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Article

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EMERGING TRENDS IN CONSUMER PREFERENCES LEVERAGING PRODUCTS DERIVED FROM FOOD INDUSTRY BY-PRODUCTS

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Abstract

This study explores market opportunities for sustainable products, using functional wafers with added malt-used grains, a by-product of the fermentation industry, as a case study. Unlike other research focused on the use of by-products in food, this study adopts an integrated approach, evaluating both consumer acceptability, by identifying factors influencing purchasing decisions, and economic viability reflected from the generated added value and the application of a circular business model. The methodology combined physico-chemical, sensory analysis with a quantitative approach based on questionnaires administered to a sample of 133 respondents and the Analytic Hierarchy Process (AHP), thus providing a comprehensive assessment of the product's impact. Consumers value sustainability (45%), nutritional value (30%) and the story of the product (25%). Furthermore, 79% of participants expressed willingness to recommend functional wafers, confirming the high consumer interest in sustainable products and suggesting their commercial potential. The contribution of this study lies in identifying an opportunity for wafer manufacturers to diversify their product portfolios and differentiate in the market through marketing strategies focused on sustainability, nutrition, and local origin, thus supporting the circular economy and reducing food waste.

Keywords: circular economy, hierarchical analytical method, food sustainability, consumer preferences, functional products, valorisation of by-products from the food industry.

JEL Classification: L66, O31, O44, Q18.

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Introduction

In an economic context marked by rapid changes and increasing pressures on food markets, understanding consumer preferences becomes essential for adapting the strategies of actors within the food chain (Noor et al., 2022).

The diversification of consumer behaviour, orientation towards sustainable products, growing health concerns, climate change, the globalisation of information, and the reduction of food waste are emerging trends shaping contemporary markets (Bojnec et al., 2019; Amicarelli et al., 2022). These factors drive the emergence of innovative solutions, not only in food product design but also in the use of available resources, with a focus on the circular economy and the valorisation of industrial by-products (Casonato et al., 2023; Galanakis, 2024). The shift from ultra-processed products to natural ones, free of preservatives and rich in nutrients, reflects a profound change in perceptions related to nutrition (Boncinelli et al., 2021; Rybak, Burton, and Berry, 2024).

Another trend is the growing demand for products that incorporate supply chain transparency, sustainable packaging, and reduced environmental impact (Zambujal- Oliveira and Fernandes, 2024). This shift is encouraged by awareness campaigns and public policy initiatives focused on sustainability, including the European Green Deal (Stefanis et al., 2024). The European Green Deal influences the food industry through specific regulations and strategies that impose major changes in production, distribution, and consumption. An important objective is to reduce food waste by 50% across the entire supply chain by 2030, which drives companies in the food sector to implement recycling solutions and valorisation of by-products (Stefanis et al., 2024).

The food market exhibits profound changes driven by consumers' growing concerns about health, sustainability, and reducing food waste (Principato et al., 2021; Amicarelli et al., 2022). These emerging preferences are influencing the entire food chain, prompting producers to focus on innovative solutions that efficiently use available resources. At the European Union level, the total food waste calculated for 2022 exceeded 59 million tons, with by-products and waste from the food industry accounting for 19% of this total, or more than 11 million tons (EUROSTAT, 2024).

Although numerous studies analyse sustainable consumption trends and their impact on the food market in countries such as Spain, the United Kingdom, Estonia, Greece, the Czech Republic, and Denmark (Bojnec et al., 2019; Amicarelli et al., 2022), research specifically exploring consumer perception of food products derived from by-products and the real impact of their characteristics on purchase intention in Romania remains limited.

The food industry generates approximately 90 million tons of food by-products annually, which pose serious environmental and economic challenges, leading to an economic cost of €2.6 trillion and an 8-10% increase in greenhouse gas emissions, equivalent to 3.3t CO₂ per year. Sustainable Development Goal (SDG) 12.3 from the 2030 Agenda for Sustainable Development aims for a 50% reduction in food losses and waste by 2030 (Belardi et al., 2025). Reducing by-products from the food industry has also become a subject of interest for researchers in identifying ways to reintegrate them into the economic cycle (Ahuja et al., 2024). Malt-exposed grain, a fibre and protein rich by-product of the beer and whisky industry, is generated annually in significant quantities – 40 million tons in beer production and approximately 2,400 tons per million litres of whisky. Its valorisation in the food industry reduces waste, supports sustainability, and meets the demand for natural and nutritious

products, contributing to innovative and eco-friendly solutions (Chetrariu and Dabija, 2022). The circular economy provides a valuable framework for reducing waste and creating products with low environmental impact. The bioeconomy, in turn, addresses the possibilities of transforming renewable biological resources into economically and bioenergetically viable products (Galanakis, 2024). Although the circular economy and bioeconomy provide a solid theoretical framework for reintroducing by-products into the economic cycle, there is a lack of applied studies assessing the feasibility and acceptability of such products at the consumer level. This article analyses how consumer preferences influence market opportunities for malt-spent grain wafers in Romania. The study explores three main dimensions: (1) consumer perception of products derived from food industry by-products, with a focus on their acceptance and appeal; (2) the role of attributes such as sustainability, nutritional value, and taste in purchasing decisions for malt-spent grain wafers; and (3) the economic viability of malt-spent grain wafers, comparing them to control products to determine their potential for market integration. By addressing these aspects, the study complements the specialised literature and provides relevant empirical data for industry and investors.

The literature review is followed by an empirical study based on physico-chemical and sensory analyses, as well as applying the AHP method, and a questionnaire on consumer perception. The results indicate a preference for wafers with 10% malt-spent grain due to the balance between taste, texture, and nutritional benefits, influenced by sustainability and the product's story. The discussions correlate the data with the literature and current trends in sustainable consumption. The conclusions highlight the commercial potential of the product and the directions for its sustainable integration and promotion.

1. Literature review

Consumers play an important role in promoting sustainable consumption patterns, and their preferences are influenced by a multitude of factors, including economic factors (e.g., price, disposable income, product availability), sensory/nutritional factors (taste, texture, nutritional value), psychological factors (awareness, education, product story, dietary habits, susceptibility to marketing strategies, branding), as well as socio-cultural factors (global trends, cultural traditions, and norms). Environmental impact is among the public values that prevail in their purchasing decisions (Toussaint, Cabanelas and González-Alvarado, 2021). On the other hand, consumers associate sustainability with healthy eating, traditional foods, and nutritional foods (Feil et al., 2020; Volgger, Cozzio and Taplin, 2022).

In Romania, studies show an increased interest in gluten-free, lactose-free, or high-fibre products, but price remains a determining factor in purchase decisions (Dumitraşcu, 2021). Furthermore, Romanian consumers show a preference for local products, perceived as more natural and sustainable (Bojnec et al., 2019).

In the food industry, the circular economy model is becoming increasingly important given the large amount of waste and by-products generated. Its principles are successfully applied in various sectors, including the use of by-products from beer production, obtaining ethanol or other food products (Kounani, Pavludi and Aggelopoulos, 2024). Brewer's spent grain is a typical example of a valuable by-product, rich in fibres, proteins, and bioactive compounds (Ngasakul et al., 2024). Its use in food products adds value both economically and sustainably, reducing waste and environmental impact. Furthermore, consumers increasingly perceive such initiatives as responsible and innovative, which enhances the acceptability of

products derived from by-products (Molinillo, Vidal-Branco and Japutra, 2020; Chetrariu and Dabija, 2022).

Current studies consider the circular economy a viable model but do not analyse consumer perceptions regarding the safety and attractiveness of such products (Hejna et al., 2024). A psychological barrier persists in the use of food by-products, and existing research provides limited data on overcoming this reluctance (Joachim, Spieth, and Heidenreich, 2018; Bollinger et al., 2022). This study examines consumer perceptions of a specific product, wafers with malt-exposed grain, and the factors that influence its acceptability.

The development of food products incorporating malt-spent grain brings benefits to the industry—by reducing storage costs for food by-products; to consumers—by offering functional products; and to the environment—by reducing pollution. Since malt spent grain is derived from food-grade raw materials, it can be incorporated into recipes for creating food products such as baked goods, biscuits, pasta, snacks, extruded products, fermented dairy products, and more (Girelli and Scuto, 2021). Until recently, food industry by-products were of little interest, being used primarily as animal feed or for compost production, yet current trends, along with their status as inexpensive yet valuable raw materials, have brought these by-products to the attention of researchers (Chetrariu and Dabija, 2022).

The use of by-products from the food industry is increasing globally, with innovative applications. In Europe, malt-spent grain enriches bakery products and serves as a substrate for microorganisms or animal feed (Cuomo et al., 2022). In the United States, it is used in protein bars and granola (Belardi et al., 2025), while in South America, it contributes to biogas production (Molinillo, Vidal-Branco and Japutra, 2020). In Asia, it is used in gluten-free pasta and nutritious noodles (Anisha et al., 2023). In Romania, its integration into flour-based, bakery, and meat products is being explored (Farcas et al., 2021). Malt-spent grain wafers are an innovative product with improved sensory characteristics and nutritional value, featuring a high content of proteins and fibres suitable for consumption by individuals with gluten intolerance, as well as by all consumer categories. On the Romanian market, there are several types of wafers available (plain, with caraway, with cheese, pizza-flavoured, with blue cheese, with onion and sour cream); however, in the category of wafers specifically designed for consumers requiring gluten-free / low-gluten options, there is a limited range of products.

2. Research Methodology

To analyse the potential of malt-spent grain wafers, this study adopted a multidimensional methodology combining quantitative methods specific to the food industry (physico-chemical analyses, sensory analysis of products obtained under laboratory conditions), statistical-economic methods (a questionnaire to evaluate consumer perception and purchasing decisions), and mixed quantitative-qualitative methods (using the Analytic Hierarchy Process [AHP] to prioritise sensory and purchasing criteria). This integrated approach enables a comprehensive understanding of consumer perception, preferences, and the factors influencing purchasing decisions.

The malt-spent grain, a by-product of whisky production obtained from the Alexandrion Group Romania, was processed through freezing, drying, grinding, and sieving to produce a finely granulated flour. This malt-spent grain was used through classical technology to develop 4 types of final products that were evaluated from physical-chemical and sensory perspectives.

2.1. Physico-chemical and sensory analysis

The determination of the physico-chemical characteristics of wafers with the addition of malt-spent grain is a standard evaluation in the food industry. This evaluation includes determining moisture content by drying in an oven at 105°C until a constant weight is achieved, ash content determination using a muffle furnace at 550°C for 8 hours, protein content determination by the Kjeldahl method, lipid content determination using the Soxhlet method, and enzymatic analysis using AOAC Method 2011.25. Sensory evaluation provides detailed information about food products but has significant limitations, is costly, time-consuming, and produces imprecise results due to variations between experts. Additionally, it does not measure the impact of quality attributes on consumer preferences and has uncertain repeatability, especially in the context of innovations (Chetrariu and Dabija, 2022).

2.2. Analytic Hierarchy Process (AHP)

The AHP method can complement sensory analysis and has been used in previous research as an alternative to selecting sensory vocabulary aimed at characterising and explaining consumer preferences, in accordance with ISO 11035 standards (RamrezRivera et al., 2020; Dabija et al., 2024). Click or tap here to enter text. AHP enables a more objective evaluation of criteria in complex contexts involving uncertainty, including intuitive, rational, and even irrational aspects (Saaty, 2021). The AHP method was first applied to identify the optimal recipe for a malt-spent grain wafer product. The 15 panellists who participated in the classical sensory analysis compared sensory attributes pairwise, providing an organised and systematic way to identify the criteria used to prioritise alternatives when selecting the best product among four wafer alternatives (control sample, sample with 5% malt-spent grain added, sample with 10% malt-spent grain addition, and sample with 15% malt-spent grain addition). The Consistency Ratio (CR) is used to assess whether the level of inconsistency in the pairwise comparison matrix is acceptable. Subsequently, the AHP method was used to rank the determining factors in the purchasing decision for malt-spent grain wafers among 30 students from "Ștefan cel Mare" University of Suceava who tasted the wafer with a 10% malt-spent grain addition compared to the control sample (Table No. 1).

Table no. 1. Criteria used in applying the AHP method in this study

Criteria used in Sensory Analysis to identify the Optimal Recipe for malt-spent grain wafers	Criteria used to identify Preferences influencing the Purchase Decision of malt-spent grain wafers
1. Appearance 2. Colour 3. Taste 4. Smell 5. Texture 6. Overall Acceptability	1. Product Sustainability 2. Nutritional Value (fibre, protein, absence of allergens, health benefits) 3. Product Origin (local origin, innovative character, product story, transparency of the production chain)

The data were analysed using the Superdecisions© v. 2.4.0 software (Creative Foundations, Pittsburgh, USA). An important limitation of the Analytic Hierarchy Process (AHP) method used in this study is the subjectivity of the responses, as the analysis relies on the individual perceptions of respondents, which may introduce cognitive bias and variations in the evaluation of product attributes (Cheng, Li, and Ho, 2002).

2.3. Questionnaire to evaluate consumer perception

This study is exploratory in nature and falls into the category of pilot studies, with the primary objective of conducting an initial assessment of consumer perception regarding wafers with malt-wasted grains and identifying the key factors influencing their acceptability.

The purpose of the research is to understand the attitudes, current behaviour, and future intentions of Romanian consumers regarding the purchase of sustainable and innovative products obtained from the valorisation of food by-products, using a case study of wafers enriched with 10% malt-spent grain. Data collection for quantitative research was carried out using an online questionnaire created on the Google Forms platform, and data were analysed using IBM SPSS Statistics. The questionnaire consisted of 25 questions (24 closed-ended and 1 open-ended), distributed across 5 sections, as follows:

- section 1 included 5 demographic questions: age category, gender, level of education, and income level;
- section 2 included 7 questions about consumers' familiarity, opinions, and willingness to purchase food products derived from industrial by-products, as well as the benefits and important characteristics of these products;
- section 3 included 7 questions exploring consumer preferences in purchasing decisions, focusing on: nutritional value, product origin, acceptability of products made from industrial by-products, sensory attributes, and criteria for choosing malt-spent grain wafer (superior taste, competitive price, nutritional benefits, sustainability, local origin);
- Section 4 included five questions evaluating consumer preferences for malt-spent grain wafers through a set of questions related to interest in the product, willingness to pay, essential attributes (taste, price, packaging, nutritional benefits), and the evaluation of organoleptic characteristics (appearance, colour, taste, smell, texture) compared to conventional wafers;
- section 5 included 1 open-ended question soliciting suggestions or comments for improving sustainable products and wafers with a 10% malt-spent grain addition.

The questionnaire was distributed via QR codes made available on the campus of "Ștefan cel Mare" University in Suceava, during the period of November 1–30, 2024. The number of respondents who answered the questions in Sections 1, 2, and 3 of the questionnaires is 147 (of which 133 were valid), while Section 4 was applied separately to a sample of 30 students who tasted wafers with a 10% malt-spent grain addition versus the control sample wafers.

Taking into account the structure of the questionnaire and the previously established objectives, the applied methodology involves testing statistical significance (chi-square test), performing correlation analyses, and using graphical methods for data representation.

3. Results and discussions

3.1. Physics-chemical analysis results

The study investigated the influence of the addition of malt-spent grain on the physics-chemical characteristics of the wafers, analysing several parameters: moisture, protein content, lipids, fibre, and ash (Figure no. 1).

The addition of malt-spent grain and chickpea flour increased the protein content in the supplemented samples compared to the control sample, confirming a positive effect of the by-product on nutritional value (Tiwari, Barooah and Bordoloi, 2020).

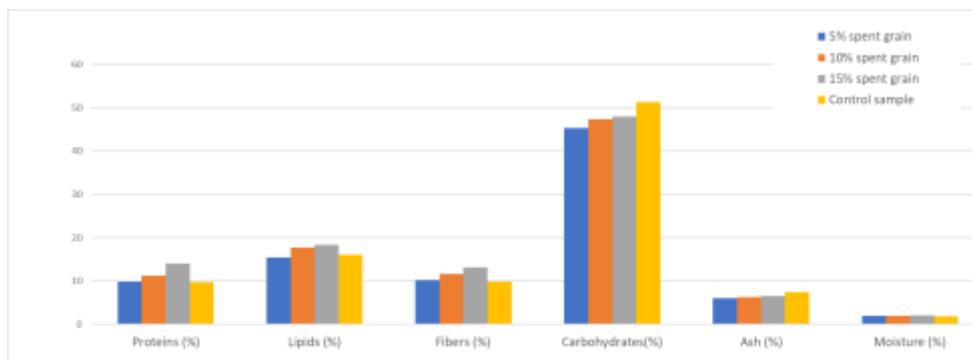


Figure no. 1. Variation of physics-chemical characteristics for wafer samples with added malt-spent grain and the control sample

3.2. Results of the AHP method used in sensory analysis to determine the optimal recipe of the final product

The results were calculated using the geometric mean of individual expert evaluations, in accordance with Saaty's recommendations (Saaty, 2021). The criteria compared included appearance, colour, taste, aroma, texture, and overall acceptability of the four alternatives. Before aggregating the evaluations, the judgments of each student were checked for consistency. After analysing individual evaluations, it was found that three panellists obtained inconsistent results (consistency ratio > 0.10). Therefore, the final analysis was carried out by aggregating the results of the group consisting of 12 students.

The highest-rated sensory property was taste (30%), followed by texture (20%) and colour - aroma (15%), while appearance and overall acceptability were considered the least important attributes (10%) (Table no. 2).

Table no. 2. Decision Matrix of criteria used for sensory analysis

Criterion	Appearance	Colour	Taste	Aroma	Texture	Overall acceptability
Appearance	1.00	0.75	0.50	0.50	0.50	0.40
Colour	1.33	1.00	0.67	0.67	0.50	0.50
Taste	2.00	1.50	1.00	1.33	1.00	1.00
Aroma	2.00	1.50	0.75	1.00	0.75	0.67
Texture	2.00	2.00	1.00	1.33	1.00	0.80
Overall acceptability	2.50	2.00	1.00	1.50	1.25	1.00

$\lambda_{max} = 6.09$ (weighted average)

Consistency Index: $CI = (6.09-6) / (6-1) = 0.018$

Consistency Ratio: $CR = CI/RI = 0.018 / 1.24 = 0.0145$ (< 0.10, acceptable consistency)

By calculating the final scores, the alternatives were ranked and an optimal recipe for wafer with malt-spent grains was identified according to panelists' preferences (Table Nno. 3).

Table no. 3. Final hierarchy of the alternatives tasted

Alternative	Appearance (10%)	Colour (15%)	Taste (30%)	Smell (15%)	Texture (20%)	Overall Acceptability (10%)	Final Score	Rank
Control sample	0.43	0.63	1.35	0.65	0.88	0.44	4.38	2
Wafer 5%	0.41	0.59	1.26	0.60	0.82	0.40	4.08	3
Wafer 10%	0.45	0.71	1.44	0.69	0.94	0.49	4.72	1
Wafer 15%	0.37	0.60	1.05	0.54	0.76	0.35	3.67	4

The results confirm the e analysis of sensory preferences of the most experts for the wafer containing 10% malt-spent grain, followed by the control sample, suggesting that an optimal malt-spent grain content (10%) can provide a balance between taste, texture, and sensory acceptability, offering a clear advantage over the conventional product. The results of the AHP method used in sensory analysis corroborate the findings of classical sensory analysis employed in the food industry, demonstrating once again the complementary and comprehensive nature of using both methods.

3.3. Results of the AHP method used in sensory analysis to identify preferences that influence the purchase decision of malt-spent grain wafers

After identifying the optimal recipe, a new analysis was performed using the AHP method this time comparing only two alternatives (the wafer with 10% malt-spent grain addition versus the control sample – conventional product) to establish the hierarchy of preferences influencing the product purchase decision. The compared criteria included *product sustainability*, *nutritional value* (fibre, protein, absence of allergens, health benefits), and *product origin* (local origin, innovative character, product story, transparency of the production chain). Following the analysis of individual evaluations, it was found that 6 evaluators had inconsistent results (consistency ratio > 0.10). Therefore, the final analysis was performed by aggregating the results of a group consisting of 24 students.

The percentage importance of the criteria influencing the purchase decision of wafers made with malt-spent grain addition show the highest-rated criterion was sustainability (45%), followed by nutritional value (30%) and product origin (25%) (Table o. 4).

Table no. 4. Decision Matrix of criteria influencing the purchase decision

Criterion	Sustainability	Nutritional Value	Product Origin	Weight
Sustainability	1.00	1.50	2.00	0.45
Nutritional Value	0.67	1.00	1.50	0.30
Product Origin	0.50	0.67	1.00	0.25

$\lambda_{max} = 3.01$ (weighted average; minor variation due to the evaluation of 2 alternatives)

Consistency Index: $CI = (3.01-3)/(3-1) = 0.005$

Consistency Ratio: $CR = CI/RI = 0.0005/0.58 = 0.00086$ (< 0.10, acceptable consistency)

Thus, by calculating the final scores, the tasted alternatives were ranked and consumer preference was identified for the wafer product with a 10% addition of malt-spent grain (Table no. 5).

Table no. 5. Final classification of the tasted alternatives

Alternative	Sustainability (45%)	Nutritional Value (30%)	Product Origin (25%)	Final score	Hierarchy
Control Sample	1.44	1.05	1.00	3.49	2
Wafer 10%	2.12	1.44	1.15	4.71	1

The results confirm a clear preference for purchasing the wafer product with 10% malt-spent grain addition, which stands out due to: *superior sustainability*, thanks to the use of malt-spent grain, a sustainably capitalised by-product; high *nutritional value*, offering higher fibre and protein content compared to the control sample, and its *innovative origin*, appreciated by consumers for the story behind the integration of a local and sustainable ingredient.

3.4. Results of the statistical analysis of the responses to the online questionnaire

Following the data processing stages, out of 147 completed questionnaires, 133 valid questionnaires were obtained, with the following social structure of the respondents:

- 32.33% men and 67.7% women;
- 80.45% of the respondents belong to the 18-29 age group, indicating a young audience, typical of students, who may be more open to innovative and sustainable products; followed by the 30-44 age group with a proportion of 15.79%, and the 45-59 age group at 3.76%;
- 76.69% of the respondents are undergraduate students, while the remaining 23.31% are master's students;
- 60.78% of undergraduate respondents have a net income below 2000 lei per month, while a majority of 61.29% of master's students have a net monthly income between 2000 and 4000 lei.

The survey results show the level of familiarity of the respondents with products derived from the food industry, highlighting the variation in knowledge levels. Thus, 35.34% are very familiar, while 22.56% are moderately familiar, indicating a significant degree of awareness. The data emphasises the need for developing and promote such products in an educational context.

The analysis of the 133 responses confirms taste as the primary factor in the perception and purchase of food products (averages: 4.54 – question 10, 4.50 – question 16; standard deviation ~0.70), indicating a strong consensus. The taste, texture, nutritional value, and sustainability are also highly appreciated (averages >4, standard deviations 0.75–0.90), suggesting high importance and moderate variation in opinions. Appearance, colour, and brand are less prioritised (averages 3.15–3.74) but remain relevant for some participants. The price is important (average ~3.9) but not decisive, indicating a preference for quality and tangible benefits. The low standard deviations (below 1.0 for most characteristics) suggest a relatively stable consensus. These results provide a solid basis for classifying essential characteristics of food products.

Responses to question 11 about the likelihood of purchasing sustainable products show high receptiveness toward such products: 69.18% of respondents are inclined to purchase them,

while 16.54% remain neutral, suggesting the need for additional information. Only 14.29% express reluctance, representing a sceptical minority. These results confirm sustainability as a key factor in purchasing decisions and highlight the opportunity to tailor marketing strategies to receptive and neutral segments. The Chi-square analysis of 151.58, with a very small p-value ($4.31e-20$), confirms a significant association between familiarity with sustainable products (FAM_PROD-Q6) and the likelihood of purchasing them (PROB_CUMP_SUST-Q11). Respondents who are more familiar with sustainable products are more likely to buy them, emphasising the importance of consumer education in increasing the purchase rate.

All three aspects of sustainability are considered important, with average scores close to 4 (Table no. 6). Sustainable packaging received the highest average score (4.01), indicating the main priority, followed by low environmental impact (3.96) and waste reduction through the valorisation of by-products (3.86). The low standard deviations (< 0.93) suggest a moderate consensus among the respondents. The Chi-square test indicates a moderate association between "Importance of Sustainability" (Q12) and "Decision to Purchase Sustainable Products" (Q17) ($\chi^2=5.06$, $p=0.281$), suggesting that the perception of sustainability may influence purchasing decisions, but without a strong correlation.

Table no. 6. Evaluation of the importance of sustainability in the purchase decision

Sustainability aspect	Mean	Standard deviation
Reducing food waste by utilising by-products	3.86	0.87
Lower environmental impact	3.96	0.92
Sustainable packaging (biodegradable, recyclable)	4.01	0.82

The results in Section 2 highlight that 46% of students are familiar with products derived from food industry by-products (46%), with 70% considering them a sustainable solution, and 60% state they would purchase, while 34% could be persuaded if quality is guaranteed. The main perceived benefits are reducing food waste and reducing environmental impact. The key purchase decision criteria include taste (4.8), general acceptability (4.7) and nutritional value (4.7). Furthermore, 86% of respondents are willing to buy products marketed as sustainable, with reducing food waste (4.8) and minimising environmental impact (4.7) being the most appreciated attributes. These results demonstrate both the commercial potential and opportunities for strategic communication focusing on sustainability and quality.

The characteristics regarding the importance of product origin have mean values between 3.82 and 3.92, with no statistically significant differences. The product story (3.92) and local origin (3.91) are the most appreciated aspects, while innovativeness has the lowest mean (3.82). Standard deviations below 1.00 indicate moderate variation and a relatively high level of agreement among respondents, confirming the importance of all characteristics, with a slight advantage for the product story and local origin. Students prioritise nutritional value in their purchases, assigning the highest scores to health benefits (4.7) and fibre content (4.6), followed by protein (4.5) and the absence of allergens (4.3). These results highlight a clear preference for products that support a healthy lifestyle, suggesting that promotional strategies should emphasise these key nutritional benefits.

The survey shows that sustainability (29%) and superior taste (26%) are the main criteria for choosing wafers made with malt-spent grain, followed by nutritional benefits (22%). Local origin and the product's story (16%) play a secondary role, while competitive pricing (7%) has the least influence. These results hint that transparency and authenticity are valued but not prioritised, and consumers are willing to pay more for a sustainable, tasty, and healthy product.

The results of Section 3 highlight that nutritional value (fibre, protein, health) is essential for consumers, with average scores above 4.5. The origin of the product and the transparency of the supply chain are determining factors. While 64% of the respondents would choose a product derived from food industry by-products if the price and quality were comparable to conventional ones, 68% are influenced by sustainability. The main reasons for opting for wafers with malt-spent grains are nutritional benefits (86%) and superior taste (75%). These data suggest a high potential for sustainable and innovative products if they emphasise nutrition, taste, and local sourcing while maintaining a competitive price.

The results from Section 4 reflect the opinions of the 30 students who tasted the wafers containing 10% malt-spent grain versus the control sample. Thus, 79% of the students (53.33% "Very likely," 26.67% "Likely") would recommend them, indicating high receptivity and strong promotional potential. Only 20% are neutral (6.67%) or hesitant (13.33%), suggesting limited scepticism that could be managed through product improvements or marketing strategies. Overall, the product is well perceived, and most consumers are willing to promote it. The participants' suggestions in response to question no. 25 emphasise the importance of promoting sustainability advantages and nutritional benefits, along with packaging that reflects the ecological concept. These results confirm a high potential for the product's success, with a focus on taste, accessibility, and sustainability-oriented marketing.

4. Discussions

Following the results of the physico-chemical analysis, the increase in protein and fibre content aligns with the data reported by Tiwari, Barooah, and Bordoloi (2020). These results highlight the nutritional potential of malt-spent grain as a functional ingredient in the food industry, supporting its use in products intended for consumers interested in healthy eating.

Sustainability is a major factor in purchasing decisions, confirming global trends toward eco-friendly products (Molinillo, Vidal-Branco, and Japutra, 2020; Kumar and Pandey, 2023). Previous research (Maesen et al., 2022) has demonstrated that the acceptability of products derived from food by-products is closely linked to consumers' perception of their nutritional benefits and positive environmental impact. In this context, the fact that 79% of participants stated that they would recommend functional wafers made from malt-spent grain confirms the attractiveness of these products.

Previous research (Toussaint, Cabanelas, and González-Alvarado, 2021; Kumar and Pandey, 2023) shows that consumers most often prefer sustainable products with superior nutritional benefits. This trend is also reflected in the present study, where sustainability (45%), nutritional value (30%), and product story (25%) were the main factors influencing the acceptance of malt-spent grain wafers. Furthermore, Feil et al. (2020) highlight that sustainability is associated with healthy and responsible eating, which aligns with the results of the statistical analysis confirming that sustainability and nutritional benefits are the

primary reasons for purchase. Similarly, Piracci et al. (2023) emphasise that transparency and an authentic product narrative enhance consumer trust and attractiveness. This aspect is also evident in the present study, where the origin and story of the product had a positive impact on acceptability.

The results of this study confirm that sustainability, nutritional value, and product presentation significantly influence consumers' purchasing decisions (Molinillo, Vidal-Branco, and Japutra, 2020). The survey results show that 69% of respondents are willing to purchase sustainable products, a percentage similar to trends observed at the European level, where consumers increasingly prioritise the environmental impact of food (Toussaint, Cabanelas, and González-Alvarado, 2021). Furthermore, 86% of the respondents identified food waste reduction as a major benefit, aligning with recent research suggesting that supply chain transparency and by-product reutilisation contribute to increased consumer trust and perceived value (Galanakis, 2024).4). Therefore, the conclusions of this study demonstrate that the integration of criteria such as sustainability, nutritional value, and product presentation into a marketing strategy can significantly improve purchase intention, reinforcing the responsible consumption trends highlighted in the specialised literature.

According to previous research, integrating by-products into the food industry not only reduces food waste and environmental impact but also offers opportunities for market differentiation, especially in the context of increasing demand for sustainable and nutritious products (Chetrariu and Dabija, 2022; Ahuja et al., 2024). The present study confirms these findings, highlighting that a marketing strategy based on sustainability, nutritional value, and local origin can positively influence product acceptability and purchase intention (Wu et al., 2017), which can be further reinforced through effective communication campaigns (Kumar and Pandey, 2023). Moreover, the recommendation to establish partnerships between beer producers and the food industry for the valorisation of malt-spent grain is supported by economic models based on the circular economy, demonstrating that integrating by-products into the food supply chain can generate competitive advantages and long-term sustainability (Bojnec et al., 2019).

Both quantitative and qualitative analyses conducted after product tastings demonstrate a strong consumer focus on sustainability and nutritional benefits, confirming trends observed in other studies on preferences for organic products. Additionally, local origin and the product's story are highly valued, suggesting that promoting these aspects can contribute to the commercial success of the product.

Conclusions

The study highlights a remarkable potential for integrating industrial by-products, such as malt-spent grain, into the food chain, demonstrated through a multidimensional methodology that included physico-chemical, sensory, statistical, and economic analyses, complemented by a questionnaire applied to a representative sample of consumers.

The use of malt-spent grain as a food ingredient represents a concrete example of applying circular economy principles. Valorising this by-product helps reduce food waste and minimise environmental impact, aligning with the Sustainable Development Goals of the 2030 Agenda. Integrating industrial by-products into the food chain not only optimises resource use but also creates economic opportunities by reducing storage and transportation costs.

This study has specific limitations, as it is a pilot study with a small and minimally diverse sample, which hinders the generalisation of results. Future research should include larger and more varied samples that represent different categories of consumers. Additionally, a longitudinal analysis of consumer perception would be useful, assessing the evolution of product acceptability over time, especially following educational campaigns and sustainability promotion efforts.

For the practical applicability of these results, the food industry can utilise malt-spent grain in new product categories such as biscuits, pasta, protein bars, or extruded products. Collaboration between beer and whiskey producers and the food sector would facilitate the integration of this by-product into the value chain, optimising resources. Furthermore, marketing strategies focused on eco-certifications and consumer education could enhance the acceptance of these innovative products. In conclusion, this study opens new avenues for the valorisation of by-products in the food industry, providing a solid foundation for the development of products that are not only nutritionally functional but also sustainable, innovative, and competitive on the market.

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