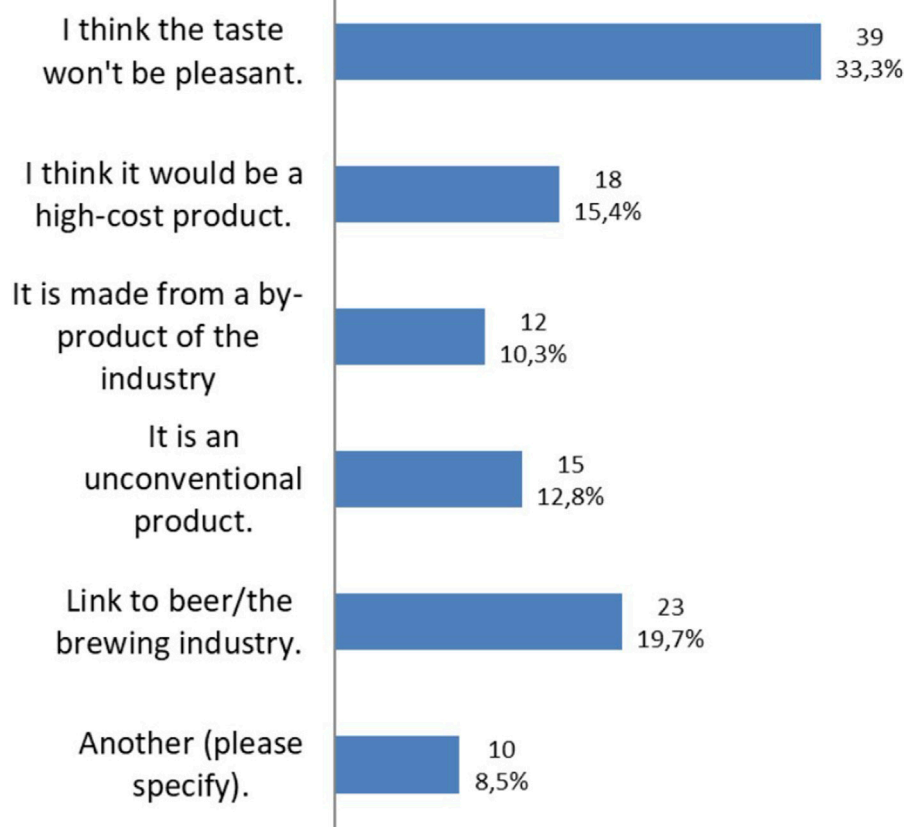


FIGURE 1  
Reasons why a food product with added BSG would not be purchased.

the age group of 35 years and upward, a higher proportion are concentrated in cluster 1 (Figure 2).

For the three variables ("Importance of the fiber content of a food product at the time of purchase," "Importance of the protein content of a food product when purchasing," "Importance of the sustainability of a food at the moment of purchase"), in cluster 1 the mean values are between 4 and 5; for cluster 2, between 3 and 4; and for cluster 3, between 2 and 3 (Table 3).

### 3.3 Relation between the socio-demographic variables of the population with intention to buy and the importance given to sustainability at the time of purchase

People from the age group of 20–54 years mostly rated the importance of sustainability of a food product at the time of purchase (51.3%) as a 4 on a 5-point scale, whereas among people aged 55 years or older a higher percentage is observed giving a value of 5 (50%). A statistically significant relationship was observed between the age range and the importance given to sustainability ( $p < 0.05$ ).

Among women, 46.2% gave sustainability a value of 4, followed by the value 5 with 23.7% of this gender. For men, 41% gave the

value of 4 to sustainability, followed by a 30.6% rating it as 3. A statistically significant relationship was found between gender and the importance given to sustainability ( $p < 0.05$ ).

Regarding the level of perceived income, within all quintiles there is a higher percentage of people giving a value of 4 to the importance of the sustainability of a food product (between 39% and 52%). The highest percentages are seen in quintiles 4 and 5. There is a statistically significant relationship between the level of perceived income and the importance given to sustainability ( $p < 0.05$ ).

### 3.4 Relation between the age range and the importance given to the sustainability, fiber, and protein content of a food product at the time of purchase

The age range from 20 to 54 years concentrates a higher percentage of ratings of 4 to the importance of protein content of a food product at the time of purchase, while the age range of 55 years or older concentrates a higher proportion of people granting a number of 5, within the 5-point scale. There is a statistically significant relationship between the age range and the level of importance given to protein content (Table 4).

As for the fiber content, the age range between 20 and 25 years concentrates a higher percentage of people giving a value of 3 to their

TABLE 2 Characterization of the population willing to buy a food product with added BSG.

| Variable   | Total and Percentage |
|--|----------------------|
| Age  |                      |
| Between 20 and 34 years old  | 396 (54%)            |
| Between 35 and 44 years old  | 232 (32%)            |
| Over 55 years old  | 106 (14%)            |
| Género   |                      |
| Female   | 561 (76%)            |
| Male   | 173 (24%)            |
| Nivel educativo alcanzado  |                      |
| Level 1 (Primary and Secondary Education)                                | 164 (22%)            |
| Level 2 (Incomplete University, Technical Career Students and Graduates) | 354 (48%)            |
| Level 3 (University Professionals)                                       | 216 (30%)            |
| Socioeconomic level  |                      |
| First quintile   | 150 (20%)            |
| Second quintile  | 121 (17%)            |
| Third quintile   | 156 (21%)            |
| Fourth quintile  | 196 (27%)            |
| Fifth quintile   | 111 (15%)            |

importance, the 26–54 years concentrate a higher percent of people granting a number of 4, and the 55 years or older range concentrates a higher proportion of people awarding a score of 5 within the 5-point scale. There is a statistically significant relationship between the age range and the level of importance given to the fiber content (Table 4).

### 3.5 Analysis of statistical relationships between purchasing factors and food preferences

No statistically significant relationship was found between the intention to purchase a BSG-added food product and the importance of the sustainability of a food product at the time of purchase ( $p > 0.05$ ).

Similarly, no statistically significant relationships were found between the importance given to protein or fiber content in a food product and the variables gender, educational level achieved, or income level.

Finally, no significant relationship was found between the intention to purchase a BSG-added food product and the importance given to fiber and protein content ( $p > 0.05$ ). Additionally, no statistically significant relationship was found between educational level and the importance attached to sustainability ( $p > 0.05$ ).

## 4 Discussion

The primary objective of this study was to assess the intention to purchase pasta incorporating Brewer's Spent Grain, focusing on its nutritional composition (fiber and protein) and its contribution to sustainability within the Uruguayan adult population.

The aim was to characterize the population with an explicit intention to purchase, in order to determine whether the distinctive features of the product (sustainability, fiber source, protein source) are the main determining factors. It was also sought to determine whether the intention to purchase the product was significantly influenced by the distinctive features mentioned or whether it could be due to external factors not addressed in this paper.

From the characterization of the population with the intention to buy, a sample is found consisting mostly of women, young people, university students, and graduated university professionals. Income levels are distributed evenly.

This study found that a significant majority of the surveyed population (86%) expressed a willingness to purchase the product, while only 24% indicated not being interested. The observed purchase intention ranged from 80% to 88% across all age groups, from 84% to 88% among individuals with various educational levels, and from 83% to 89% among those at different income levels. Additionally, 85.5% of women and 88.7% of men expressed intention to buy the product. These findings indicate no significant correlation between socio-demographic factors and the intention to purchase. Sousa et al. (2021), in their research, also concludes that the appreciation of by-products was positive; participants perceived them as natural, healthy, stimulating, safe, and environmentally friendly, despite considering them modern and little known. However, in the same study, people were found with a general lack of knowledge of food by-products and with a negative perception, considering them cheap, common, with a possibly unpleasant taste, of lower quality, and a direct association with waste from industry (Sousa et al., 2021). This is correlated with the results of the present investigation, as people who would not buy the product expressed that its taste would be unpleasant, associated it negatively with the brewery industry, with being a waste of the industry, and believed that it would be a high-cost, unknown, unconventional, and suspicious product.

If we look at the importance of the sustainability of a food product, it is older people (55 years of age or older) who give it the highest proportion of importance. The results of this study agree with Moraes Prata Gaspar et al. (2022), who found an association between the importance attached to sustainability and age and came to realize that older people (55 years and older) are more influenced by sustainable and health factors than younger people. Furthermore, it is possible that they have a more nuanced understanding of the significance of their actions concerning environmental impact.

With regard to gender, women tend to attach higher values to the importance of the sustainability of a food product than men. These results were also seen in several studies that have demonstrated greater concern in this group for environmental issues, as well as a greater level of knowledge and interest in sustainable consumption (García-González et al., 2020; Panzone et al., 2016; Grasso and Asioli, 2016; Lee, 2008). However, it should be noted that Moraes Prata Gaspar et al. (2022) stated that their



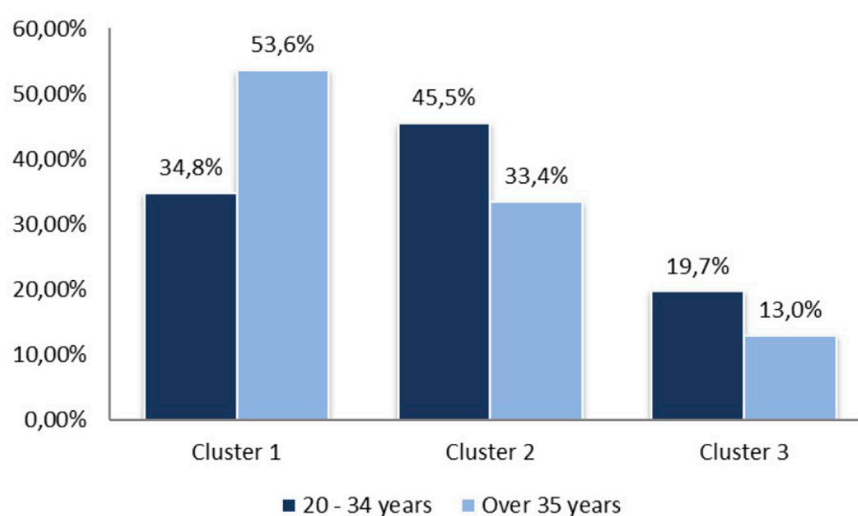


FIGURE 2  
Distribution of age groups in clusters.

TABLE 3 Mean responses in each cluster for the importance of fiber, protein, and sustainability of a food product.

|              | Importance of dietary fiber content# | Importance of protein content# | Importance of sustainability# |
|--------------|--------------------------------------|--------------------------------|-------------------------------|
| Cluster 1    | 4.4                                  | 4.6                            | 4.3                           |
| Cluster 2    | 3.7                                  | 3.7                            | 3.5                           |
| Cluster 3    | 2.1                                  | 2.6                            | 2.7                           |
| Mann-Whitney | $p < 0,0001^*$                       | $p < 0,0001^*$                 | $p < 0,0001^*$                |

On a scale of 1–5, where 1 = not important at all, and 5 = very important.

\*Significant at the 0.05 level.

studies did not reveal statistically significant relationships between gender and factors influencing food choices.

Within the perceived income levels, there was a tendency in the categories of people belonging to larger quintiles to value sustainability more, and no studies were found to counter this. Nor was there a link between the importance attached to the sustainability of a food product and the level of education. In other studies, some researchers (Akehurst et al., 2012) did not identify a statistically significant relationship, while others (Roberts, 1996; Zhao et al., 2014) pointed to greater ecologically conscious behavior as well as social and environmental responsibility in people with a higher educational level.

In the analysis of the valuation of the importance of the fiber and protein content of a food product, it is observed that at larger age ranges, a greater proportion of people within their category value more positively the presence of these components. Bautista (2022) investigated in a population the socio-demographic characteristics and determining factors that influence the choice and consumption of food, resulting in older people giving more importance to the nutritional content in the choice of consume since they are the ones who take the most care of their health and their body weight.

There is no statistically significant relationship between gender, educational level achieved, income level perceived, and the importance accorded to the presence of fiber and protein in food. This could be explained by the composition of the sample that

responded to the survey, with most people with a middle-to-high educational level and an income level that allows them to meet their basic needs, as well as the nutritional content of the foods they choose to consume. Roos (Roos et al., 1996) in his research, unlike the present work, said that both income level and educational level directly influence the ability to understand and evaluate nutritional content and to develop positive behaviors towards the adoption of healthy eating habits. For their part, Bautista (2022) found a relationship between gender and importance towards various nutritional components, explained by the greater inclination that women have to value the factors “health, nutritional value, and natural content” when choosing foods, as well as to look at labels.

It was also sought to determine the influence of sustainability as well as differential nutritional components (being a source of fiber and protein) on the intention of buying pasta with the incorporation of BSG. Despite the high willingness to buy the BSG-enriched pasta, no statistically significant relationship were found between purchase intention and its sustainability, fiber, or protein content, as well as between the intent to buy and the sociodemographic variables of the population, which inexorably leads to the idea that there are other external factors that motivate it. It should be noted that the present study investigated the purchase of a specific product, such as pasta. The inclusion of other specific products or generic food could be considered in future studies to further discuss these relationships.

TABLE 4 Relationship between age range and the importance given to the variables “sustainability of a food product at the time of purchase,” “fiber content of a food product at the time of purchase,” and “protein content of a food product at the time of purchase.”

| Relationship between sociodemographic variables and the importance given to |     |      |      |      |      |         |
|---|-----|------|------|------|------|---------|
| Sustainability of a food product at the time of purchase                    |     |      |      |      |      |         |
|   | 1   | 2    | 3    | 4    | 5*   |         |
| Age range   | %   | %    | %    | %    | %    | % Total |
| 20–25 years   | 8.5 | 10.6 | 29.6 | 42.3 | 9.0  | 100     |
| 26–34 years   | 5.3 | 7.7  | 22.2 | 46.9 | 17.9 | 100     |
| 35–44 years   | 2.9 | 7.2  | 18.8 | 54.4 | 16.7 | 100     |
| 45–54 years   | 3.2 | 6.4  | 16.9 | 42.6 | 30.9 | 100     |
| 55–64 years   | 1.3 | 2.6  | 11.6 | 39.0 | 45.5 | 100     |
| Over 65 years   | 3.4 | 0.0  | 6.9  | 27.6 | 62.1 | 100     |
| Fiber content of a food product at the time of purchase                     |     |      |      |      |      |         |
|   | 1   | 2    | 3    | 4    | 5*   |         |
| Age range   | %   | %    | %    | %    | %    | % Total |
| 20–25 years   | 9.0 | 7.4  | 35.5 | 34.9 | 13.2 | 100     |
| 26–34 years   | 5.3 | 7.7  | 22.2 | 46.9 | 17.9 | 100     |
| 35–44 years   | 2.9 | 7.2  | 18.8 | 54.4 | 16.7 | 100     |
| 45–54 years   | 3.2 | 6.4  | 16.9 | 42.6 | 30.9 | 100     |
| 55–64 years   | 1.3 | 2.6  | 11.6 | 39.0 | 45.5 | 100     |
| Over 65 years   | 3.4 | 0.0  | 6.9  | 27.6 | 62.1 | 100     |
| Protein content of a food product at the time of purchase                   |     |      |      |      |      |         |
|   | 1   | 2    | 3    | 4    | 5*   |         |
| Age range   | %   | %    | %    | %    | %    | % Total |
| 20–25 years   | 3.7 | 5.8  | 26.5 | 35.4 | 28.6 | 100     |
| 26–34 years   | 2.9 | 3.4  | 27.5 | 41.6 | 24.6 | 100     |
| 35–44 years   | 3.6 | 2.2  | 23.9 | 45.7 | 24.6 | 100     |
| 45–54 years   | 2.1 | 4.3  | 19.1 | 38.3 | 36.2 | 100     |
| 55–64 years   | 1.3 | 1.3  | 12.9 | 35.1 | 49.4 | 100     |
| Over 65 years   | 6.9 | 6.9  | 6.9  | 20.7 | 58.6 | 100     |

Bianchi et al. (2013) state that consuming is not a neutral act and that every time the consumer buys, it does so by following a series of conscious and unconscious criteria that have been very elaborate until the time the product reaches their hands, whereas Furman et al. (2020) argue that consumer decisions are closely linked to the lifestyle of consumers and that simple analyses related to their sociodemographic characteristics are not sufficient to clarify the various dimensions of the lifestyle and, therefore, require additional research of values, motivational factors, personality traits, behaviors, habits, and identification of sociocultural relationships.

## 5 Limitations

One of the limitations identified in this study is the design of the instrument (form), which may have included questions that were conceptually difficult for the surveyed population to understand. Questions more directly related to the objectives raised could have been included in order to produce more conclusive results.

With regard to the answers obtained, Groves et al. (2000) have demonstrated that the relevance of the survey topic influences the response rate, which could be one of the reasons why not all people

completed the form. Goyder (Goyder, 1986) states that there is a relationship between the probability that an individual will not respond to the survey and the means of contact, with the most effective method of obtaining answers being direct contact between respondent and interviewer. Furthermore, McMahon et al. (2003) and others (Solomon, 2000; Couper, 2001; Leeuw and Heer, 2002; Survey, 2000) have agreed that response rates tend to be lower for online surveys compared to traditional surveys. With this in mind, the online method could be complemented by traditional surveys. This could enable a greater number and representativity of respondents based on their sociodemographic characteristics to achieve the desired sampling heterogeneity. It should be noted that the time and resources allocated in that case would be greater, which was considered in the selection of the method of dissemination and its channels in the present study.

In a study by researchers Singer et al. (2000), it is noted, as in the present study, that higher levels of education have a positive link with cooperation with surveys and also that monetary incentives significantly increase such cooperation in terms of response rate, as well as reduction in desertion. However, in this study no remuneration or any other incentive was offered for completing the survey form, which could have influenced the response rate obtained.

As for the clusters, they were formed from the responses to three variables, and moreover, because the average obtained for their formation is a punctual estimate, it is not statistically possible to state that one category of a sociodemographic variable attaches more importance than another of the same variable to the sustainability, the fiber content, or the protein content of a food product at the time of purchase. Clusters were used to characterize the potential consumer population of the product, given the statistical significance found, but do not provide broader inferences beyond those highlighted.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by Ethics Committee of the School of Nutrition, Universidad de la República with a letter numbered No 8218936 – 21/June/2023. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

AS: Formal Analysis, Methodology, Writing–review and editing, Conceptualization, Investigation. EA: Formal Analysis, Investigation, Methodology, Writing–review and editing. VA: Formal Analysis, Investigation, Writing–original draft. GM: Formal Analysis, Investigation, Writing–original draft, Methodology. SV: Formal Analysis, Investigation, Methodology, Conceptualization, Writing–review and editing. LR: Formal

Analysis, Methodology, Writing–review and editing, Funding acquisition, Supervision.

## Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research work was funded through the grant of Investigator Laura Ma Raggio Grade 3 of PEDECIBA-Chemistry (MEC-Universidad de la República).

## Acknowledgments

We would like to thank the people who participated in the survey by completing the questionnaire. The results presented were obtained within the framework of the thesis of completion of the degree to obtain the degree of Bachelor in Nutrition from the University of the Republic. The research was conducted at the School of Nutrition of the University of the Republic.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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