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ALIMENTAÇÃO COLETIVA

Implementation of an environmental labelling system in university canteens: Impact on consumer choice

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Implementação de um sistema de rotulagem ambiental em cantinas universitárias: Impacto na escolha do consumidor

Implementation of an environmental labelling system in university canteens: Impact on consumer choice

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Resumo

Os sistemas alimentares apresentam impactos ambientais significativos, tornando relevante a implementação de estratégias que promovam escolhas alimentares mais sustentáveis. Este estudo teve como objetivo avaliar o impacto de uma estratégia de rotulagem ambiental nas escolhas alimentares dos utilizadores de uma cantina universitária. Foi realizado um estudo quantitativo, descritivo e quase-experimental na Universidade de Aveiro, com 1186 participantes, dos quais 94,1% eram estudantes, com média de idades de $23,1 \pm 6,9$ anos. O impacto ambiental das refeições foi avaliado através da pegada de carbono, pegada hídrica e uso do solo, recorrendo a um sistema de cores tipo semáforo. As escolhas alimentares foram analisadas através dos registos Unicard em quatro momentos e a perceção e influência do rótulo através de um questionário aplicado em duas fases. As refeições de carne apresentaram, globalmente, os maiores impactos ambientais, enquanto as opções vegetarianas apresentaram os menores valores. Durante a intervenção, verificou-se uma redução da proporção de refeições de maior impacto na maioria dos dias. O rótulo foi reconhecido por 73,1% dos participantes e 89,2% consideraram a sua interpretação fácil ou muito fácil, embora 42,4% o tenham considerado não determinante na escolha. A proporção de participantes sem predisposição para escolher opções mais sustentáveis diminuiu de 16,6% para 8,8%. Conclui-se que a rotulagem ambiental é uma estratégia viável e bem aceite, embora, isoladamente, apresente influência limitada nas escolhas alimentares.

Palavras-chave: Rótulo ambiental; cantina universitária; sustentabilidade; escolha alimentar.

Abstract

Food systems have significant environmental impacts, highlighting the importance of implementing strategies that promote more sustainable food choices. This study aimed to assess the impact of an environmental labelling strategy on the food choices of users of a university canteen. A quantitative, descriptive and quasi-experimental study was conducted at the University of Aveiro, involving 1,186 participants, 94.1% of whom were students, with a mean age of 23.1 ± 6.9 years. The environmental impact of meals was assessed using three indicators: carbon footprint, water footprint and land use, classified through a traffic-light colour system. Food choices were analysed using Unicard records at four time points, while participants' perception of and response to the label were assessed through a questionnaire administered in two phases. Meat-based meals generally showed the highest environmental impacts, whereas vegetarian options had the lowest values. During the intervention, the proportion of higher-impact meals decreased on most days. The label was recognised by 73.1% of participants, and 89.2% considered it easy or very easy to interpret, although 42.4% reported that it did not influence their meal choice. The proportion of participants who were not at all willing to choose more sustainable options decreased from 16.6% to 8.8%. Environmental labelling appears to be a feasible and well-accepted strategy, although, when used alone, it has a limited influence on food choices.

Keywords: Environmental label; university canteen; sustainability; food choice.

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Acronyms and abbreviation

GHG - Greenhouse Gas

CH₄ - Methane

N₂O - Nitrous oxide

CO₂ - Carbon dioxide

FAO - Food and Agriculture Organization

CO₂-eq - Carbon dioxide equivalents

DIPASI - Dietary Pattern Sustainability Index

IAN - AF - National Food and Physical Activity Survey

SDG - Sustainable Development Goals

LCA - Life Cycle Assessment

QR Code - Quick Response Code

FCNAUP - Faculty of Nutrition and Food Sciences of the University of Porto

GDPR - General Data Protection Regulation

m² - Square metres

Kg CO₂-eq./meal - Kilograms of carbon dioxide equivalent per meal.

L/meal - Litres per meal

M²/meal - Square metres per meal

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1. Introduction

1.1 Environmental impact of food systems

Food systems are among the main contributors to global greenhouse gas (GHG) emissions, accounting for approximately 21% to 37% of total anthropogenic emissions worldwide ^(1, 2). More recent estimates suggest that food systems may be responsible for nearly one-third of global GHG emissions when considering the entire food supply chain, including production, processing, transport, retail, and consumption stages ⁽³⁾.

Traditionally, agricultural production has been identified as the largest source of emissions within food systems. Methane (CH₄) emissions from enteric fermentation in ruminant livestock, nitrous oxide (N₂O) emissions associated with the fertilizer application, and carbon dioxide (CO₂) emissions resulting from land-use change and deforestation constitute the main sources of environmental impact ⁽⁴⁾. According to the Food and Agriculture Organization of the United Nations (FAO), livestock supply chains emit approximately 7.1 gigatonnes of CO₂ equivalent annually, representing 14,5% of all anthropogenic GHG emissions worldwide. Cattle production alone accounts for approximately 65% of emissions from the livestock sector, mainly due to enteric fermentation, feed production, and manure management ⁽⁵⁾. However, recent studies indicate that post-production stages, such as food processing, packaging, distribution, retail, and household consumption, contribute substantially to total food-system emissions and are becoming increasingly important contributors to total emissions, reflecting the increasing complexity and industrialization of global food supply chains ⁽⁶⁾.

Importantly, environmental impacts vary substantially among food categories. Animal-based foods, particularly red meat and dairy products, are associated with significantly higher GHG emissions compared with plant-based foods ^(7, 8). These differences highlight the critical role of dietary patterns in shaping the environmental footprint of food systems and reinforcing the importance of individual food choices in climate change mitigation strategies ^(9, 10).

In addition to GHG emissions, food systems exert substantial pressure on natural resources, particularly land and water. Agriculture occupies approximately 43% of the Earth's ice-free land surface ⁽²⁾ and represents the primary driver of global

land-use change ⁽⁷⁾. Agricultural expansion contributes to deforestation, ecosystem fragmentation, and biodiversity loss. Furthermore, animal-based food production requires a disproportionately large share of agricultural resources ⁽¹¹⁾. Poore and Nemecek estimated that livestock production occupies approximately 83% of global farmland while providing only 18% of global energy supply and 37% of protein supply, highlighting the considerable environmental burden associated with animal-derived foods and underscoring the potential benefits of more sustainable dietary patterns ^(2, 5).

Water use also represents a major environmental concern. Approximately 70% of global freshwater withdrawals are allocated to agriculture, mainly for irrigation purposes ⁽⁷⁾. This intensive use frequently occurs in regions already affected by water scarcity, contributing to resource depletion and increasing pressure on ecosystems ⁽²⁾.

Agricultural intensification has generated substantial environmental challenges associated with the excessive use of fertilizers and pesticides. These practices increase the concentration of nutrients and toxic substances in surface and groundwater, contributing to water pollution, eutrophication of aquatic ecosystems, soil degradation, and nutrient imbalances that reduce long-term soil fertility ^(12, 13). In addition, changes in land management and the simplification of agricultural ecosystems negatively affect biodiversity and compromise the capacity of ecosystems to provide essential goods and services. Although synthetic fertilizers have played a fundamental role in increasing global food production, their inefficient use results in significant nutrient losses, as only 30-50% of applied nitrogen and approximately 45% of phosphorus are absorbed by crops, while the remaining nutrients are released into the environment. These processes increase pressure on natural resources, compromise ecosystem functioning, and may adversely affect human health, highlighting the need for more sustainable and resource-efficient agricultural practices ^{(14) (15)}.

In response to these environmental challenges, increasing attention has been given to the promotion of sustainable diets. According to the FAO, sustainable diets are dietary patterns that have low environmental impacts while contributing to food and nutrition security and healthy lives for present and future generations. They should also preserve biodiversity and ecosystems, be culturally acceptable,

economically fair and affordable, and promote the efficient use of natural and human resources ⁽¹⁶⁾.

1.2 Environmental indicators used to assess food sustainability

The environmental pressures associated with food production and consumption are complex and multidimensional, affecting climate, freshwater resources, land use and biodiversity ⁽²⁾. Consequently, multiple environmental indicators have been developed to quantify and compare the environmental performance of foods and dietary patterns. Among the most widely applied indicators are carbon footprint, water footprint, and land use, which provide complementary information on greenhouse gas emissions, freshwater resource use, and land use ⁽²⁾.

Carbon footprint represents the greenhouse gas emissions associated with the production of a food product, expressed as carbon dioxide equivalents (CO₂-eq), and is widely used to evaluate the contribution of foods and dietary patterns to climate change ⁽²⁾. Water footprint measures the volume of freshwater required throughout the production process and provides information on the pressure exerted on water resources, while land use reflects the amount of land required to produce a food product and its associated impacts on terrestrial ecosystems, including deforestation and biodiversity loss ^(2, 17).

Together, these indicators provide complementary perspectives on the environmental performance of foods and dietary patterns, enabling a more comprehensive assessment of food sustainability than any single indicator alone ^(2, 17). Their combined use has increasingly been supported by the development of environmental assessment frameworks and environmental labelling systems designed to promote more informed and sustainable consumer food choices ^(2, 17, 18). The multidimensional nature of food sustainability has been increasingly recognized, highlighting the limitations of relying on a single environmental indicator to evaluate dietary patterns. In response to this challenge, Bôto et al. developed the Dietary Pattern Sustainability Index (DIPASI), a multidimensional framework that integrates carbon footprint, water footprint, land use and nutritional quality to assess the overall sustainability of individual diets ⁽¹⁹⁾. This

approach recognizes that improvements in one sustainability dimension may not necessarily be accompanied by improvements in others, reinforcing the importance of evaluating multiple complementary indicators when assessing dietary sustainability ⁽²⁰⁾.

Recent evidence from the Portuguese population reinforces the dual relevance of environmental and nutritional sustainability. Using a quadrant-based segmentation of the IAN-AF 2015-2016 cohort, Bôto et al. (2026) showed that individuals whose diets combined the best environmental and nutritional scores, characterised by higher plant-based food consumption, presented 33% lower carbon footprint, 36% lower water footprint, 50% lower land use, and 87% higher nutritional quality compared with the population median. Conversely, the group with the worst performance on both dimensions consumed more red and processed meat, sweets and alcoholic beverages. Notably, two intermediate groups displayed dissociation between environmental and nutritional performance, highlighting that environmentally favourable choices do not automatically guarantee nutritional adequacy. This nuance is particularly relevant for institutional settings, where labelling systems that signal environmental impact alone may inadvertently steer consumers towards choices that are "green" but nutritionally suboptimal ⁽¹⁹⁾.

Although nutritional quality is a fundamental dimension of dietary sustainability, the present study focused specifically on the environmental dimension to develop and evaluate a labelling system based on environmental impact. Accordingly, carbon footprint, water footprint and land use were selected as the environmental indicators used to assess the environmental impact of meals served in university canteens and to support the development of the environmental labelling system under investigation.

1.3 University food environments as drivers of sustainable food choices

University food environments play a fundamental role in promoting healthier and more sustainable dietary behaviours, particularly among young adults who are developing long-term eating habits and increasing their autonomy in food choices ⁽²¹⁾. As educational institutions, universities have the capacity to influence not

only knowledge and attitudes but also the food environments in which daily decisions are made, positioning themselves as important agents for achieving the Sustainable Development Goals (SDG), particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action), all of which are directly relevant to institutional food services, and for fostering sustainable lifestyles ^(22, 23).

Higher education institutions are increasingly recognised as key actors in sustainable development through their educational mission, research activities, campus operations, and community engagement ⁽²²⁾. By integrating sustainability principles into governance, teaching, and institutional practices, universities can contribute to the development of environmentally responsible citizens while simultaneously reducing the environmental impacts associated with their own activities ⁽²²⁾. Environmental sustainability should therefore be embedded across university policies and management strategies rather than being limited to isolated educational initiatives ⁽²²⁾.

University canteens represent one of the most direct opportunities for implementing sustainability interventions, as they serve large numbers of meals and provide an environment where food choices can be influenced through changes in food availability, menu design, information, and pricing strategies ^(21, 24). Consequently, they constitute ideal settings for promoting dietary patterns with lower environmental impacts while maintaining nutritional adequacy and consumer acceptance ^(21, 24).

Recent experimental evidence demonstrates that modifying the food environment can effectively encourage more sustainable food choices. In a stepped-wedge cluster randomised controlled trial conducted in six workplace cafeterias, increasing the availability of vegetarian meals increased the likelihood of selecting a vegetarian option by 41%, while simultaneously reducing greenhouse gas emissions, energy content, and other environmental indicators without negatively affecting cafeteria revenue or food waste ⁽²¹⁾. These findings suggest that relatively simple modifications to food environments can effectively promote healthier and more sustainable eating behaviours without compromising consumer satisfaction or business performance ⁽²¹⁾.

The promotion of sustainable food environments within higher education institutions is also aligned with current European policies aimed at transforming food systems. The European Commission, through the Farm to Fork Strategy, identifies public food procurement and institutional food services as key instruments for accelerating the transition towards healthy and environmentally sustainable diets, highlighting the responsibility of public institutions to facilitate food choices that are both nutritionally adequate and environmentally responsible ⁽²⁵⁾. Universities, as public institutions serving large and diverse populations, are therefore well positioned to contribute to these objectives by integrating sustainability principles into campus food services.

In addition to providing nutritionally balanced meals, university canteens can promote environmental awareness by incorporating strategies that encourage consumers to consider the sustainability of their food choices. Through the combination of educational initiatives and modifications to the food environment, universities can strengthen environmental literacy, foster sustainable consumption behaviours, and contribute to the development of food systems that are more resilient and aligned with climate and public health goals ⁽²⁶⁾. This institutional commitment reinforces the role of universities as agents of change capable of influencing both individual behaviours and broader societal transitions towards sustainability.

Such interventions are particularly relevant in university settings, where institutional policies can shape food choices on a large scale and contribute to establishing social norms that favour sustainable diets ⁽²²⁾. By combining educational initiatives with structural modifications of the food environment, universities have the potential to act as living laboratories for sustainability, encouraging behavioral change and supporting the transition towards more environmentally sustainable food systems ^(22, 24).

1.4 Environmental food labelling and consumer food choice

Environmental food labelling has gained increasing attention as a strategy to promote more sustainable food choices by translating complex environmental information into formats that are easily understood by consumers at the point of purchase or meal selection ^(27, 28). As concerns regarding the environmental impacts of food systems continue to grow, these communication tools have been proposed as an effective means of reducing information asymmetry and supporting consumers in making more sustainable food choices ^(27, 28).

Traditionally, food labels have focused on nutritional composition, ingredients, allergens, and food safety. However, increasing awareness of climate change, biodiversity loss, freshwater depletion, and resource use has expanded the scope of food information to include environmental sustainability. As a result, environmental food labels have emerged as complementary tools that allow consumers to consider not only the nutritional quality of foods but also their environmental performance when making food choices ^(27, 28).

Environmental labels are frequently based on Life Cycle Assessment (LCA), a methodology used to quantify the environmental impacts associated with the life cycle of a product, from primary production and processing to packaging, transport, distribution, consumption, and waste management ⁽²⁷⁾. Because LCA generates complex technical information, environmental labels seek to simplify these data into accessible visual formats that facilitate rapid interpretation by consumers with different levels of environmental literacy ^{(27) (28)}.

Several environmental labelling systems have been developed during the last decade. Some communicate a single environmental indicator, such as carbon footprint, while others integrate multiple dimensions of sustainability into composite scores or interpretative classifications ^(27, 28). Multi-indicator approaches are particularly relevant because food sustainability is inherently multidimensional and cannot be adequately represented by a single metric. In addition to greenhouse gas emissions, environmental impacts include freshwater use, land use, biodiversity loss, eutrophication potential, and resource depletion, all of which contribute to the overall environmental performance of food products ⁽²⁷⁾.

Different communication formats have been proposed to facilitate consumer understanding, including numerical values, logos, letter grades, color-coded scales, and traffic-light systems ^(27, 28). Among these, interpretative labels are particularly relevant because they reduce the cognitive effort required to process complex information and allow consumers to compare alternatives rapidly without requiring technical knowledge of environmental assessment methodologies ⁽²⁷⁻²⁹⁾. By presenting simplified visual information, these labels may facilitate decision-making and increase the salience of sustainability considerations during food selection ⁽²⁹⁾.

Beyond their informative function, environmental labels have the potential to improve transparency throughout food supply chains. They provide consumers with information that would otherwise remain inaccessible while simultaneously encouraging producers, retailers, and food service providers to improve the environmental performance of their products and services ⁽²⁸⁾. Consequently, environmental food labelling may generate benefits beyond individual consumer behaviour by stimulating innovation, sustainable procurement practices, and the development of foods associated with lower environmental impacts ⁽²⁸⁾.

The increasing adoption of environmental food labels is supported by evidence demonstrating that consumers show growing interest in sustainability information when making food choices. Nevertheless, several studies indicate that consumers often experience difficulties interpreting environmental information and comparing products, particularly when labels are complex or inconsistent across different schemes ⁽²⁸⁾. Therefore, the design of environmental labels plays a fundamental role in determining their effectiveness, highlighting the importance of simple, credible, and easily interpretable communication formats capable of supporting informed and sustainable food choices ^(27, 28).

Although environmental food labels have considerable potential to improve consumer information and promote sustainable diets, their actual effectiveness in changing food choices remains a subject of ongoing research ⁽²⁷⁾. The relationship between environmental information and consumer behaviour is complex and influenced by multiple individual, social, and contextual factors. Consequently, the presence of an environmental label does not necessarily translate into changes in purchasing decisions or food selection, highlighting the importance of

understanding how consumers perceive, interpret, and use sustainability information ^(27, 28).

Systematic evidence suggests that environmental sustainability labels can positively influence the selection, purchase, and consumption of foods associated with lower environmental impacts. Potter et al. reviewed experimental studies evaluating environmental food labels and concluded that these interventions generally encourage more sustainable food choices, although the magnitude of their effects varies considerably according to label design, food category, and study context ⁽²⁷⁾. The authors also highlighted the limited number of real-world interventions, emphasising the need for additional studies conducted in natural food environments rather than hypothetical purchasing scenarios.

Consumer understanding represents one of the main determinants of environmental label effectiveness. Sustainability information is frequently perceived as complex, particularly when communicated through numerical values or technical indicators without contextual interpretation. Narrative evidence suggests that interpretative labels based on colors, symbols, summary scores or traffic-light systems facilitate information processing, reduce cognitive effort and improve the usability of sustainability information, thereby increasing the likelihood that environmental criteria will be incorporated into food choices ^(28, 30). This simplified presentation is particularly important in institutional food environments, where food choices are frequently made within a limited period and under routine conditions.

Behavioral science provides further evidence that modifying the food environment can promote healthier and more sustainable choices without restricting consumer freedom. Interventions combining simplified information, visual cues and increased availability of sustainable options have consistently demonstrated positive effects on food selection in real-life settings, highlighting the importance of integrating environmental labelling within broader food environment strategies ^(24, 30)

However, consumer responses to environmental labels are heterogeneous and influenced by several factors, including environmental awareness, nutritional knowledge, personal values, socioeconomic characteristics, price sensitivity, and habitual food preferences ^(27, 28). Taste, convenience, and cost frequently remain

the primary determinants of food choice, while environmental considerations tend to play a secondary role. Consequently, the effectiveness of environmental labels is likely to depend on the interaction between consumer characteristics and the food environment in which decisions are made.

Evidence from systematic reviews further suggests that the effectiveness of environmental interventions depends not only on the information provided but also on the context in which food choices are made. Real-life behavioral interventions, including environmental labelling, menu redesign, increased availability of sustainable options, and informational prompts, have demonstrated the potential to encourage more sustainable dietary behaviours by modifying the food environment rather than relying exclusively on individual motivation. These findings highlight the importance of combining environmental information with structural changes that facilitate sustainable choices, particularly in institutional settings where food decisions are made routinely and repeatedly ⁽³¹⁾.

Evidence also suggests that consumers demonstrate a positive willingness to support environmentally sustainable foods when credible sustainability information is provided. A systematic review and meta-analysis of discrete choice experiments reported that environmental sustainability labels are generally associated with higher willingness-to-pay values, indicating that consumers recognise and value environmental information during food purchasing decisions ⁽³²⁾. Nevertheless, the strength of these effects varies according to product category, label format, and consumer trust, reinforcing the importance of transparent and scientifically robust environmental communication.

Taken together, these findings indicate that environmental food labels should not be considered isolated interventions but rather components of broader strategies designed to promote sustainable diets. Their effectiveness appears to increase when combined with supportive food environments, educational initiatives, improved availability of sustainable options, and institutional policies that facilitate healthier and more environmentally responsible food choices ^(27-29, 32).

Although environmental food labelling has shown promising results in experimental settings, evidence from real-life university food environments remains limited, particularly regarding multi-indicator labelling systems integrating carbon footprint, water footprint and land use. Addressing this gap is

essential to better understand whether environmental information can effectively influence meal choices in institutional settings and support the transition towards more sustainable food systems. Against this background, the present study aimed to implement and evaluate a multi-indicator environmental labelling system in university canteens, assessing its influence on consumer food choices and perceptions.

2. Objectives

2.1 General objective

To evaluate the impact on consumer choice of implementing an environmental labelling strategy at university canteens' menus.

2.2 Specific objectives

1. To calculate the environmental impact of the menu, considering carbon footprint, water footprint, and land use indicators;
2. To classify the environmental impact of the menu, according to the thresholds proposed for the Portuguese population's dietary intake;
3. To compare the food choices of canteen users before and after the labelling system implementation;
4. To evaluate the perception and understanding of the environmental label featured on the menu;
5. To identify the main determinants influencing meal selection;
6. To analyze the intention to choose more sustainable meals following the implementation of the tool.

3. Methods

3.1 Meal options included in the environmental assessment

The study was conducted in a university canteen at the University of Aveiro, which serves approximately 1,000 meals per day. All the meal options offered daily for main dish were analyzed over a four-week cycle of rotating menus in place during the 2025/2026 academic year: meat, fish, diet and vegetarian dish. The diet dish was characterised by the use of simpler seasonings and cooking methods, predominantly boiling and grilling, resulting in meals with a lower energy content. Vegetarian dishes were defined as meals that did not contain any ingredients of animal origin, according Portuguese Law no. 11/2017 ⁽³³⁾.

These options differed in terms of availability, composition, and purpose. At lunch, meat, fish, diet and vegetarian dishes were available from Monday to Friday. At dinner, only meat or fish dishes and a vegetarian option were available. During weekends, both at lunch and dinner, meat or fish dishes and a vegetarian option were available. Whenever necessary, a backup dish was used in situations where one of the planned menu options was unavailable.

The analysis focused exclusively on the main dishes available on the menu. Soup and dessert were not considered in the present evaluation.

3.2. Study design

The study adopted a quantitative, descriptive, and quasi-experimental design, with data collection conducted before and after the implementation of an environmental labelling system on the menus.

3.3. Population and sample

The target population consisted of students and staff of the University of Aveiro aged 18 years and older who attended the university canteen during the intervention period. The sample, of a non-probabilistic convenience nature,

included all individuals who used the canteen during the data collection period and voluntarily agreed to participate by completing the administered questionnaire, following informed consent.

3.4. Environmental sustainability indicators and menu assessment

The identification of the environmental sustainability indicators used in this study was based on a literature review conducted between October and November 2025. The indicators selected were those most commonly applied in food labelling systems, with greater data availability and the ability to clearly communicate the environmental impacts of meals to consumers, namely greenhouse gas (GHG) emissions (carbon footprint), water consumption associated with food production (water footprint), and land use ⁽³⁴⁾.

The assessment of menu sustainability focused exclusively on the environmental domain. For this purpose, the reference values established by Lukas et al. (2015) were adopted, as adapted by Selivanova (2025) for the portuguese population and for the specific characteristics of the meals analysed in this study.

Considering the age range of the study population (≥ 18 years), 30% of the recommended daily energy intake was allocated to each main meal (lunch and dinner) ⁽³⁵⁾.

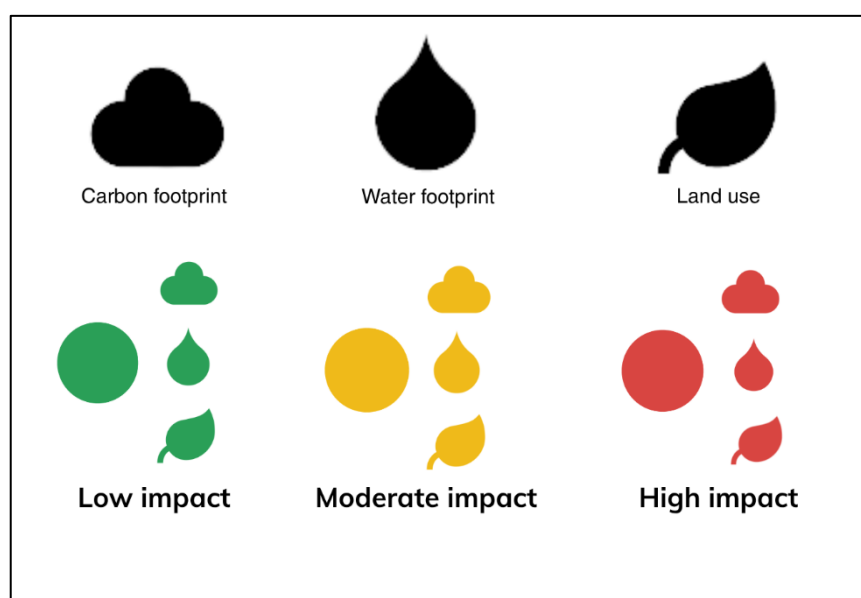
The environmental labelling system developed in this study is based on three main indicators: carbon footprint, water footprint, and land use. The thresholds used to classify the environmental impact of food consumption in the Portuguese population, for both lunch and dinner meals, were those proposed by Selivanova A. (2025) ⁽³⁶⁾ (Table 1).

The classification of the environmental impact of meals was carried out using a traffic light-type color-coded system (Figure 1) (green - low impact, yellow - moderate impact, and red - high impact), allowing for a rapid and intuitive interpretation by consumers ⁽³⁶⁾.

Table 1 - Thresholds for the environmental impact classification of the lunch and dinner meal.

Indicators	Low impact (green)	Medium impact (yellow)	High impact (red)
Carbon footprint (kg CO ₂ eq./meal)	<0.747	0.747 - 1.121	>1.121
Water footprint (l/meal)	<676.57	676.57 - 1014.85	>1014.85
Land use (m ² /meal)	<1.39	1.39 - 2.09	>2.09

Source: Selivanova A., 2025 ⁽³⁶⁾

**Figure 1** - Color scheme of the Environmental Label.

Different reference databases were considered for the assessment of carbon footprint, water footprint, and land use. For the calculation of the carbon footprint, the *SuEatable Life* database ⁽³⁷⁾ was primarily used. Whenever the required information was not available, complementary data were obtained from the *SHARP ID* ⁽³⁸⁾ and *Big Climate Database* ⁽³⁹⁾, in order to ensure a more comprehensive and reliable estimation ⁽³⁶⁾.

The assessment of the water footprint was also based on data available from the *SuEatable Life* database ⁽³⁷⁾, which provides approximate values for water

consumption across the food life cycle. Land use was calculated using data from the *SHARP ID* database ⁽³⁸⁾, which includes specific indicators related to land use in agricultural and livestock production systems ⁽³⁶⁾.

In line with the methodology used by *Bôto et al.* (2024), whenever data for a specific food item were unavailable, the highest recorded value for a food within the same subgroup was used. When specific information was not available for multi-ingredient foods or ultra-processed products, the highest individual footprint of one of the product's ingredients was applied. In cases where multiple datasets existed for the same product (e.g., dried, frozen, or fresh), the mean value was used ⁽²⁰⁾.

The water footprint of fish and seafood associated with marine capture fisheries and marine aquaculture was considered to be zero, as freshwater use in these systems is negligible. For freshwater aquaculture, and due to the high variability in freshwater requirements preventing the use of a reliable estimate the water footprint was also assumed to be zero ^(17, 20, 36, 40, 41)

Ingredients used in quantities below 1,5 g were not considered in the calculation of environmental footprints ⁽³⁶⁾.

3.5. Data collection

3.5.1 Meal choice data collection

Food choice data were obtained using the Unicaard - Meal Management System, which records the type of dish selected at the point of sale. Meal payments are made using a student or staff card, and each transaction is automatically recorded within the platform, together with the user's sex and institutional affiliation.

Unicaard data were collected over one week at four different time points. The first data collection took place four weeks before the introduction of the environmental label and the first questionnaire administration. The second data collection coincided with the first phase, at the start of the intervention. The third took place during the second phase. The fourth took place four weeks after the second questionnaire administration, by which time the environmental label had been continuously displayed for eight weeks. At both time points, data were

collected during week 4 of the four-week rotating menu cycle. This ensured that the same meal options were available in all four periods, allowing a direct comparison of meal choices.

3.5.2 Questionnaire data collection

A questionnaire was developed to assess the perception and influence of the environmental label on users' food choices, and its administration was structured in two phases, each lasting one week: the first phase, corresponding to the initial implementation of the environmental label, and the second phase, four weeks later. The environmental label remained continuously available after its introduction. Although the environmental footprint was calculated for all meal options across the full four-week menu cycle, questionnaire data were collected only during week 4 of the rotating menu cycle in both phases, consistent with the Unicard data collection and ensuring that the same meal options were available for comparison. The questionnaire was administered through the online platform forms.ua.pt.

Before questionnaire administration, a pilot test was conducted with 15 participants with characteristics similar to those of the target population, aiming to assess the clarity and accessibility of the questions, the average time required to complete the questionnaire, the adequacy of the language used, and to collect suggestions for improvement. All feedback obtained was reviewed and incorporated to optimize the clarity and robustness of the instrument.

The questionnaire was divided into three sections (Appendix 1): (I) informed consent, (II) visual perception and evaluation of the environmental label, and (III) sample characterization.

The first section was dedicated to informed consent. In the second section, participants were asked about the presence of the environmental label, the level of difficulty in interpreting it, and the extent to which it influenced their meal choice. In the second phase of questionnaire administration, an additional question was included regarding the dish selected by the participant in that specific meal. Participants were then asked to identify, in order of importance,

the three main determinants influencing their food choice. At this stage, the probability of choosing more sustainable meals in the canteen was also assessed, along with suggestions for improving the labelling system.

The third section aimed to characterize the participants' sociodemographic profile, including sex, age, educational level, relationship with the institution, field of study ⁽⁴²⁾, student residence status (local or non-local), and frequency of canteen use. Local students were defined as those living in their home region or city, whereas non-local students were those studying away from their home region or city.

The same questionnaire was administered to both students and staff and was made available in Portuguese (Portugal) and English to ensure accessibility to the entire target population.

Following the analysis of predominant food choices, the questionnaire was made available to the academic community in digital format via a QR code after the meal service. Participation was voluntary and responses were confidential.

3.5.3 Intervention

The environmental labelling system was implemented once, coinciding with the first phase, and remained continuously displayed to canteen users throughout the study period, including the second phase. The intervention consisted of making information on the environmental impact of meals available at different points of contact with canteen users, ensuring this information was accessible before meal selection, and covered lunch and dinner services from Monday to Sunday in both weeks.

An explanation of the environmental label was displayed in the canteen access area, namely along the waiting line (Figure 2). Throughout this path, the menu with the corresponding environmental impact information for each meal was also displayed, allowing users to be exposed to the information prior to selecting their meal (Figure 3). In addition to being displayed physically, the menu was also available online (Figure 4), including the respective environmental label. For takeaway service users, and as it was not possible to integrate the questionnaire

into the ordering platform, access was provided via a leaflet containing an explanation of the environmental label and a corresponding QR code (Figure 2).

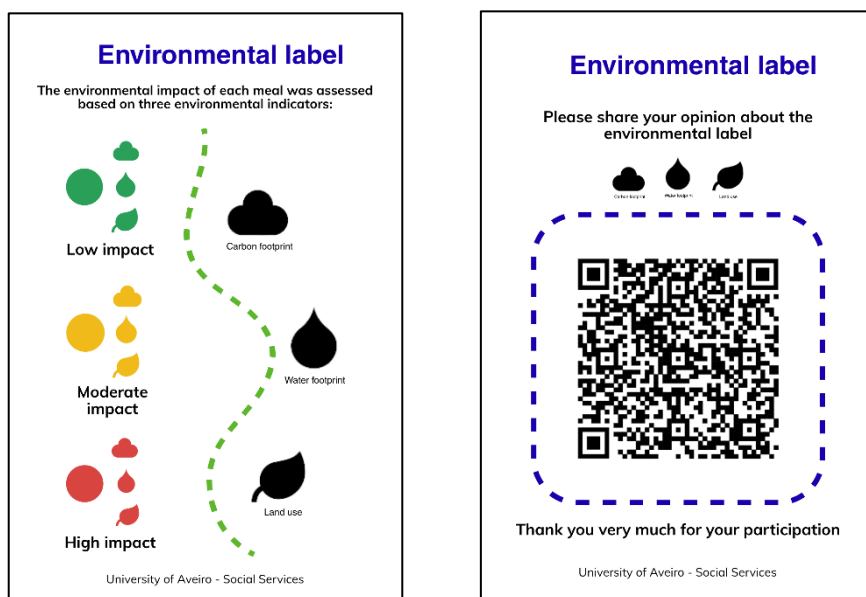


Figure 2 - Informational leaflet on the environmental label.

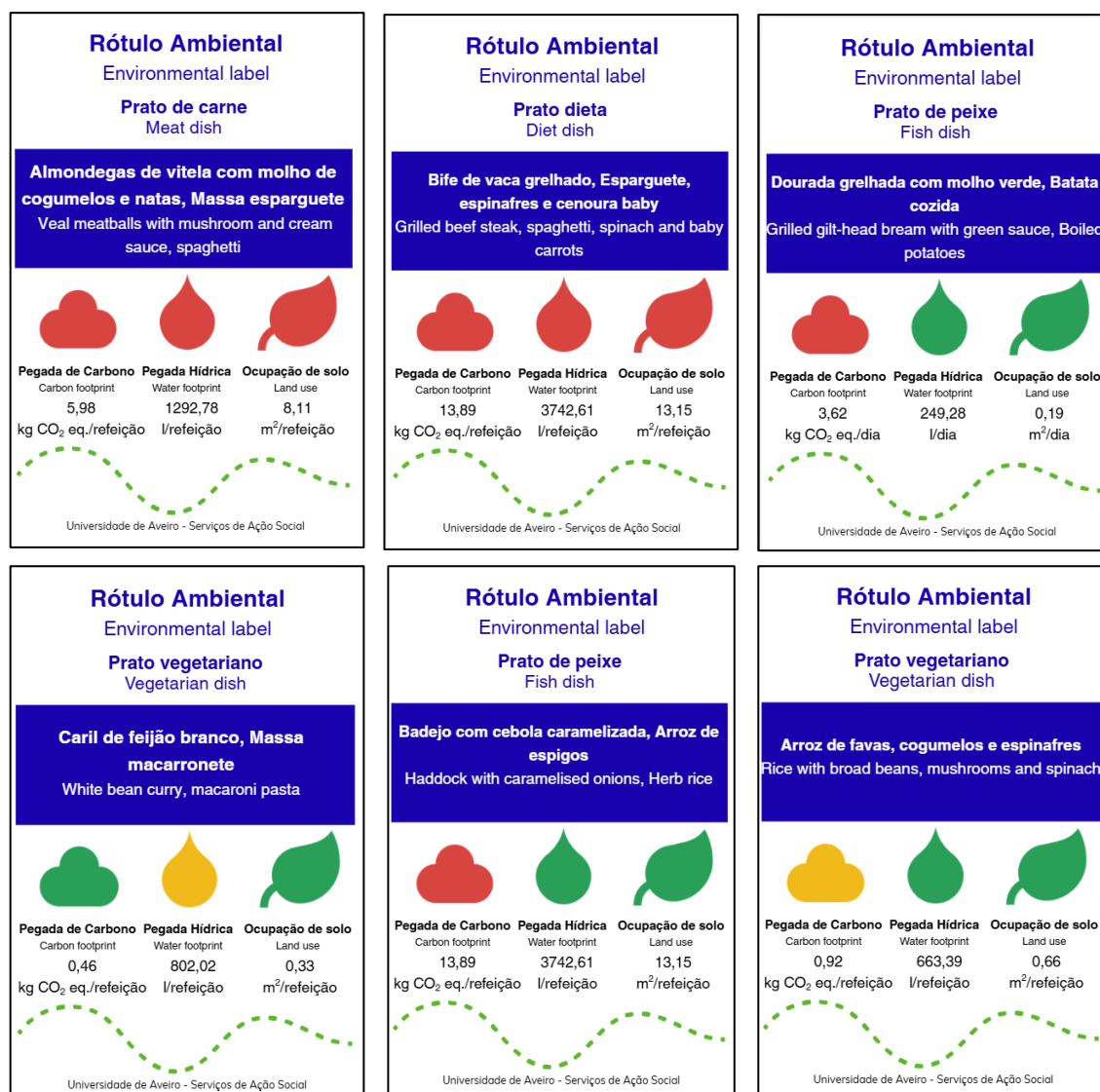


Figure 3 - Menu available in the canteen access area (serving line).

Dia	Ementa
Almoço Quarta 08/04/2026	Sopa - Sopa juliana   
	Carne - Almondegas de vitela com molho de cogumelos e natas 1,6,10,12 Massa esparguete 1,3   
	Dieta - Bife de vaca grelhado Massa esparguete, espinafres e cenoura baby 1,3   
	Peixe - Dourada grelhada com molho verde 1,2,4,6,10,11,12,14 Batata cozida   
	Vegetariana - Caril de feijão branco 1,5,6,8,10,11 Massa macarronete 1,3   
Legendas relativas ao rótulo ambiental e alergénios no rodapé desta página.	
Jantar Quarta 08/04/2026	Sopa - Sopa juliana   
	Peixe - Badejo com cebola caramelizada 1,2,4,6,10,12,14 Arroz de espigos   
	Vegetariana - Arroz de favas, cogumelos e espinafres 1,6,10,12   
Legendas relativas ao rótulo ambiental e alergénios no rodapé desta página.	

Figure 4 - Screenshot of the online menu platform with environmental labelling, presented in Portuguese.

Additionally, the questionnaire was made available through QR codes placed on dining tables and via the leaflet distributed in the takeaway service.

During the intervention, the menu was displayed along the serving line, and an email was sent to the academic community to clarify the meaning of the environmental label and inform users where it was available.

3.5.4 Ethical considerations

The study was conducted in accordance with the ethical principles for research involving human participants and received approval from the Ethics Committee of the Faculty of Nutrition and Food Sciences of the University of Porto (FCNAUP), under opinion nº 224/2026. Prior to participation, all participants were provided with detailed information regarding the objectives, procedures, confidentiality, and voluntary nature of the study and gave their informed consent electronically before accessing the questionnaire. Participation was entirely voluntary, and participants could withdraw from the study at any time without any consequences. Data were collected anonymously, ensuring that no personally identifiable information was recorded. Furthermore, data extracted from the Unicard Meal Management System were anonymized prior to analysis, guaranteeing that

participants could not be identified at any stage of the study. All information was treated confidentially and used exclusively for research purposes, in accordance with the General Data Protection Regulation (GDPR) and applicable national legislation.

4. Results

4.1 Environmental footprint assessment of the daily menus

The environmental assessment of the seven-day menu cycle revealed considerable variability in carbon footprint, water footprint, and land use across the different meal options (Table 2). Meat-based dishes consistently presented the highest environmental impacts, with most exceeding the defined thresholds for all three indicators and therefore being classified in the red category. In particular, dishes containing lamb, beef and veal showed the highest greenhouse gas emissions, and also contributed to the highest mean carbon footprint among meal types (5.77 kg CO₂ eq/meal), followed by fish (3.35 kg CO₂ eq/meal), diet (2.28 kg CO₂ eq/meal) and vegetarian meals (0.73 kg CO₂ eq/meal). Overall, vegetarian dishes, particularly those based on tofu, pulses and cereals, exhibited the lowest environmental impacts and were predominantly classified as green across the three indicators. Fish dishes generally showed intermediate environmental impacts, whereas diet dishes performed better than both meat- and fish-based options, particularly regarding water footprint and land use.

The water footprint of the meals also showed considerable variability across the menu analysed, ranging from 194.9 to 4372.6 L/meal. When grouped by meal type, meat dishes presented the highest mean water footprint (1985.27 L/meal), followed by vegetarian (935.29 L/meal), diet (673.97 L/meal) and fish dishes (408.12 L/meal). The higher mean water footprint observed for meat dishes was mainly driven by beef- and veal-based recipes, whereas the intermediate mean value for vegetarian dishes was influenced by specific ingredients, particularly legumes. Overall, diet and fish dishes presented lower mean water footprint values, although some variability was observed depending on the species and recipe composition.

Land use also varied substantially across the meals included in the menu cycle (Table 2), ranging from 0.15 to 16.75 m²/meal. When grouped by meal type, meat dishes presented the highest mean land use (6.05 m²/meal), followed by diet (1.72 m²/meal), fish (0.65 m²/meal) and vegetarian dishes (0.59 m²/meal).

Table 2 - Environmental footprint assessment of the daily menus.

Day of intervention	Meal	Dish	Menu	Carbon footprint (Kg CO ₂ -eq./meal)	Water footprint (l/meal)	Land use (m ² /meal)
Day 1	Lunch	Fish	Baked salmon with aromatic herb crust, Mashed potatoes	1.27 	468.5 	1.28 
Day 1	Lunch	Diet	Grilled salmon, Boiled potatoes, Broccoli	1.22 	211.9 	1.00 
Day 1	Lunch	Meat	Chickpea Ranch, Noodle Pasta	7.54 	2701.9 	8.2 
Day 1	Lunch	Vegetarian	Red bean chilli, Brown rice	0.73 	646.82 	0.73 
Day 1	Dinner	Meat	Beef steak with beer sauce, Bay rice	14.2 	3587.6 	1.34 
Day 1	Dinner	Vegetarian	Mushroom burger with caramelized onions, Rustic fries	0.38 	491 	0.73 
Day 2	Lunch	Meat	Turkey cutlets with orange, Pasta	2.04 	1455.88 	3.77 
Day 2	Lunch	Diet	Grilled turkey steak, Rice, Spinach and leek	2.06 	1186.82 	3.17 
Day 2	Lunch	Fish	Monkfish rice	4.79 	287.42 	0.33 
Day 2	Lunch	Vegetarian	Portuguese broad beans, Boiled potatoes	0.73 	706 	0.77 
Day 2	Dinner	Fish	Roasted sea bass with peppers, Roasted potatoes	7.67 	382.98 	2.04 
Day 2	Dinner	Vegetarian	Lentil Bolognese, Whole meal Spaghetti	0.36 	437.26 	0.33 
Day 3	Lunch	Fish	Roasted perch loin with lemon sauce and spices, Baked potatoes	3.82 	341.94 	0.26 
Day 3	Lunch	Diet	Grilled perch loin, Boiled potatoes, courgette and eggplant	4.18 	290.66 	0.23 
Day 3	Lunch	Meat	Veal chilli, Rice	6.80 	3455.97 	11.3 
Day 3	Lunch	Vegetarian	Polenta with ratatouille	0.69 	198.23 	0.25 
Day 3	Dinner	Meat	Turkey cubes with sweet and sour sauce, Spiral dough	2.14 	1327.78 	3.16 

Day of intervention	Meal	Dish	Menu	Carbon footprint (Kg CO ₂ -eq./meal)	Water footprint (l/meal)	Land use (m ² /meal)
Day 3	Dinner	Vegetarian	Pepper stuffed with black-eyed peas and vegetables, Brown rice	1.04 	1008.37 	0.49 
Day 4	Lunch	Meat	Roast Pork Loin with Rosemary, Rice	2.95 	1643.18 	4.37 
Day 4	Lunch	Diet	Grilled pork ribs, Rice, Cauliflower and green beans	2.82 	1485.54 	4.04 
Day 4	Lunch	Fish	Tentacles of pota à lagareiro, Potato with punch	3.60 	374.35 	0.33 
Day 4	Lunch	Vegetarian	Soy lasagne	0.88 	753.11 	0.84 
Day 4	Dinner	Fish	Tuna pasta with mushrooms and cream	2.06 	540.4 	0.54 
Day 4	Dinner	Vegetarian	Gomes de Sá Tofu, Boiled Potato	0.34 	430.39 	0.66 
Day 5	Lunch	Fish	Fried cod, bean Rice	1.37 	506.77 	0.45 
Day 5	Lunch	Diet	Cooked cod, Boiled potatoes, Cabbage and carrots	1.12 	194.94 	0,15 
Day 5	Lunch	Meat	Lamb stew, Boiled potatoes	17.89 	1688.8 	16.75 
Day 5	Lunch	Vegetarian	Valencian-style Brown rice	0.80 	446.33 	0.57 
Day 5	Dinner	Meat	Barbecue chicken, French fries	1.02 	1129.11 	4.23 
Day 5	Dinner	Vegetarian	Lentil roll with mushroom sauce	1.76 	614.62 	0.5 
Day 6	Lunch	Meat	Grilled chicken steak with onion, Spaghetti pasta	0.99 	1224.35 	3.09 
Day 6	Lunch /Dinner	Vegetarian	Butter bean and vegetable casserole, Whole wheat pasta	0.50 	908.4 	0.60 
Day 6	Dinner	Fish	Cod pastries, Naughty tomato rice	1.68 	401.48 	0.22 
Day 7	Lunch	Fish	Roast perch with butter sauce, Roast potatoes with rosemary	3.86 	369.25 	0.38 
Day 7	Lunch / Dinner	Vegetarian	Quinoa salad with chickpeas	0.56 	647.6 	0.60 
Day 7	Dinner	Meat	Pork curry, Rice	3.02 	1638.15 	4.31 

4.2 Food choices before and after the implementation of the environmental labelling system

Food choice data obtained through the Unicard Meal Management System, expressed as the percentage of meals served corresponding to the meal options classified as having the highest and lowest environmental impact, varied across the seven days of the evaluated menu week and across the four data collection time points: 4 weeks before the first phase, during the first phase, the second phase, and 8 weeks after the first phase.

On Day 1 (Figure 5), the highest-impact meal accounted for 24.21% of meals served 4 weeks before the first phase, increasing to 33.14% during the first phase and to 39.13% during the second phase, before decreasing to 26.45% 8 weeks after the first phase. The lowest-impact meal accounted for 1.45%, 3.28%, 2.48% and 2.34% of meals served at the same time points, respectively.

On Day 2 (Figure 6), the highest-impact meal accounted for 75.79% of meals served 4 weeks before the first phase, decreasing to 53.92% during the first phase and to 48.82% during the second phase, before increasing to 74.85% 8 weeks after the first phase. The lowest-impact meal accounted for 4.21%, 7.47%, 4.91% and 4.39% of meals served, respectively.

On Day 3 (Figure 7), the highest-impact meal accounted for 57.89% of meals served 4 weeks before the first phase, decreasing to 52.28% during the first phase, remaining similar during the second phase (53.64%), and decreasing further to 41.32% at 8 weeks after the first phase. The lowest-impact meal accounted for 2.33%, 2.00%, 2.74% and 2.79% of meals served, respectively.

On Day 4 (Figure 8), the highest-impact meal accounted for 58.98% of meals served 4 weeks before the first phase, decreasing to 53.70% during the first phase and to 41.08% during the second phase, before returning to a similar level, 8 weeks after the first phase (59.56%). The lowest-impact meal accounted for 1.65%, 2.35%, 2.10% and 1.79% of meals served, respectively.

On Day 5 (Figure 9), the highest-impact meal accounted for 51.40% of meals served, 4 weeks before the first phase, decreasing to 45.81% during the first phase and to 37.77% 8 weeks after the first phase. The lowest-impact meal accounted for 4.90%, 7.46% and 6.40% of meals served at the same time points, respectively.

No meals were served during the second phase on this day owing to a canteen strike.

On Day 6 (Figure 10), the highest-impact meal accounted for 66.53% of meals served 4 weeks before the first phase, decreasing progressively to 57.93% during the first phase, 54.02% during the second phase and 55.17%, 8 weeks after the first phase. The lowest-impact meal accounted for 1.66%, 3.07%, 2.32% and 2.22% of meals served, respectively.

On Day 7 (Figure 11), the highest-impact meal accounted for 75.57% of meals served 4 weeks before the first phase, decreasing to 59.88% during the first phase and to 55.42% during the second phase, and decreasing further to 26.95% 8 weeks after the first phase. The lowest-impact meal accounted for 3.43%, 2.79%, 3.97% and 3.68% of meals served, respectively.

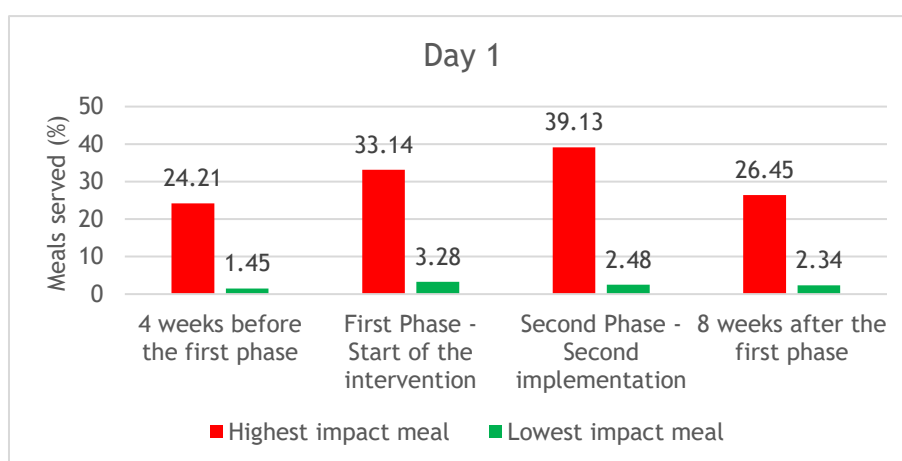


Figure 5 - Food choices before and after the implementation of the environmental labelling system - Day 1.

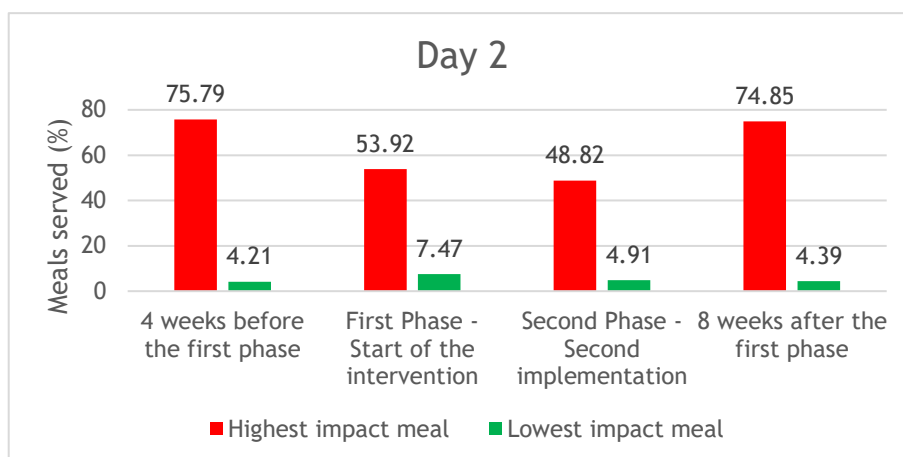


Figure 6 - Food choices before and after the implementation of the environmental labelling system - Day 2.

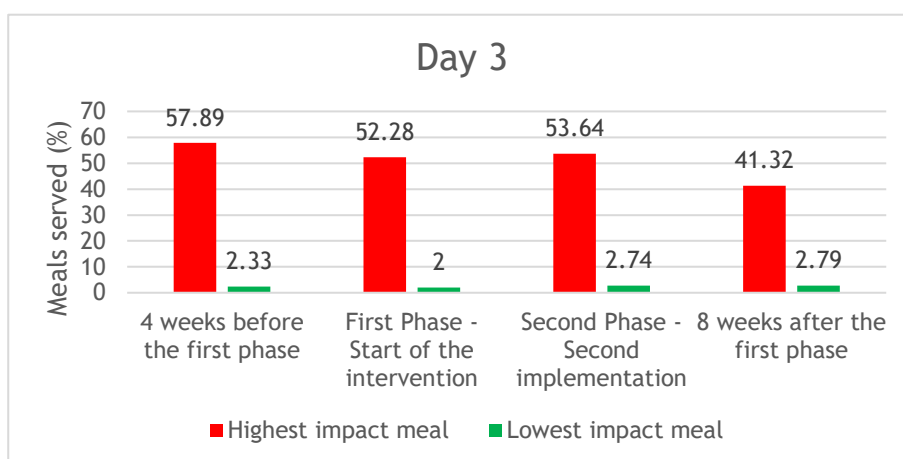


Figure 7 - Food choices before and after the implementation of the environmental labelling system - Day 3.

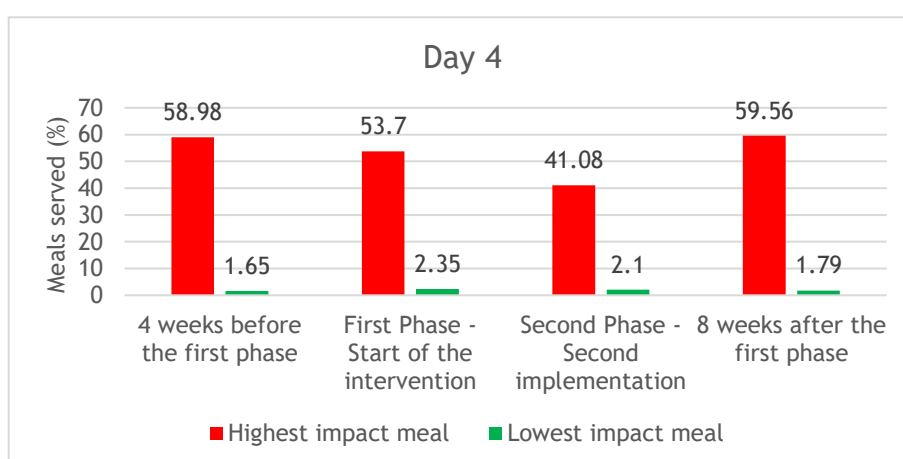


Figure 8 - Food choices before and after the implementation of the environmental labelling system - Day 4.

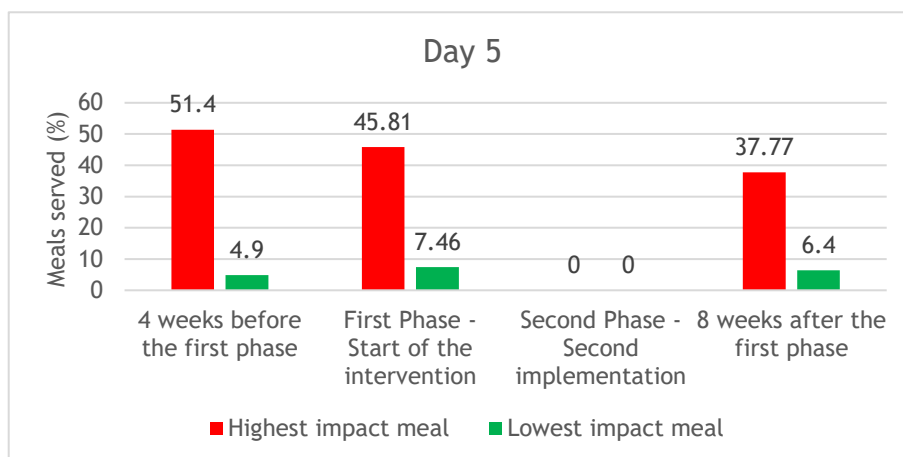


Figure 9 - Food choices before and after the implementation of the environmental labelling system - Day 5.

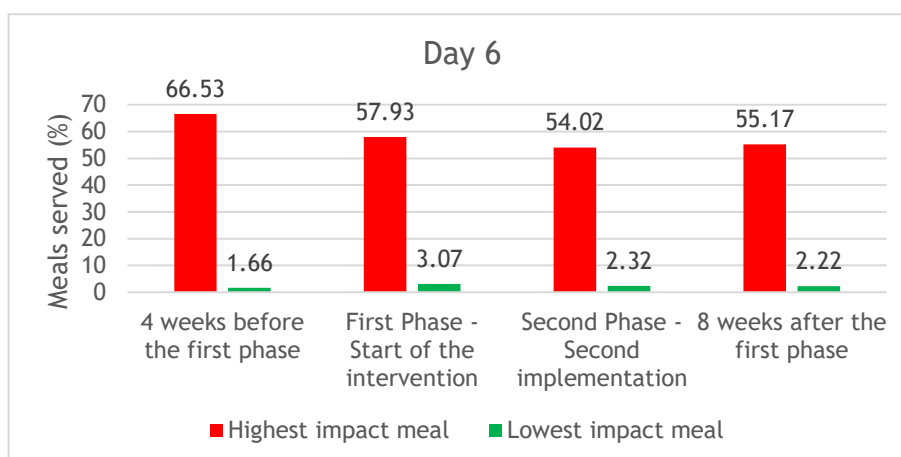


Figure 10 - Food choices before and after the implementation of the environmental labelling system - Day 6.

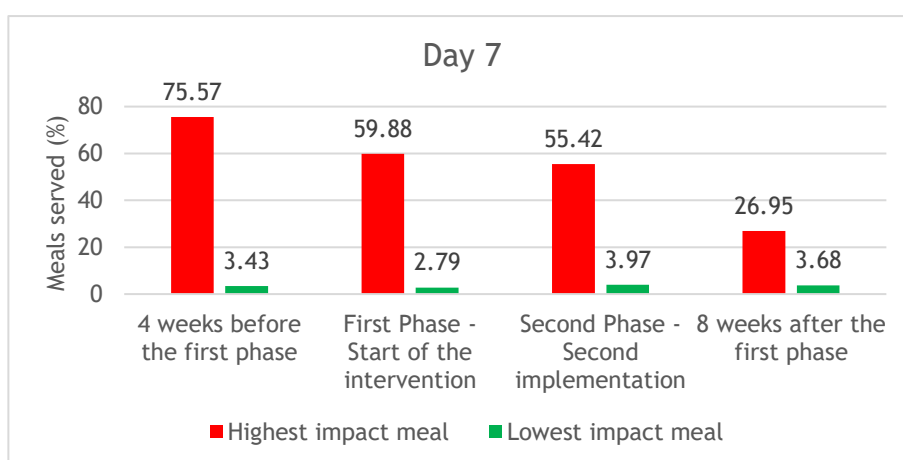


Figure 11 - Food choices before and after the implementation of the environmental labelling system - Day 7.

4.3 Sample characteristics

The characteristics of the study population are presented in Table 3 for the overall sample and separately for the periods before and after the implementation of the environmental labelling intervention.

A total of 1186 participants completed the questionnaire and were included in the study. The study population was predominantly composed of male participants (57.9%, $n = 687$), while 38.7% ($n = 459$) were female and 3.4% ($n = 40$) preferred not to disclose their sex. Participants ranged from 18 to 67 years old, with a mean ($\pm$ SD) age of 23.1 (± 6.9) years.

The majority of respondents were students (94.1%, $n = 1,116$), while 5.9% ($n = 70$) were staff members. Among student participants, 56% ($n = 625$) were non-local and 44% ($n = 491$) were local. Most participants indicated that secondary education was the highest level of education they had completed. Science and Technology was the predominant field of study (62.3%, $n = 695$), followed by Information Technology and Computer Science (16%, $n = 179$) and Arts, Humanities and Communication (6.3%, $n = 70$). The characteristics of the study population are presented in Table 3 for the overall sample and separately for the periods before (1st phase) and after the implementation (2nd phase) of the environmental labeling intervention.

Most participants reported using the university canteen on a regular basis, with 38.0% ($n = 451$) attending 3-4 times per week and 33.4% ($n = 396$) attending five or more times per week. Lunch was the meal most frequently consumed at the university canteen, accounting for 74.5% ($n = 884$) of participants, whereas 25.5% ($n = 302$) usually attended the dinner service, (Table 3).

Table 3 - Characteristics of the study population

Characteristics	Total, % (n)	1 st phase % (n)	2 nd phase % (n)
Sex			
Female	38.7 (459)	38.4 (349)	39.6 (110)
Male	57.9 (687)	58.5 (531)	56.1 (156)
Prefer not to disclose	3.4 (40)	3.1 (28)	4.3 (12)

Characteristics	Total, % (n)	1 st phase % (n)	2 nd phase % (n)
Relationship with the institution			
Student	94.1 (1116)	94.1 (854)	94.2 (262)
Staff	5.9 (70)	5.9 (54)	5.8 (16)
Student type			
Non-local student	56 (625)	52.6 (449)	63.3 (176)
Local student	44 (491)	47.4 (405)	32.8 (86)
Highest level of education completed			
Basic education (9th grade)	0.3 (3)	0.1 (1)	0.7 (2)
Secondary education (12th grade)	50.2 (595)	48.2 (438)	56.5 (157)
Bachelor's degree	30.3 (359)	31.7 (288)	25.5 (71)
Master's degree	13.5 (160)	14.8 (134)	9.4 (26)
Doctoral degree (PhD)	5.1 (61)	4.3 (39)	7.9 (22)
Other	0.7 (8)	0.9 (8)	0 (0)
Field of study			
Arts, Humanities and Communication	6.3 (70)	6.9 (59)	4.2 (11)
Agricultural and Environmental Sciences	1.8 (20)	1.9 (16)	1.5 (4)
Science and Technology	62.3 (695)	62.4 (533)	61.8 (162)
Economics, Management and Law	5.3 (59)	5.6 (48)	4.2 (11)
Social Sciences and Humanities	3.8 (42)	3.6 (31)	4.2 (11)
Education and Training	1.5 (17)	1.5 (13)	1.5 (4)
Health Sciences	2.6 (29)	2.6 (22)	2.7 (7)
Information Technology and Computer Science	16 (179)	15.1 (129)	19.1 (50)
Tourism, Leisure and Services	0.4 (5)	0.4 (3)	0.8 (2)
Frequency of university canteen use			
1-2 times per week	21.6 (256)	21.6 (196)	21.6 (60)

Characteristics	Total, % (n)	1 st phase % (n)	2 nd phase % (n)
3-4 times per week	38 (451)	38.1 (346)	37.8 (105)
5 or more times per week	33.4 (396)	33.7 (306)	32.4 (90)
Rarely	7 (83)	6.6 (60)	8.3 (23)
Meal usually consumed at the university canteen			
Lunch	74.5 (884)	74.1 (673)	75.9 (211)
Dinner	25.5 (302)	25.9 (235)	24.1 (67)

4.4 Influence of the environmental label on food choices

4.4.1 Influence of the environmental label on food choices by sex

A significant association was observed between sex and participants' likelihood of choosing more sustainable meal options after viewing the environmental labels ($p < 0.001$) (Table 4). The highest proportions of female participants selected the response "Likely" (39.7%), followed by "Indifferent" (27.0%). Among male participants, the most frequent responses were "Likely" (27.2%), "Not very likely" (25.6%), and "Indifferent" (24.5%), as shown in Table 4. Only a small proportion of participants in both groups reported being "Very likely" to choose more sustainable options.

Table 4 - Likelihood of choosing more sustainable options in the cafeteria after viewing the environmental labels, by sex (% (n)).

After seeing the environmental labels, how likely are you to choose more sustainable options in the cafeteria?	Female % (n)	Male % (n)	Prefer not to disclose % (n)	p
Not at all likely	8.2 (27)	18.7 (95)	17.9 (5)	<0.001
Not very likely	16.4 (54)	25.6 (130)	28.6 (8)	
Indifferent	27 (89)	24.5 (124)	32.1 (9)	
Likely	39.7 (131)	27.2 (138)	21.4 (6)	
Very likely	8.8 (29)	3.9 (20)	0 (0)	

* p-value according to the Chi-Square test with a 95% confidence level.

A significant association was observed between sex and the perceived influence of the environmental label on meal choice ($p = 0.006$). “Not at all determinant” was the most frequently selected response across all groups, accounting for 33.4% of female participants and 47.5% of male participants. Among female participants, “Slightly determinant” (32.8%) and “Moderately determinant” (24.6%) were also commonly reported responses. Overall, female participants tended to report higher levels of influence of the environmental label on meal choice than male participants (Table 5).

Table 5 - Extent to which the environmental label influenced meal choice, by sex (% (n))

To what extent did the environmental label influence your meal choice?	Female % (n)	Male % (n)	Prefer not to disclose % (n)	p
Not at all determinant	33.4 (110)	47.5 (241)	53.6 (15)	0.006
Slightly determinant	32.8 (108)	28.8 (146)	32.1 (9)	
Moderately determinant	24.6 (81)	17 (86)	14.3 (4)	
Highly determinant	6.1 (20)	4.7 (24)	0 (0)	
Completely determinant	3 (10)	2 (10)	0 (0)	

* p-value according to the Chi-Square test with a 95% confidence level.

4.4.2 Influence of the environmental label on food choices by student residence status

No significant association was found between student residence status and the likelihood of choosing more sustainable meal options after viewing the environmental labels ($p = 0.138$) (Table 6). Across both groups, “Likely” was the most frequently selected response, reported by 33.4% of non-local students and 29.4% of local students. Similar proportions were also observed for the remaining response categories, indicating a broadly comparable distribution of responses between the two groups.

Table 6 - Likelihood of choosing more sustainable options in the cafeteria after viewing the environmental labels, by student residence status (% (n)).

After seeing the environmental labels, how likely are you to choose more sustainable options in the cafeteria?	Non-local student % (n)	Local student % (n)	p
Not at all likely	12.5 (55)	16.2 (60)	0.138
Not very likely	20.2 (89)	25.1 (93)	
Indifferent	27.3 (120)	24.8 (92)	
Likely	33.4 (147)	29.4 (109)	
Very likely	6.6 (29)	4.6 (17)	

* p-value according to the Chi-Square test with a 95% confidence level.

No significant association was found between student residence status and the perceived influence of the environmental label on meal choice ($p = 0.405$) (Table 7). In both groups, “Not at all determinant” was the most frequently selected response, reported by 40.7% of non-local students and 44.1% of local students.

Table 7 - Extent of the environmental label's influence on meal choice, by student residence status.

To what extent did the environmental label influence your meal choice?	Non-local student % (n)	Local student % (n)	p
Not at all determinant	40.7 (179)	44.1 (163)	0.405
Slightly determinant	30 (132)	31.9 (118)	
Moderately determinant	20.9 (92)	18.6 (69)	
Highly determinant	5.5 (24)	3.8 (14)	
Completely determinant	3 (13)	1.6 (6)	

* p-value according to the Chi-Square test with a 95% confidence level.

4.4.3 Influence of environmental labels on sustainable food choices across fields of study

The likelihood of choosing more sustainable meal options after exposure to the environmental labels was analysed according to participants' field of study (Table 8). A significant association was observed between field of study and the likelihood

of choosing more sustainable meal options after viewing the environmental labels ($p = 0.004$). “Likely” was the most frequently selected response in most fields of study, reaching its highest proportions among Education and Training (55.6%), Social Sciences and Humanities (48.1%), and Arts, Humanities and Communication (40.5%). In contrast, students from Information Technology and Computer Science reported the lowest proportion of “Likely” responses (18.5%) and the highest proportion of “Indifferent” responses (32.9%).

Table 8 - Willingness to choose more sustainable options after viewing environmental labels, by field of study

After seeing the environmental labels, how likely are you to choose more sustainable options in the cafeteria?	Not at all likely	Not very likely	Indifferent	Likely	Very likely	p
Arts, Humanities and Communication	16.7 (7)	11.9 (5)	19 (8)	40.5 (17)	11.9 (5)	0.004
Agricultural and Environmental Sciences	11.1 (2)	16.7 (3)	22.2 (4)	33.3 (6)	16.7 (3)	
Science and Technology	11.8 (60)	23.8 (121)	25.1 (128)	34 (173)	5.3 (27)	
Economics, Management and Law	18.9 (7)	21.6 (8)	29.7 (11)	16.2 (6)	13.5 (5)	
Social Sciences and Humanities	7.4 (18.9)	22.2 (6)	14.8 (4)	48.1 (13)	7.4 (2)	
Education and Training	11.1 (1)	11.1 (1)	22.2 (2)	55.6 (5)	0 (0)	
Health Sciences	5 (1)	15 (3)	35 (7)	40 (8)	5 (1)	
Information Technology and Computer Science	23.3 (34)	23.3 (34)	32.9 (48)	18.5 (27)	2.1 (3)	
Tourism, Leisure and Services	33.3 (1)	33.3 (1)	0 (0)	33.3 (1)	0 (0)	

* p-value according to the Chi-Square test with a 95% confidence level.

The perceived influence of the environmental label on meal choice differed significantly across fields of study ($p = 0.002$) (Table 9). “Not at all determinant” was the most frequently selected response in most fields of study, reaching its highest proportions among students from Information Technology and Computer Science

(52.1%) and Economics, Management and Law (48.6%). In contrast, students from Arts, Humanities and Communication reported the highest proportion of responses indicating that the label was “Highly determinant” (17.1%). Across several fields of study, “Slightly determinant” was also commonly selected, particularly among students from Education and Training (50.0%) and Health Sciences (40.0%).

Table 9 - Perceived influence of environmental labels on meal choice, by field of study

To what extent did the environmental label influence your meal choice?	Completely determinant	Highly determinant	Moderately determinant	Slightly determinant	Not at all determinant	<i>p</i>
Arts, Humanities and Communication	4.9 (2)	17.1 (7)	17.1 (7)	26.8 (11)	34.1 (14)	0.002
Agricultural and Environmental Sciences	11.1 (2)	5.6 (1)	16.7 (3)	38.9 (7)	27.8 (5)	
Science and Technology	1.6 (8)	3.7 (19)	22.7 (116)	31.4 (160)	40.6 (207)	
Economics, Management and Law	8.1 (3)	8.1 (3)	21.6 (8)	13.5 (5)	48.6 (18)	
Social Sciences and Humanities	0 (0)	11.1 (3)	18.5 (5)	29.6(8)	40.7 (11)	
Education and Training	0 (0)	12.5 (1)	12.5 (1)	50 (4)	25 (2)	
Health Sciences	0 (0)	10 (2)	15 (3)	40 (8)	35 (7)	
Information Technology and Computer Science	2.7 (4)	1.4 (2)	11.6 (17)	32.2 (47)	52.1 (76)	
Tourism, Leisure and Services	0 (0)	0 (0)	33.3 (1)	0 (0)	66.7 (2)	

* p-value according to the Chi-Square test with a 95% confidence level.

4.4.4 Influence of environmental labels on sustainable food choices by age

Regarding age, the descriptive results showed that participants who reported a greater willingness to choose more sustainable meal options generally had slightly higher mean ages.

Participants who reported being “Very likely” to choose more sustainable meal options after viewing the environmental labels ($n = 49$) had the highest mean age (24.4 ± 7.6 years), followed by those who selected “Likely” ($n = 275$; 24.0 ± 7.4 years). Lower mean ages were observed among participants who were “Indifferent” ($n = 222$; 22.4 ± 5.9 years) or “Not very likely” ($n = 192$; 22.5 ± 6.2 years) to choose more sustainable options. Participants who reported being “Not at all likely” ($n = 126$) had a mean age of 23.4 ± 7.5 years. A statistically significant difference across the different response levels was observed according to the age group ($p = 0.004$).

The relationship between participants’ age and the perceived influence of the environmental label on meal choice was also explored descriptively. Participants who considered the label to be “Highly determinant” ($n = 44$) had the highest mean age (26.6 ± 10.4 years), followed by those who reported it as “Moderately determinant” ($n = 171$; 23.9 ± 7.2 years) and “Completely determinant” ($n = 20$; 23.6 ± 5.1 years). Lower mean ages were observed among participants who considered the label “Slightly determinant” ($n = 263$; 22.5 ± 5.7 years) or “Not at all determinant” ($n = 365$; 23.0 ± 6.8 years). A statistically significant difference in age was observed across the different response levels was observed according to the age group ($p = 0.031$).

4.5 Perception of the environmental label

Table 10 presents participants’ awareness, comprehension and perceived influence of the environmental label. Overall, most participants reported noticing the environmental label on the menus (73.1%, $n = 867$), with a statistically significant difference between phases ($p = 0.048$). The label was generally considered easy to interpret, with 45.7% ($n = 395$) rating it as “very easy” and

43.5% ($n = 376$) as “easy”, however, the difference between phases was not statistically significant ($p = 0.121$).

Although the largest proportion of participants reported that the label was “not at all determinant” in their meal choice (42.4%, $n = 366$), a small increase was observed in the proportion of participants who considered it “highly determinant”, rising from 4.2% ($n = 27$) in the first phase to 7.9% ($n = 17$) in the second phase (after intervention), although this difference was not statistically significant ($p = 0.209$).

Table 10 - Perception and influence on meal choice of the environmental label.

Variable		Total % (n)	1 st phase % (n)	2 nd phase % (n)	<i>p</i>
Did you notice the environmental label available on the menus?	No	26.9 (319)	28.3 (257)	22.3 (62)	0.048
	Yes	73.1 (867)	71.7 (651)	77.7 (216)	
What is the level of difficulty in interpreting the label	Non opinion	2.3 (20)	2.9 (19)	0.5 (1)	0.121
	Very easy	45.7 (395)	45.6 (297)	46 (98)	
	Easy	43.5 (376)	42.2 (275)	47.4 (101)	
	Hard	6.6 (57)	7.1 (46)	5.2 (11)	
	Very hard	1.9 (16)	2.2 (14)	0.9 (2)	
To what extent did the environmental label influence your meal choice?	Not at all determinant	42.4 (366)	43.8 (284)	38 (82)	0.209
	Slightly determinant	30.4 (263)	30.2 (196)	31 (67)	
	Moderately determinant	19.8 (171)	19.4 (126)	20.8 (45)	
	Highly determinant	5.1 (44)	4.2 (27)	7.9 (17)	

Variable	Total % (n)	1 st phase % (n)	2 nd phase % (n)	<i>p</i>
Completely determinant		2.3 (20)	2.3 (15)	2.3 (5)

*p value according with the Chi-Square test to a confidence level

4.6 Main factors influencing meal choice

Figure 12 presents the main determinants of meal choice according to their ranking of importance. Individual preferences and personal tastes were the most frequently factor selected as the highest priority (Classification 1). Sensorial characteristics of the dish, including visual appearance and smell, were most commonly ranked as the second priority (Classification 2). Nutritional value was consistently represented across all three classifications, indicating a moderate influence on meal choice.

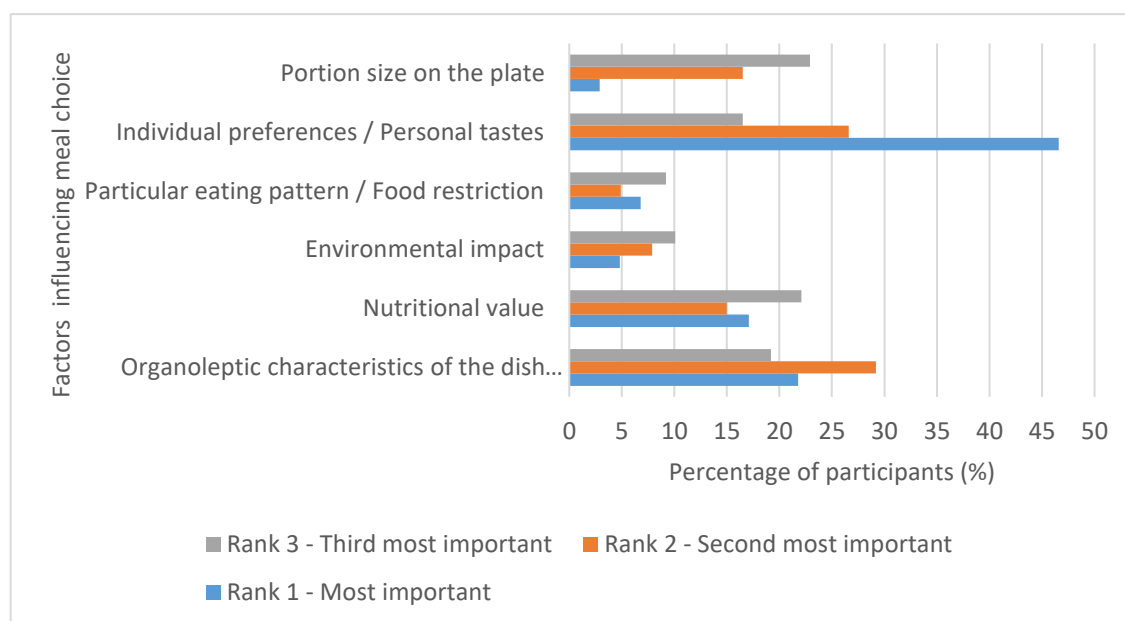


Figure 12 - Main factors influencing meal choice according to order of importance.

4.7 Likelihood of choosing more sustainable meal options

Table 11 presents participants' reported likelihood of choosing more sustainable meal options. The most frequently selected response was "Likely" (31.8%), with little variation between the two phases. Only 5.7% of participants indicated that

they were “Very likely” to choose more sustainable meal options. Nevertheless, the proportion of participants who were “Not at all likely” to make such choices decreased substantially between phases (16.6% vs. 8.8%).

Table 11 - Participants' likelihood of choosing more sustainable meal options after viewing the environmental labels.

Variable		Total % (n)	1 st phase % (n)	2 nd phase % (n)	p
After seeing the environmental labels, how likely are you to choose more sustainable options in the cafeteria?	Not at all likely	14.7 (127)	16.6 (108)	8.8 (19)	0.063
	Not very likely	22.2 (192)	21.4 (139)	24.7 (53)	
	Indifferent	25.7 (222)	24.5 (159)	29.3 (63)	
	Likely	31.8 (275)	31.8 (207)	31.6 (68)	
	Very likely	5.7 (49)	5.7 (37)	5.6 (12)	

*p value according with the Chi-Square test to a confidence level

4.8 Suggestions for improving the environmental label

Figure 13 summarises participants' suggestions for improving the environmental label. Overall, the most common response was that no changes were required, with 33.7% (n = 400) of participants selecting “*Nothing*”. Among those proposing modifications, the inclusion of additional information on the product's environmental impact was the most frequently reported suggestion (19.5%, n = 231). Other commonly identified improvements included increasing the clarity and ease of understanding of the information provided (12.0%, n = 142) and enhancing the label's visual design and presentation (12.0%, n = 142).

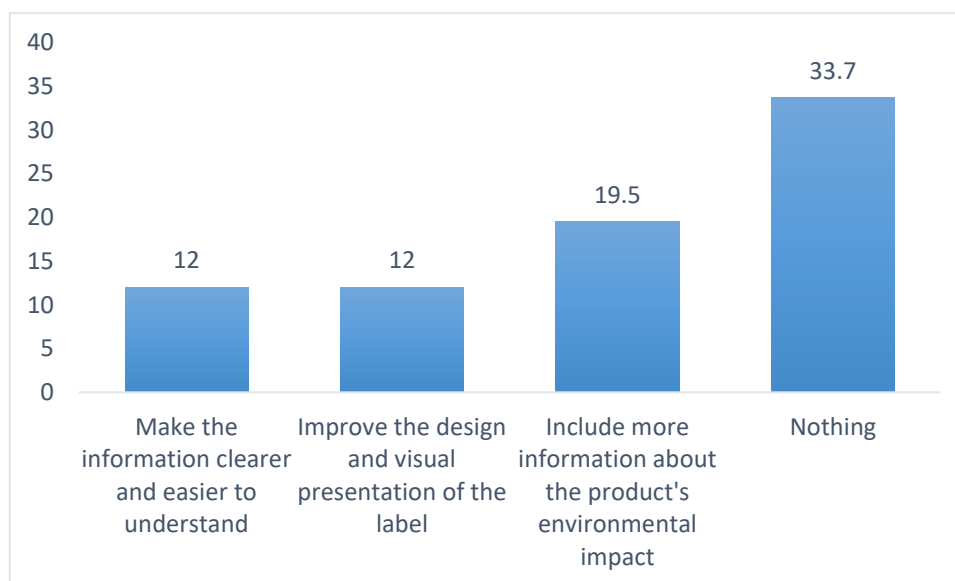


Figure 13 - Suggestions for improving the environmental label.

5. Discussion

The present study evaluated the impact of a multi-indicator environmental labelling system, integrating carbon footprint, water footprint and land use, on consumer perception and meal choices in a Portuguese university canteen. Overall, participants reported that the environmental label was highly visible and easy to understand, but its self-reported influence on meal selection remained limited. A modest favourable shift was nevertheless observed between the two phases of implementation, with a reduction in the proportion of participants who reported being unwilling to choose more sustainable options after exposure to the label. These findings are broadly consistent with field studies indicating that environmental labels can generate small but meaningful effects on consumer awareness and intention, while their translation into actual behavioural change remains limited and context-dependent ^(27, 32).

Substantial differences were observed between the meals analysed across all environmental indicators. Dishes based on ruminant meat, namely beef, lamb and veal, presented the highest environmental impacts, whereas vegetarian options were among the lowest-impact meals. These results are consistent with the literature, which shows that meals containing a lower proportion of animal-based

foods, particularly ruminant meat, generally have lower greenhouse gas emissions and require less land use ^(10, 43). This association has also been observed in the Portuguese context, based on data from IAN-AF 2015-2016, reported that individuals adhering to predominantly plant-based dietary patterns exhibited a 33% lower carbon footprint, a 36% lower water footprint and a 50% lower land use compared with those characterised by higher consumption of red and processed meats, reinforcing the environmental advantages of diets based on plant-derived foods ⁽¹⁹⁾, reflecting the influence of meal composition on overall environmental performance.

In support of these findings, when considering the 20-year Global Warming Potential, the environmental impact of high meat-eater diets was approximately 5.1 times greater than that of vegan diets, with estimates ranging from 3.5 to 8.4 times higher, further emphasizing the substantial climate benefits associated with plant-based dietary patterns ⁽¹⁰⁾.

The environmental impact patterns observed in this study closely resemble those reported in previous assessments of Portuguese institutional food services. In a multidimensional assessment of Portuguese school menus, Selivanova (2025) reported mean carbon footprint values of 2.54 kg CO₂ eq./meal for meat-based dishes and 1.20 kg CO₂ eq./meal for plant-based meals, with land use approximately four times higher for meat-based meals than for fish-, egg- or plant-based alternatives ⁽³⁶⁾.

With regard to water footprint, clear differences were also observed between meal categories. These findings are particularly relevant in university food services, where menus are planned centrally and served to a large number of consumers every day. Meat-based dishes were associated with the highest average water footprint, a finding that is consistent with previous studies identifying animal-source foods, particularly beef, as the greatest contributors to freshwater use within food systems. This reflects the substantial volumes of water required throughout livestock production, including feed cultivation, animal husbandry and processing, compared with most other food groups ^(44, 45).

Although meat dishes remained the most water-intensive option, the average values observed for vegetarian, diet and fish dishes were more variable, suggesting that the water footprint of a meal depends not only on the type of

protein source but also on the combination and origin of its ingredients ⁽⁴⁵⁻⁴⁷⁾. Previous evidence indicating that the water footprint is highly influenced by agricultural production systems, climatic conditions and irrigation practices, which can lead to substantial differences between foods within the same dietary category ⁽⁴⁸⁾.

Land use varied substantially across meal categories, with meat-based dishes requiring considerably more land, on average, than vegetarian, fish and diet meals. This pattern is consistent with previous life cycle assessment studies, which have shown that ruminant meat production, particularly beef and lamb, is among the most land-intensive food production systems due to the extensive land required for grazing and feed cultivation. In contrast, plant-based meals generally require considerably less agricultural land, reflecting the greater resource efficiency of producing plant-derived foods compared with animal-derived products ^(49, 50). Fish dishes also exhibited relatively low land use values, although these may vary depending on the species and production system. The promotion of meals with a higher proportion of plant-based ingredients has been identified as a strategy for reducing pressure on land resources and supporting the transition towards more sustainable food systems ⁽⁵¹⁾. Overall, these findings indicate that the land use associated with a meal is primarily determined by the nature and combination of its ingredients, underscoring the importance of evaluating recipes individually when assessing their environmental impact ⁽⁵²⁾.

Consequently, relatively small modifications in recipe composition or menu planning may translate into substantial cumulative reductions in environmental impacts ^(53, 54).

The proportion of meals corresponding to the highest-impact option decreased during the intervention on most days, although the magnitude and persistence of this change varied across the menu week. Eight weeks after the first phase, the reductions were maintained on several days, particularly on Days 3, 5, 6 and 7, whereas on Days 2 and 4 the values returned to levels close to those observed four weeks before the first phase. This variability suggests that the influence of the environmental label may have depended, in part, on the specific meals available each day and on other determinants of food choice, such as individual preferences and sensory appeal.

The lowest-impact meal remained a small proportion of the total meals served throughout the study, although its proportion 8 weeks after the first phase was higher than that observed before the intervention on all seven days. These results suggest a possible behavioural shift towards more sustainable choices, rather than a substantial change in meal selection. This pattern is consistent with the questionnaire results, which showed that the environmental label was well perceived and understood but had a limited influence on self-reported food choice.

Similar findings have been reported in university food-service settings, where environmental labelling produced modest or variable changes in actual meal choices, particularly in reducing the selection of higher-impact options ^(55, 56).

Evidence from previous studies suggests that environmental labels can enhance consumers' awareness of the environmental impacts of food choices while encouraging more sustainable food selection. However, these positive intentions do not always translate into actual changes in purchasing or food selection behaviour ^(30, 57). In particular, repeated exposure to sustainability information may gradually increase awareness and acceptance of environmentally friendly food choices, even when immediate behavioural changes remain limited ⁽⁵⁸⁾.

The limited effect observed in the present study may also reflect the well-described intention-behaviour gap, whereby individuals express favourable attitudes or intentions towards sustainable consumption but do not necessarily translate these intentions into actual food choices. Several barriers, including habitual purchasing behaviour, taste preferences, convenience, price and time constraints, may prevent consumers from acting according to their environmental intentions ⁽⁵⁹⁾. Consequently, willingness to choose more sustainable meals should not be interpreted as evidence that participants would consistently modify their behaviour in real-life situations.

Environmental labels may represent an important first step towards promoting more sustainable food choices by encouraging consumers to consider environmental information when selecting meals. However, achieving meaningful behavioural change is likely to require environmental labelling to be integrated with broader interventions, including nutrition and sustainability education, menu

reformulation, improved availability of sustainable meal options and choice architecture strategies that facilitate environmentally favourable decisions ^(27, 57). Responses to the environmental label differed according to participants' sociodemographic characteristics, suggesting that environmental labelling may not influence all consumers equally. Different response patterns were observed according to sex and field of study, whereas local and non-local students showed broadly similar perceptions of the environmental label and willingness to choose more sustainable meal options. Growing evidence indicates that individual characteristics influence both sustainable food consumption behaviours and consumers' responsiveness to environmental information ⁽³⁰⁾.

Female participants reported greater willingness to choose more sustainable meal options after viewing the environmental labels and were more likely than male participants to perceive the label as influencing their food choices. This pattern is consistent with previous literature showing that women generally exhibit stronger pro-environmental attitudes, greater concern about the environmental consequences of food production, and higher engagement in sustainable dietary behaviours than men ⁽⁶⁰⁾. Similarly, a systematic review on sustainable food consumption among university students found that female students consistently reported higher adoption of sustainable food behaviours across most studies, although contextual and situational factors may influence the magnitude of these differences ⁽⁶¹⁾.

Several mechanisms may explain this pattern, with previous research suggesting that men's food choices are more frequently influenced by sensory attributes, habitual behaviours and convenience ⁽⁶²⁾. Consequently, environmental information presented at the point of choice may be more easily integrated into women's decision-making processes.

In contrast, residence status was not associated with participants' responses to the environmental label. This finding suggests that, within a university food service setting, sharing the same food environment may reduce potential differences between local and non-local students. Regardless of where students lived, all participants were exposed to the same menus, pricing structure and environmental information, which may have contributed to the similar behavioural intentions observed between both groups.

Differences were also identified according to participants' field of study. Participants' responses suggest that the influence of environmental labels on intended food choices varied across academic disciplines. Students enrolled in Education and Training, Social Sciences and Humanities, and Arts, Humanities and Communication appeared more receptive to choosing more sustainable meal options after exposure to the environmental label, whereas those from Information Technology and Computer Science were comparatively less likely to report such intentions. A similar pattern was observed regarding the perceived influence of the label on meal selection, with participants from Information Technology and Computer Science more frequently indicating that the label was not determinant in their choices.

Although relatively few studies have specifically examined responses to environmental food labels according to field of study, these findings are consistent with previous research indicating that academic background may shape students' environmental knowledge, sustainability attitudes and food-related behaviours ⁽⁶³⁾. University programmes that incorporate topics related to education, social sciences, environmental issues or public health may provide greater exposure to concepts of sustainability, potentially increasing awareness of the environmental consequences of food choices and receptiveness to sustainability interventions. In contrast, students from more technology-oriented disciplines may have fewer opportunities to engage with sustainability issues within their curricula, which may reduce the salience of environmental information during food selection ⁽⁶³⁾. These observations are also consistent with studies showing that environmental concern and pro-environmental behaviours are influenced by environmental literacy. Individuals with greater knowledge and awareness of sustainability issues are generally more likely to value environmental information and to consider it during purchasing decisions, including food choices ⁽⁶⁴⁾. Consequently, environmental labels may be more effective among consumers who already possess higher levels of environmental awareness, whereas their impact may remain limited among those with lower initial engagement ^(27, 65).

It should also be considered that the disciplinary differences observed in the present study may not solely reflect educational background. Food choice is a multidimensional behaviour influenced by multiple interacting factors, including

personal values, social norms, dietary habits and interest in environmental issues^(66, 67). Therefore, the greater responsiveness observed among some academic fields may partly reflect pre-existing attitudes towards sustainability rather than the educational programme itself. Further studies assessing environmental knowledge and sustainability literacy directly would help clarify the mechanisms underlying these differences ^(66, 68, 69).

Evidence regarding the influence of age on consumers' responses to environmental labels remains inconsistent. While some studies have reported that older consumers are more responsive to environmental labels, others have found stronger effects among younger individuals, and some have observed no differences between age group ⁽⁷⁰⁻⁷³⁾. In the present study, statistically significant differences in age were observed across the different response levels, both regarding the self-reported likelihood of choosing more sustainable meal options after viewing the environmental labels ($p = 0.004$) and the perceived influence of the label on meal choice ($p = 0.031$). Participants who reported a greater willingness to choose sustainable options tended to have slightly higher mean ages, while those who considered the label "Highly determinant" also had the highest mean age. However, this pattern was not fully consistent across all response levels, and the absolute differences in mean age were relatively small. These findings suggest that age may be associated with participants' responses to environmental labelling, but they do not support a clear or linear relationship between increasing age and greater responsiveness to the label.

Therefore, the small differences in mean age observed in the present study, together with the relatively narrow age range of the participants, are insufficient to establish age as a clear determinant of responses to environmental labelling. The environmental label implemented in the present study was generally well accepted by participants, with most respondents reporting that they had noticed the label and considered it easy or very easy to interpret. These findings suggest that the visual design of the label was sufficiently clear and accessible for use in a university food service setting. The use of a simple colour-coded, multi-indicator format may have facilitated participants' understanding by allowing environmental information to be interpreted quickly at the point of choice, an important characteristic for interventions implemented in institutional catering

environments where purchasing decisions are often made within a limited time (74, 75).

While the environmental label was widely noticed and easily understood, its influence on meal selection remained limited overall, despite a modest increase in its perceived importance following the intervention. The largest proportion of participants reported that the label was "not at all determinant" in their food choice, although a modest increase was observed in the proportion considering it "highly determinant" after the intervention.

Similarly to this, previous systematic reviews indicate that environmental labels are generally effective at increasing awareness and improving consumers' understanding of the environmental impacts associated with food choices, while their effects on purchasing behaviour are typically small to moderate and highly context-dependent (27, 57). This suggests that, although environmental labels can effectively communicate environmental information, awareness and understanding alone may not be sufficient to modify food choices (27, 30).

Regarding the determinants of meal choice, several factors may explain the limited behavioural influence observed in the present study. Food choices are determined by a complex interaction of individual preferences, habitual behaviours, sensory characteristics, convenience and price, with environmental considerations generally representing only one component of the decision-making process (66, 69). In university settings, where students often make rapid meal choices based on familiarity and personal preference, environmental information alone may therefore be insufficient to substantially alter established eating habits (66, 76). This interpretation is further supported by the present findings, in which personal preferences and sensory attributes emerged as the primary determinants of meal selection, whereas environmental considerations appeared to play a comparatively minor role (76-78).

Following exposure to the environmental labels, most participants reported that they were "Likely" to choose more sustainable meal options in the university canteen, while only a small proportion indicated that they would be "Very likely" to do so. Although the overall distribution of responses changed only modestly, the proportion of participants who reported being "Not at all likely" to choose more sustainable meals decreased, suggesting a reduction in resistance towards

selecting more sustainable meal options following exposure to the environmental labels.

Overall, the environmental label was well accepted by participants, suggestions for providing more detailed environmental information and improving the clarity and visual presentation of the label indicate that users value both comprehensiveness and ease of interpretation. Optimising these aspects may further enhance the label's effectiveness in communicating environmental information at the point of meal selection.

The smaller, but not negligible, proportion of participants requesting clearer information or a more appealing visual design indicates that, although the current format works well overall, there is still scope to refine both content and presentation in order to maximise the label's usefulness and engagement.

These results are consistent with previous research showing that consumers tend to value simple front-of-pack or point-of-choice labels for rapid decision-making, while simultaneously appreciating access to more comprehensive information when it is available ^(79, 80). Likewise, the suggestions related to clarity and visual presentation are in line with evidence indicating that labels which are visually intuitive, employ simple colour-coded schemes and minimise cognitive effort are more likely to capture attention and facilitate understanding at the point of purchase ^(79, 81). Although the visual design of the label was generally well accepted, future initiatives could focus on providing additional information and educational materials to help consumers better understand the environmental indicators and their implications, thereby increasing the potential effectiveness of environmental labelling in university food service settings.

Several limitations should be considered when interpreting the findings of the present study. The quasi-experimental design without a control group limits the ability to establish a causal relationship between exposure to the environmental label and the observed changes in participants' perceptions and stated intentions. Although comparisons were performed before and after the implementation of the intervention, the absence of a control group means that the observed changes cannot be attributed exclusively to the environmental label.

Data were collected in a single university canteen in Portugal using a convenience sample of students and staff. The findings may therefore not be generalisable to other university food service settings or institutional catering environments.

The sample size differed substantially between the two data collection phases ($n = 908$ in Phase 1 versus $n = 278$ in Phase 2), reducing the statistical power of the second phase and limiting the comparability of pre- and post-intervention estimates, particularly within sociodemographic subgroups. In addition, during the second intervention period, a strike occurred on one of the data collection days, during which no meals were served and, consequently, no questionnaire responses were obtained. The lower participation observed in Phase 2 may also partly reflect reduced motivation to complete the questionnaire among individuals who had already participated in the first phase.

The intervention was implemented over a relatively short period, which may not have been sufficient for participants to become fully familiar with the environmental label or to integrate environmental information into routine food choices. The menu week selected for the labelling intervention was determined by the scheduling of questionnaire administration rather than by formal assessment of its representativeness within the four-week cycle, which may limit the generalisability of the reported environmental footprint values to the broader menu rotation. Behavioural change related to sustainability is often gradual and may require repeated exposure and longer-term intervention before measurable effects emerge ⁽⁸²⁾.

Despite these limitations, the study presents several important strengths. To the authors' knowledge, this is the first study conducted in a Portuguese university food service to evaluate the implementation of a multi-indicator environmental labelling system incorporating carbon footprint, water footprint and land use. The intervention was implemented under real-life conditions, increasing the ecological validity of the findings, and the relatively large sample size allowed a comprehensive evaluation of both the environmental performance of university menus and consumer perception of environmental labelling.

This study contributes to the still limited body of scientific evidence regarding the implementation of multi-indicator environmental labelling systems in real-world university food service settings, providing useful information to support

universities and other institutions in promoting more sustainable food environments. It also highlights the importance of the *intention-behaviour gap*, demonstrating that high levels of awareness and understanding of environmental information do not necessarily translate into corresponding changes in food choice behaviour ⁽⁵⁹⁾.

From a research perspective, the results emphasise the need to further investigate the factors influencing the effectiveness of environmental labelling and to identify the most appropriate strategies for enhancing its behavioural impact. Future research should seek to determine which communication formats are most effective for different consumer groups, while also evaluating the interaction between environmental labelling and other interventions aimed at promoting sustainable food choices.

Further studies should involve longer intervention periods, multiple institutions and the inclusion of control groups, as well as objective measures of food choice behaviour, particularly through the analysis of sales records, to determine whether the observed changes in consumers' intentions are reflected in their actual purchasing decisions. In addition, future research should investigate the effectiveness of different environmental labelling formats and their combination with educational interventions and choice architecture strategies, thereby contributing to the development of more effective approaches for promoting food systems that are both healthier and more environmentally sustainable.

6. Conclusion

The present study evaluated the implementation of a multi-indicator environmental labelling system, based on carbon footprint, water footprint and land use, in a Portuguese university canteen, while simultaneously assessing the environmental performance of the meals offered and consumers' perceptions of the label and its influence on food choices.

The environmental assessment of the menus revealed considerable variability across meal types. Meat-based dishes, consistently exhibited the highest environmental indicators, whereas vegetarian meals generally presented the

lowest environmental impacts across all three indicators. This reinforces existing evidence that meal composition and protein source are among the main determinants of the environmental impact of meals in institutional food service settings.

The environmental label was widely recognised by participants and was considered easy or very easy to interpret by most respondents, demonstrating that a colour-coded multi-indicator format represents an accessible approach to communicating environmental information in a university food service setting. Nevertheless, its self-reported influence on meal selection remained limited. Personal preferences and sensory characteristics continued to be the primary determinants of food choice, although a favourable shift was observed following the intervention, reflected by reduced resistance towards choosing more sustainable meal options and a slight increase in the influence attributed to the environmental label. Variation in responses was also observed according to sex and field of study, suggesting that the effectiveness of environmental labelling may differ across population groups within the university community.

Overall, the results indicate that environmental labelling is a feasible and well-accepted strategy for increasing awareness of the environmental impacts associated with food choices. However, they also demonstrate that the provision of environmental information alone is unlikely to be sufficient to promote substantial behavioural change. Environmental labelling should therefore be regarded as one component of a broader institutional strategy incorporating sustainability education initiatives, menu reformulation, increased availability and promotion of more sustainable meals, and other behavioural interventions designed to facilitate healthier and more environmentally sustainable food choices.

From a practical perspective, the findings suggest that integrating environmental labelling into institutional food service may provide a valuable complementary tool for nutritionists, food service managers and institutional decision-makers seeking to promote more sustainable dietary choices. The use of this type of information may contribute to the development of food environments that simultaneously support health and environmental sustainability, particularly when

embedded within institutional policies and accompanied by effective communication and nutrition education strategies targeting consumers.

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8. Appendixes

Appendix 1 - Questionnaire: Implementation of an environmental labeling system in university canteens: Influence on consumer choice

(I) Informed Consent

Please read the content of this document carefully. If you require any additional information regarding the study or the processing of your data, you may contact Sara Almeida Gonçalves, Nutritionist at the Social Action Services of the University of Aveiro and Master's student in Collective Nutrition at the Faculty of Nutrition and Food Sciences of the University of Porto, via email: sara.almeida.goncalves@ua.pt.

Dear Participant,

This study, entitled “Implementation of an Environmental Labelling System in University Canteens - Influence on Consumer Choice”, is being conducted as part of the master's dissertation of nutritionist Sara Almeida Gonçalves, under the supervision of Professor Margarida Liz, from the Coimbra Health Technology School, and co-supervision of Professor Ada Rocha, from the Faculty of Nutrition and Food Sciences of the University of Porto.

The study aims to evaluate the impact of implementing an environmental labeling strategy on a university cafeteria menu. Participation involves completing an anonymous questionnaire that takes approximately 3 minutes.

Participation is voluntary, and participants may refuse or withdraw at any time. The data collected through this survey are anonymous and will be used solely to evaluate the implementation of an environmental labeling strategy on cafeteria menus.

The questionnaire does not request personal identification information, ensuring participant anonymity. Data collected via the Unicard platform, which records purchased meals, will be processed in a coded manner and analyzed exclusively for scientific purposes. Results will be presented in aggregate form, making it impossible to identify any individual participant.

The collected data will be stored in the institutional database of the University of Aveiro for the estimated processing period of approximately four months. After

the statistical analysis is completed, the data will be securely and permanently deleted. The information may be accessed by the project supervisor and co-supervisor exclusively for scientific supervision purposes.

No financial compensation is provided for participation in the study.

This is a quantitative, descriptive, and quasi-experimental study, and therefore no specific insurance for participants is required.

Participation in this study does not present foreseeable risks. Although there are no direct benefits for participants, the results may contribute to the development of strategies to promote more sustainable food choices in the university context.

We appreciate your willingness to participate and are available for any further clarification.

By proceeding to the questionnaire, you declare that you have read and understood the information provided, had the opportunity to ask any questions, and voluntarily agree to participate in the study.

(II) Environmental Label

1 - Which dish did you choose for this meal?

- Meat
- Fish
- Diet
- Vegetarian

2 - Did you notice the environmental label on the menu?*

- Yes
- No

(If yes)

3 - What is the level of difficulty in interpreting the label?*

- Very difficult
- Difficult
- Easy

- Very easy
- No opinion

4 - To what extent did the environmental label influence your choice of meal?*

- Not at all decisive
- Not very decisive
- Moderately decisive
- Very decisive
- Extremely decisive

5 - Identify the three main factors that influenced your choice of meal, in order of importance (from most important to least important).*

- Organoleptic characteristics of the dish (visual appearance, smell, ...)
- Nutritional value
- Environmental impact
- Particular eating pattern/Food restriction
- Individual preferences / Personal tastes
- Portion size on the plate
- Other: _____

6 - After seeing the environmental labels, how likely are you to choose more sustainable options in the canteen?*

- Not at all likely
- Not very likely
- Indifferent
- Likely
- Very likely

7 - What changes would you make to the label?*

- Make the information clearer and easier to understand
- Improve the design and visual presentation of the label
- Include more information about the product's environmental impact

- Nothing
- Other: _____

(III) Sample Characterization

8 - Sex*

- Male
- Female
- Prefer not to say

9 - Age* (open answer)

10 - Highest level of education completed*

- Basic education (9th grade)
- Secondary education (12th grade)
- Bachelor's degree
- Master's degree
- PhD
- Other: _____

11 - Relationship with the institution*

- Staff
- Student

(If student)

12 - Field of study*

- Arts, Humanities and Communication
- Social Sciences and Humanities
- Economics, Management and Law
- Science and Technology
- Agricultural and Environmental Sciences
- Education and Training
- Health

- Information Technologies
- Tourism, Leisure and Services

13 - Type of student*

- Non-displaced
- Displaced

14 - Frequency of use of the university canteen*

- 5 or more times per week
- 3 to 4 times per week
- 1 to 2 times per week
- Rarely

* Mandatory questions

