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Consumer Perception of the Circular Economy Concept Applied to the Food Domain: An Exploratory Approach

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Abstract: Every year, agri-food industries in industrialised countries produce approximately 1.3 billion tonnes of food loss and waste. The adoption of a circular economy policy has received special attention by the agri-food industries, allowing for the creation and development of new food products made of by-products that would otherwise be wasted or used for secondary applications. The present work, of an exploratory nature, aims to assess how consumers conceptualise the circular economy in order to identify consumer recognition of the use of by-products from the food industry to upcycle food products and to evaluate attitudes towards the circular economy. To this end, a mixed-methodology was applied to 340 participants. The first part was qualitative and used free word association to evaluate consumers' conceptualisation of the circular economy and use of by-products as foods. Data were analysed by grouping the responses into exclusive and exhaustive categories and a correspondence analysis was also performed to originate perceptual maps. Additionally, a questionnaire was designed to evaluate major concepts and attitudes correlated with the circular economy. Data were reduced by principal component analysis (PCA) and participants grouped through clustering. Results showed that consumers understand circular economy as related mainly into Sustainability, Economy, and Circularity dimensions. Participants had great difficulty identifying the by-products used as foods or as food ingredients. From the quantitative data, four groups were identified based on the associations to the six principal components originated by the PCA. However, the results highlighted a very low association with all clusters of the Food Valorisation dimension within the concept of the circular economy, and also a lack of a clear understanding of consumers' attitudes towards food products from the circular economy. Greater promotion and dissemination by the competent entities aimed at the general public may contribute towards greater integration, participation and acceptance of the circular economy concept for the upscaling of food by-products.

Keywords: circular economy; consumers; exploratory study; food by-products; food industry; knowledge; upcycled food product

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1. Introduction

The food and drink industry is a major contributor to Europe's economy. In 2016, the European Union (EU) food and drink industry generated a turnover of 1.2×10^{12} Euro and a value added of 246×10^{9} Euro. With 43×10^{9} Euro invested in 2017, the food and drink industry was also the manufacturing sector with the highest capital spending. This industry provides 4.82 million jobs, ranking it amongst the top three manufacturing industries in terms of turnover and employment in most member states, ahead of other large manufacturing sectors, such as the automotive industry [1]. In Portugal, the food and drink industry

is fundamental to the country's growth strategy. With a turnover of 17.6×10^9 Euro in 2019, this industry was made up of around 11,589 companies and 118,830 employees. In 2019, the exports from the food and drink industry were approximately 5.1×10^9 Euro, representing 8.4% of total Portuguese exports [2,3].

Nevertheless, this high food production by the food and drink industry is accompanied by food waste and food loss along the food chain. Every year, about 30% of the total food produced in the world for human consumption is lost or wasted. This occurs both at the level of the food chain itself (food loss) and during consumption (food waste), corresponding to approximately 1.3×10^9 tonnes of lost or wasted food [4]. In Europe, the amount of industrial food waste or loss varies between 19% and 39% of the total food loss in the food supply chains [5]. Food losses and waste cost the world economy about USD 990×10^9 annually and contribute to increased food insecurity and malnutrition [6]. In addition, food that is ultimately lost or wasted consumes approximately a quarter of all water used for agricultural purposes. It is also estimated to account for 8% of global greenhouse gas emissions and contribute to biodiversity loss [7].

Until recently, the current economic model was essentially underpinned by linearity. This production and consumption concept consists of the triptych "produce—consume—eliminate", which can lead to environmental, economic, and social problems as well as large-scale food loss production [8]. To avoid these consequences, it is becoming increasingly important to redirect production and consumption, particularly in the context of food consumption, towards a more circular approach.

The concept of a "Circular Economy" emerged in the 90s, and consists of a production and consumption model involving sharing, reusing, repairing, and recycling existing materials and products, thus extending their life cycle [9]. The adoption of a circular economy has certain implications. Upstream, the approach is the rationalisation of critical raw materials and resource efficiency; downstream, the approach represents the need to foster sustainable consumption patterns based on sharing rather than ownership [10]. This new paradigm is in line with the United Nations' Sustainable Development Goal 12 in Agenda 2030: "ensure sustainable production and consumption patterns" [11]. In this context, according to the Ellen McArthur Foundation, the transition to a circular economy is not limited to minor adjustments aimed at reducing the negative impacts of the linear economy. It represents a systemic shift towards long-term resilience, which will generate economic and financial opportunities as well as environmental and social benefits [12].

To achieve these benefits, the European Union has been developing policies to encourage the practice of an increasingly circular economy. In 2015, the European Commission adopted an action plan to help speed up Europe's transition to a circular economy, to boost global competitiveness, promote sustainable economic growth, and create new jobs. The action plan (rectified and adopted again on 28 March 2020) set out 54 measures to "close" the life cycle of products, starting from production and consumption and closing in waste management and markets for secondary raw materials. As part of the EU's Urban Agenda partnership for the circular economy, the Circular Economy Package was also created. In the cities program, EU countries and the European Commission sought to identify innovative solutions to stimulate the reuse, repair and recycling of existing materials and products. The latest initiative implemented by the European Commission with the main objective of making the EU economy sustainable was The European Green Deal. This programme provides an action plan to boost the efficient use of resources by moving to a clean, circular economy, restoring biodiversity and cutting pollution. The European Green Deal proposes 50 measures to make Europe carbon neutral by 2050, uniting all European Commission (EC) countries in joint action [13].

Following this new framework, several food companies have developed solutions to promote a circular economy, namely to avoid huge food loss. This strategy consists of creating new foods by reusing lost food, giving rise to the term "upcycled food". Upcycled foods use food ingredients that are safe for human consumption and that would otherwise be lost in the food supply chain, often resulting in the valorisation of by-products. This

approach proves to be a superior solution for the better resolution of food loss compared to other solutions, such as the use of these losses for animal feed and composting [14,15]. In this fashion, processed, partially processed or unprocessed products are reused for human consumption, thus more directly fighting the serious social consequences of food loss, such as poverty and malnutrition [10,16]. Additionally, the production of upcycled foods also aims to satisfy current consumer trends, which are associated with the demand for increasingly healthy, sustainable and convenient food products [17,18]. The food industry incorporates food by-products as ingredients of upcycled foods. Food by-products have a high nutritional value or beneficial properties for the health of consumers. They transform the final product into a sustainable value-added product with high functional power. Several current studies have considered the production of numerous ingredients from by-products, including the use of by-products from: cereals to obtain fibres, hemicelluloses [19], beta-glucans [20] and prebiotic oligosaccharides [21]; root crops to obtain polyphenols [22] and organic acids [21]; oil crops to obtain phytosterol [23] and polyphenols [24]; fruit and vegetables to obtain pectin [25] and carotenoids [26]; meat to obtain proteins [27], peptides or amino acids [28]; fish and crustaceans for protein [29], chitin and chitosan [30]; and, finally, milk by-products, mainly whey, for various proteins [31] and peptides or lactose [32]. The production of upcycled foods in the form of powders, flours or dehydrated snacks also helps to increase both the convenience of the products and their shelf life, thus responding to this market trend [33].

Despite all these responses and adaptations by the food industry to the main demand trends, the information available to the consumer on food products incorporating by-products into their composition is still very limited. In addition, there is also a lack of legislation associated with the marketing of these products [34]. Some by-products, used as ingredients in upcycled foods, can be considered novel foods. This translates to acquiring a status that allows them to be marketed and incorporated into other foods only if they follow very restricted and limited legislation [35]. The EU regulation 2015/2283, which lays down rules for placing novel foods on the EU market and ensures the effective functioning of the internal market, presents rather complex procedures that require a long time to be accepted (9 months–12 months). Apart from this regulation, there are yet to be other regulations that certify this type of product. This is particularly relevant, as consumers are increasingly informed and tend to worry more about the quality and safety of the food they eat and buy [36]. Therefore, the lack of information and specific legislation for upcycled food products can be a major barrier to consumer acceptance of this type of food product [37]. Another major barrier to upcycled food acceptance may arise from the use of technologies that are unfamiliar to consumers in the processing of this type of product. Lesser known processes, such as extraction, isolation or ultrafiltration, can lead consumers to high levels of neophobia towards food technology, as consumers increasingly demand less processed and more natural products [37]. Despite all these studies, research on consumer acceptance and perception of the circular economy concept is still restrained to concepts such as consumption of different forms of energy (electricity, fuel, renewables, etc.), the reuse of clothing, and to the extension of the lifetime of large and small house appliances, among others [38]. Nevertheless, the exploration of this subject applied to the food domain is still scarce. To the best of our knowledge, no studies have explored the level of consumer knowledge regarding the concept of the circular economy and the products that this production and consumption model can create when applied to the food industry.

The main objectives of this exploratory work are to assess the way consumers conceptualises the model of the circular economy, as well as to identify consumer recognition and perception of food products from the circular economy. This work also allowed us to study consumers' knowledge about upcycled food or food by-products. In addition, the present research may contribute to the design of education programs and to improve environmental and educational awareness campaigns to increase consumer knowledge regarding circular economy policies, sustainable development and behaviour, especially regarding food industry by-products.

2. Materials and Methods

2.1. Participants

The questionnaire, designed on LimeSurvey®, consisted of two parts carried out simultaneously, due to the length of the overall questionnaire. Respondents were selected through convenience samples. Participants for both parts, were recruited through an online questionnaire administered in Portugal by e-mail invitation and social networks between September 2020 and February 2021. The main region where the questionnaire was disseminated was the North of Portugal, particularly form the Great Oporto Area, the second largest urban area in Portugal. Participation took place in an anonymous form, with informed consent, and data was retrieved, stored and treated following the European General Data Protection Regulation [39].

2.2. Questionnaire

2.2.1. Conceptualisation through Free-Word Association

The first part sought to ascertain perceptions of participants in relation to the concept of the circular economy. Given that this is a subject that is not well known by consumers [9], the qualitative methodology was employed with views to explore the consumer's point of view so that the responses obtained might be the least constructed and at most rationalised [40]. To this end, using the free word association methodology [41–44], the participants were asked to write down the first three words that came to mind when they thought of the term "Circular Economy", classifying each word as "positive", "neutral" or "negative". In the second part, participants were asked to name three food products that they knew were by-products of the food industry, or which were incorporated as ingredient(s) some by-product(s) of that industry, and were also asked to rate these by-products as "unpleasant", "neutral" or "appealing".

2.2.2. Attitudes towards the Circular Economy and Sustainability in the Food Chain

In the second part of the survey, 30 different items, adopted from relevant literature [9], were presented, and participants indicated, through a 5-point Likert scale (1 = low association, 5 = high association), how they assessed the degree of association of each term with the circular economy concept. For each term they should also indicate whether this association was positive, neutral, or negative. If participants did not identify any association, they should select the option "0 = not associated at all" and classify the association as "neutral". The polarity assigned to each term was re-coded as negative (−1), neutral (1) and positive (2).

The second question of this part used a 7-point semantic differential scale and aimed to assess participants' attitudes on the characteristics of food products from the circular economy, adopted from previous research with other food products [45]. As an exploratory question, the use of semantic differentials has specific advantages over the more common Likert-style scales, as it enables respondents to express their opinion about a concept more fully; that is, they have a range of negative to positive response options to choose from.

At the end the of the questionnaire, participants reported socio-demographic information, namely: gender, age, marital status, education, profession, area of residence (urban vs. rural), financial situation (fairly good vs. fairly difficult), food expenses (quality vs. price) and lifestyle (unhealthy vs. fairly healthy).

2.3. Data Analysis

For the first part of the study, data from the free word association were analysed based on a thematic analysis, which allowed for grouping the terms defined by participants into different dimensions according to their similarity. For this analysis, the researchers performed a triangulation approach [41,46]: (a) each researcher performed a semantic analysis of the words, according to their personal interpretation and developed their dimensions individually; (b) then, the researchers compared their dimensions; (c) the final assignment of terms to the dimensions was defined in a consensual way. The frequency

of the mentions of each dimension resulting from the content analysis was calculated and a minimum percentage frequency value of 5% was set for future analyses so as not to lose information [42,44]. Finally, a correspondence analysis was performed to assess the association between the different significant dimensions resulting from the triangulation and between the observed sociodemographic characteristics (age, gender, and education).

For the second part of the study, for each of the 30 items, a new variable was generated by multiplying the score on the degree of association by the polarity score assigned to each term, thus varying between −5 and +10. From this new set of variables, an exploratory principal component analysis (PCA) with *varimax* rotation and Kaiser normalisation was used. Reliability coefficients (Cronbach's alpha) were computed to identify the factors displaying adequate levels of internal consistency [47]. Individual factorial scores were computed by averaging the individual scores of each of the main items projected into the factor. Participants were clustered according to their factorial scores following a *k-means* clustering with a Wilks' Lambda criterion. The analysis used to determine the number of clusters to adopt was based on a hierarchical cluster analysis, using Ward's method [48]. Finally, Chi-square and Kruskal–Wallis tests were performed to ascertain the differences between clusters. Statistical significance was set at $p < 0.05$.

All data analyses were performed using the XL-STAT®, v. 2020.5.1 (Addinsoft, New York, NY, USA) and IBM SPSS Statistics, v. 26.0. (IBM, New York, NY, USA).

3. Results

3.1. Conceptualisation through Free-Word Association

3.1.1. Sociodemographic Characteristics

After data collection, it was observed that 227 participants started the questionnaire by fully answering the free-word association questions. However, only 140 participants fully completed the questionnaire, providing the sociodemographic data, resulting in a response rate of 63%, and a potential sample bias. As shown in Table 1, 60% of participants are female and have a mean age of 33.18 ± 12.21 years old. The sample is mostly composed of single individuals with higher education.

Table 1. Sociodemographic characteristics of the panel for the first part of the study (n = 140).

	Participants (%)
Sex	
Male	84 (60%)
Female	56 (40%)
Age (years)	
18–34 (young adults)	93 (66%)
35–54 (adults)	33 (24%)
+55 (mature adults)	14 (10%)
Education level	
No higher education	38 (27%)
Higher education	102 (73%)
Marital status	
Single	84 (60%)
Married	50 (36%)
Divorced	6 (4%)

3.1.2. Word Association: Dimensions and Categories

In total, for the study of consumers' perceptions of the concept of the circular economy, 259 different terms were mentioned by participants. After the triangulation process, the terms with a significant value were grouped into 27 categories, which were later grouped into 13 dimensions (Table 2).

Table 2. Frequency with which the categories regarding the study of the circular economy Concept were mentioned and examples of the terms (in brackets) that form each one (n = 227).

Dimension	Category (Examples of the Most Relevant Individual Words)	Number of Mentions				Participants (%)
		Polarity			Total	
		Positive	Neutral	Negative		
Sustainability	The Three R's (Recycle, Recycling, Reuse, Reusing)	126	2		128	38
	Sustainability	81	3	2	86	33
	Utilisation (Utilisation, Valuing)	54	1		55	22
	Waste	5	5	1	11	5
	Save	9	2		11	5
	Balance	4		1	5	2
	Total	**279**	**13**	**4**	**296**	
Economy	Money	42	17	7	66	26
	Economy (Economy, Transaction, Invest)	21	17	4	42	17
	Commerce (Buy, Sell, Trade)	20	13		33	12
	Management (Management, Financial management)	6	2	1	9	3
	Service	5			5	2
	Total	**94**	**49**	**12**	**155**	
Circularity	Circularity (Circulation, Movement)	20	13		33	13
	Cycle (Cycle, Return)	16	10	1	27	11
	Total	**36**	**23**	**1**	**60**	
Innovation and production	Innovation (Development, Growth, Advantage)	26	2	1	29	11
	Production (Transformation, Functional)	16	1	1	18	8
	Total	**42**	**3**	**2**	**47**	
Society	Society (Society, People)	17	2	1	20	9
	Cooperation	4	1		5	2
	Total	**21**	**3**	**1**	**25**	
Politics	Politics (Politics, Country)	16	4	9	19	7
Environment	Environment	15	3		18	7
Behaviour	Consumption (Consumption, Consumerism)	4	5	2	11	5
	Faults		1	2	3	1
	Behaviour			2	2	1
	Total	**4**	**6**	**6**	**16**	
Resources	Resources (Goods, Energy, Products)	8	7		15	6
Future	Future	3	2		5	2
Global	Global (Global, Planet)	12	2		14	7
Health and nutrition	Health (Health, Life)	6	1		7	3
Unawareness	Unawareness				4	1

The dimension that presented the highest frequency was 'Sustainability', representing 62% of participants. This dimension was composed of six categories, where 'The Three R's', 'Sustainability' and 'Utilisation' were the ones that presented the highest percentage of participants (22–38%). 'Economy' was the second dimension with the greatest impact (44%). This dimension was composed of five categories, with 'Money', 'Economy' and 'Commerce' being the ones with the highest impact (12–26%). The dimensions 'Circularity' (23%), 'Innovation and production' (18%) and 'Society' (10%), were the third, fourth and fifth, with the highest percentage of participants associating them with the circular economy concept. Other dimensions with a lower frequency of terms (<10%) were also observed, having less of an impact on the association with the term under study. The dimensions 'Health and nutrition', 'Future' and 'Unawareness' had frequencies below 5% and were not considered for further analysis. 'Global' and 'Behaviour' dimensions were also disregarded, as there

was not enough socio-demographic data to consider the minimum percentage frequency value of 5% in order to avoid losing a large amount of information.

Regarding the question which aimed to identify three by-products of the food industry or foods incorporating by-products of that industry in their composition, participants enunciated 207 different terms. After the triangulation process, the terms with a significant value were grouped into 24 categories, which were divided into seven dimensions (Table 3). The dimension with the highest number of mentions, therefore representing a higher association with the subject, was 'Food' (57%). This dimension was comprised of 14 categories, where 'Cereals and derivatives' and 'Dairy products' had the highest percentage of participants (18–26%). 'Food by-products' was the second dimension with the greatest impact on the study (27%). This dimension was composed of 10 categories, with 'Fruit by-products' and 'Meat by-products' being the ones with the highest percentage of participants (8–11%). The 'Unawareness' dimension, composed of three categories with terms that are not closely associated with the subject under study, was the third most influent dimension in this study and comprised 5% of participants. This dimension was disregarded in further analysis, as there was not enough socio-demographic data.

Table 3. Frequency in which the categories regarding the study of by-products of the food industry were mentioned and examples of the terms (in brackets) forming each one (n = 227).

Dimension	Category (Examples of the Most Relevant Individual Words)	Number of Mentions				Participants (%)
		Polarity			Total	
		Appealing	Neutral	Unpleasant		
Food	Cereals and derivatives (Oat, Rice, Bread, Cereals)	54	21		75	26
	Dairy products (Milk, Ice cream, Yogurt)	31	20	2	53	18
	Drinks (Beer, Wine, Natural juices)	21	6	1	28	12
	Fruit (Apple, Orange, Banana)	23	7	1	31	12
	Pastry ingredients and products (Cakes, Honey, Sugar)	18	7	2	27	11
	Vegetables	16	8		24	10
	Meat (Meat, Steak)	15	4		19	8
	Fats (Oil, Butter)	10	7	1	18	8
	Fish (Fish, Tuna)	13	4	1	18	8
	Other	25	9	3	39	16
	Total	**226**	**93**	**11**	**330**	
By-products	Fruit by-products (Fruit peels, Banana bread)	16	13	2	31	11
	Meat by-products (Gelatine, Skin, Fat, Bones)	12	8	2	22	8
	Drink by-products (Bagasse, Distiller grains, Alcohol)	10	5	1	16	7
	Dairy by-products (Whey)	7	8		15	6
	Fish by-products (Fish bones, Surimi, Fish scale)	7	3		10	4
	Vegetable by-products (Vegetable peels, Soups and broths)	3	4	1	8	4
	Other	6	6	1	13	6
	Total	**61**	**47**	**7**	**115**	
Unawareness	Packages	3			3	1
	Non-food (Clothes, Domestic appliance, Batteries)	6	3	2	11	4
	Misinterpretation (Food, Agricultural products, Local market)	4	1		5	2
	Total	**13**	**4**	**2**	**19**	
Food additives	Food additives (Preservatives, Colourings)	4	1	3	8	3
Waste	Waste (Leftovers, Waste, Remains)	3	2	1	6	2
Novel foods	Novel foods (Seaweeds, Insects)	1	4	1	6	3
Nutrients	Nutrients (Protein, Calcium, Magnesium)	2	3		5	2

The remaining dimensions, 'Food additive', 'Waste', 'Novel foods' and 'Nutrients' had frequencies lower than 5% and were not considered in the following analysis. It is also important to highlight that nearly 30% (n = 67) of participants could not answer the question completely, failing to list three different by-products of the food industry.

3.1.3. Conceptual Differences between Participants of Different Gender, Age, and Education Levels

Correspondence Analysis yielded the perceptual maps shown in Figure 1 (perception of the circular economy) and Figure 2 (perception of by-products), built based on the main dimensions (Tables 1 and 2) with frequency percentages above 5%, mentioned by the participants who fully provided socio-demographic data (n = 140).

For the first question (Figure 1), middle-aged male adults (35–54 years) with no higher education and mature female adults (+55) with a higher education, mainly positively associated the circular economy concept with the 'Innovation and production' dimension. Young adults (18–34 years old) with no higher education negatively associated the aspects of 'Economy' and 'Circularity' to this concept. Young adults with a higher education positively considered 'Sustainability', 'Economy' and 'Circularity' as the main dimensions associated to the circular economy concept. Female adult participants negatively considered the 'Politics' dimension as being most related to this issue; while male participants, in general and regardless of the polarity, highly associated the concept of the circular economy with the dimension 'Economy'. It was also possible to observe a high association of the circular economy concept with the 'Society' dimension by mature adults without a higher education.

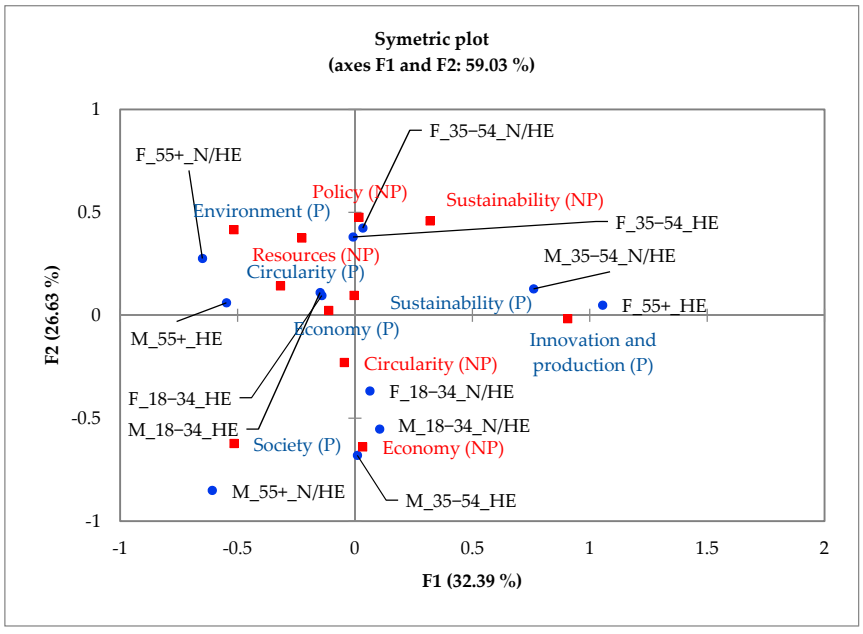

Figure 1. Projection of the dimensions concerning the study of the circular economy concept and the sociodemographic characteristics (F—Female; M—Male; N/HE—No higher education; HE—Higher education; NP (red)—Non-positive polarity (neutral or negative); P (blue)—Positive polarity) in the correspondence analysis space.

In relation to the second question (Figure 2), it was possible to conclude that, in general, participants with a higher education mentioned terms belonging to the 'By-products' dimension. In this sociodemographic group, it was also possible to observe that female young adults considered by-products and ingredients in a more appealing way and female mature adults in a more unpleasant and neutral manner. Participants with no higher education identified more terms belonging to the 'Food' dimension, with young adult

participants considering the identified food products in an appealing way and mature female participants in a more unpleasant and neutral manner.

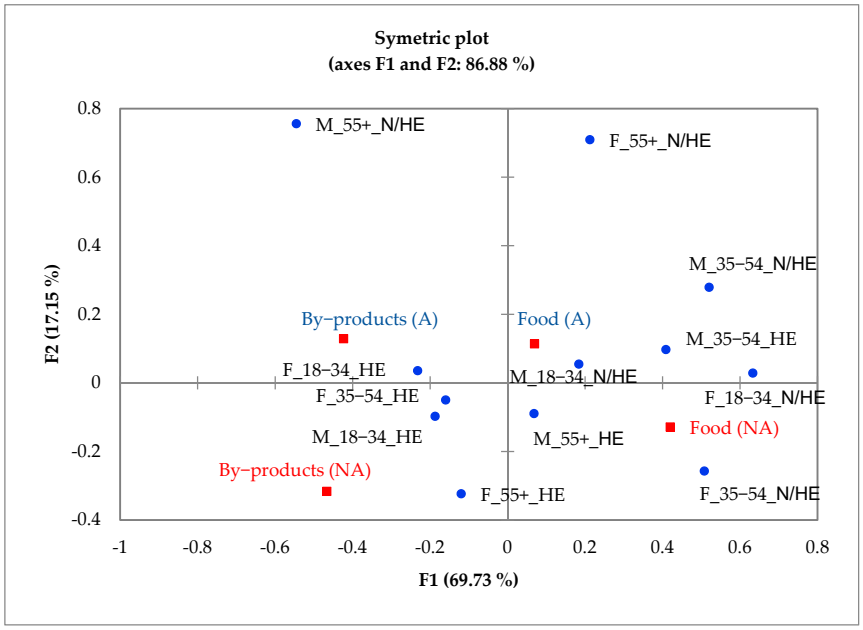

Figure 2. Projection of the dimensions concerning the study of by-products of the food industry and the sociodemographic characteristics (F—Female; M—Male; N/HE—No higher education; HE—Higher education; NA (red)—Non-appealing polarity (neutral or unpleasant); A (blue)—Appealing polarity) in the correspondence analysis space.

3.2. Attitudes toward the Circular Economy and Sustainability in the Food Chain

3.2.1. Sociodemographic Characteristics

For the second part of the study, it was found that 422 people started the questionnaire and 377 completed questionnaires were achieved, giving a response rate of 89%. Eleven outliers were initially identified as not making a scale breakdown. Additionally, following the Mahalanobis' distance, 26 multivariate outliers were also identified. After the elimination of the outliers, the final sample consisted of 340 valid questionnaires. As shown in Table 4, 67% of participants were female and had a mean age of 35.83 ± 17.04 years old. The sample was mostly composed of single individuals with a higher education.

Table 4. Sociodemographic characteristics of the panel for the second part of the study (n = 340).

	Participants (%)
Sex	
Male	237 (67%)
Female	114 (33%)
Age (years)	
18–34 (young adults)	179 (51%)
35–54 (adults)	118 (34%)
+55 (mature adults)	54 (15%)
Education level	
No higher education	147 (42%)
Higher education	204 (58%)
Marital status	
Single	175 (50%)
Married	147 (42%)
Divorced	29 (8%)

3.2.2. Principal Component Analysis

To understand participants' attitudes towards the circular economy, a total of 18 of the original 30 items were included in the final solution, with a Kaiser–Meyer–Olkin (KMO) equal to 0.857 (Table 5). Many of the original items were dropped as they presented low communalities (<0.4) and/or low factorial loadings (<0.3) [48]. Sixteen of the retained items had factor loadings greater than 0.6. These were projected into six principal components (PC), representing 62.4% of the total variance, with Cronbach's alpha coefficients ranging from 0.517 to 0.767. The PCs were named and are described below (Table 5).

Table 5. Factorial structure of the Principal Components (PC 1 to PC 6), emerging from the evaluation of 18 items related to the circular economy concept. Mean (± standard deviation—SD) core values for both PC's and items are expressed over a scale ranging from −5 to +10.

Items in the Circular Economy (Explained Variance -var-, Cronbach's Alpha -α-), KMO = 0.857	**Mean ± SD**	**Loadings**
PC 1—Sustainability (var: 15.8%; α: 0.767)	7.8 [a] ± 2.7	
Ecological footprint	7.0 ± 4.5	0.742
Environmental impact	6.6 ± 5.0	0.714
Reuse	8.5 ± 2.8	0.712
Sustainability	8.5 ± 2.7	0.689
Recycling	8.5 ± 2.9	0.665
PC 2—IDT (var: 10.7%; α: 0.633)	7.4 [b] ± 2.4	
Technology	7.2 ± 3.2	0.806
Education	7.1 ± 3.5	0.608
Innovation	7.9 ± 2.9	0.603
PC 3—S&Q (var: 9.3%; α: 0.675)	6.4 [c] ± 2.8	
Health	6.7 ± 3.6	0.832
Safety	5.7 ± 3.8	0.720
Quality	6.9 ± 3.3	0.450
PC 4—Community support (var: 9.2%; α: 0.514)	5.9 [d] ± 3.1	
Crowdfunding	5.0 ± 4.0	0.778
Fair trade	6.8 ± 3.7	0.693
PC 5—Environmental valorisation (var: 8.9%; α: 0.575)	7.1 [b] ± 3.1	
Biofuels	6.4 ± 4.0	0.809
Waste recovery	7.8 ± 3.3	0.740
PC 6—Food valorisation (var: 8.5%; α: 0.517)	4.2 [e] ± 2.9	
Whey protein	2.9 ± 3.8	0.827
Banana bread	3.9 ± 4.0	0.691
Agroindustry	5.3 ± 4.3	0.476

[a, b, c, d, e]—homogeneous groups among PCs, according to the Wilcoxon test, at a 95% confidence level.

PC 1 was named *Sustainability*: this component, composed of five terms related to the R's policy, ecological footprint, and environmental impact, explained the associations that participants made between a circular economy policy and the sustainability of the planet.

PC2 was named *Innovation, Development, and Technology* (IDT): This component, composed of three terms, was fundamentally related to the association of the circular economy with R&D units, with education and with all entities engaged in scientific research and technological development.

PC3 was named *Safety and Quality* (S&Q): This component, consisting of three terms, allowed us to understand whether the participants associated the circular economy policy and concept with a system of quality and safety.

PC4 was named *Community support*: this component, consisting of two terms, assessed the participants' attitudes towards associating community support, incentives and international trade modalities that seek fair pricing within the circular economy concept.

PC5 was named *Environmental valorisation*: this component, consisting of two terms, highlights the association perceived by participants between waste recovery and renewable energy, and the concept and policies of the circular economy.

PC6 was named *Food valorisation*: this component, consisting of three terms, assessed the participants' association with a circular economy with the food, agro-industry and upcycled foods perspective.

3.2.3. Cluster Analysis and Socio-Demographic Characterisation of Clusters

The cluster analysis enabled consumers to be grouped into four different groups, based on the different principal components expressing the dimensions of perception of the circular economy concept (Table 6). The first group, *ubiquitous sustainability*, comprising 46% of participants, was the group that obtained significantly higher associations to all principal components, suggesting a strong association of circular economy policy with sustainability in its broader concept, including its entire set of interdependent variables. This group was made up of a large percentage of female young adult participants with a higher education. The second group, *unrelated to sustainability*, consisted of 10% of participants, presented significantly lower associations to all CPs, demonstrating a weak association of the circular economy concept with sustainability. This was the group with the highest percentage of male participants and the highest percentage of mature adults and participants with no higher education. The third group, *environmental sustainability*, comprising 25% of participants, significantly valued environmental sustainability, considering that the circular economy enables greater management and conservation of natural resources, fundamental to life support. This was the group with the highest percentage of female participants and the highest percentage of adults and participants with a higher education. The fourth group, *non-food sustainability*, was comprised of 19% of participants and was the group that, despite having associated the concept of the circular economy with different sustainability variables, while having its main focus on the social sustainability and community support component, presented significantly fewer associations of this concept with the food valorisation component and did not establish a relationship between circular economy policies and the agro-industry and food by-products. This was the group with the highest percentage of young adults.

Table 6. Evaluation (means ± standard deviation) of the degree of association of the circular economy concept with the different principal components within the four groups of participants.

Principal Component	Cluster Case Number				*p*-Value
	Ubiquitous Sustainability (*n* = 158)	Unrelated to Sustainability (*n* = 32)	Environmental Sustainability (*n* = 86)	Non-Food Sustainability (*n* = 64)	
Sustainability	8.9 ± 1.6 ^{a}	2.3 ± 2.0 ^{d}	8.2 ± 2.1 ^{b}	7.3 ± 2.4 ^{c}	0.000
IDT	8.6 ± 1.4 ^{a}	3.3 ± 2.5 ^{d}	6.6 ± 2.2 ^{c}	7.5 ± 2.0 ^{b}	0.000
Safety and Quality	8.0 ± 1.9 ^{a}	2.7 ± 2.1 ^{d}	4.5 ± 2.6 ^{c}	7.0 ± 2.0 ^{b}	0.000
Community support	7.6 ± 2.0 ^{a}	2.6 ± 3.0 ^{b}	3.00 ± 2.4 ^{b}	7.1 ± 2.1 ^{a}	0.000
Environmental valorisation	8.8 ± 1.5 ^{a}	3.3 ± 3.6 ^{c}	7.9 ± 2.1 ^{b}	3.8 ± 2.5 ^{c}	0.000
Food valorisation	5.7 ± 2.5 ^{a}	2.4 ± 3.0 ^{bc}	3.5 ± 2.8 ^{b}	2.3 ± 1.9 ^{d}	0.000

$^{a, b, c, d}$, Homogeneous groups according to Kruskal–Wallis non-parametric test, at a 95% confidence level.

Participants were characterised, on average, as being urban or peri-urban, with an intermediate financial situation, valuing quality somewhat more than price and perceiving their lifestyle as more or less healthy. No significant differences were observed between the segments (Table 7) for sociodemographic data ($p > 0.05$).

Table 7. Socio-demographic characterisation of clusters.

		Cluster Case Number				*p*-Value
		Ubiquitous Sustainability (*n* = 158)	**Unrelated to Sustainability (*n* = 32)**	**Environmental Sustainability (*n* = 86)**	**Non-Food Sustainability (*n* = 64)**	
Gender	Male	31.6%	40.6%	24.4%	39.1%	0.184
	Female	68.4%	59.4%	75.6%	60.9%	
Age (years)	18–34 (young adults)	53.2%	43.8%	46.5%	59.4%	0.576
	35–54 (adults)	33.5%	34.4%	37.2%	25.0%	
	+55 (mature adults)	13.3%	21.9%	16.3%	15.6%	
Education level	No higher education	41.8%	53.1%	38.4%	40.6%	0.544
	Higher education	58.2%	46.9%	61.6%	59.4%	
Residential area [1]		5.8 ± 1.5	5.4 ± 1.8	5.7 ± 1.5	5.8 ± 1.7	0.678
Financial situation [2]		4.3 ± 1.3	4.3 ± 1.2	4.6 ± 1.1	4.7 ± 1.3	0.295
Food expenses [3]		4.4 ± 1.3	4.3 ± 1.3	4.7 ± 1.1	4.8 ± 1.3	0.092
Lifestyle [4]		5.5 ± 1.3	5.4 ± 1.5	5.7 ± 1.2	5.5 ± 1.4	0.748

[1] 7-point anchored scale, ranging from 1—rural to 7—urban; [2] 7-point anchored scale, ranging from 1—hard to 7—very good; [3] 7-point anchored scale, ranging from 1—price over quality to 7—quality over price; [4] 7-point anchored scale, ranging from 1—unhealthy to 7—very healthy.

3.2.4. Participants' Attitudes to Characteristics of Food Products from the Circular Economy

In the second half of the research, consumer perception of food products from a circular economy were analysed based on eleven aspects (Figure 3). In the following sections, these findings are presented (Figure 3).

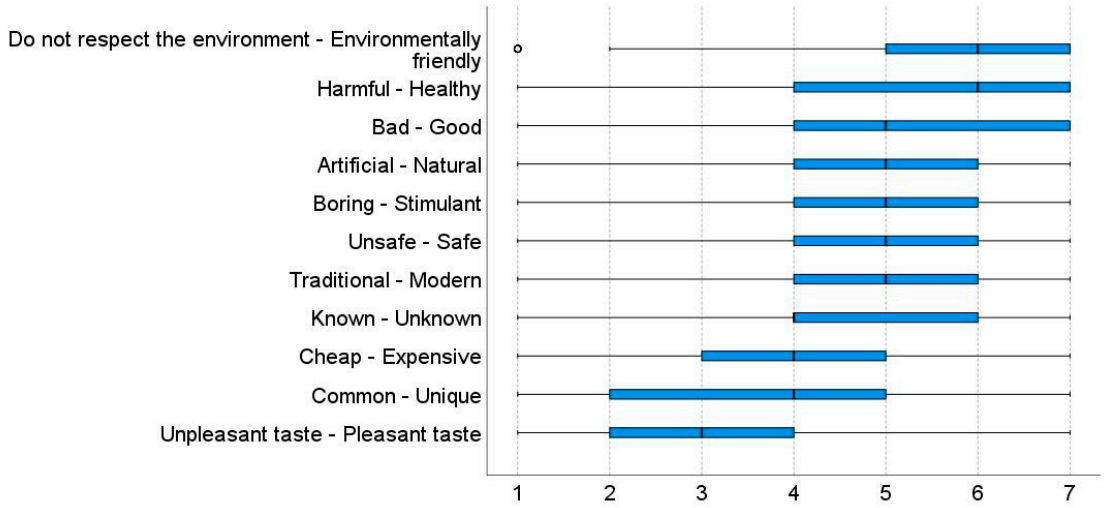

Figure 3. Participants' attitudes on characteristics of food products from the circular economy (mean and standard deviation).

The participants generally considered food products from a circular economy to be good, healthy and environmentally friendly. In general, the characterisation of these products was quite positive, considering that participants also perceived these products to be natural, stimulating and safe, despite considering them modern. However, these products are also considered cheap, common and as presenting an unpleasant taste, which carries quite a negative perception.

When searching for differences in attitudes towards food products from the circular economy between consumers' clusters, the only attribute that revealed significant differences was the one related to 'Artificial—Natural' (Table 8). For this item, the *environmental*

sustainability group considered that these products should consist of few or no artificial ingredients and that they should be processed as little as possible. The *unrelated to sustainability* group, on the other hand, perceived these products in a significantly different way, considering that they may not be so natural and, therefore, contain artificial ingredients or present high levels of food processing.

Table 8. Comparison of the attitudes towards food products from the circular economy, measured over different 7-point semantic differential scales (means ± standard deviation), within the four clusters of participants.

Attitude	Participant Cluster				*p*-Value
	Ubiquitous Sustainability (*n* = 158)	**Unrelated to Sustainability (*n* = 32)**	**Environmental Sustainability (*n* = 86)**	**Non-Food Sustainability (*n* = 64)**	
Do not respect the environment–Environmentally friendly	5.5 ± 1.6	5.2 ± 2.0	5.8 ± 1.6	5.7 ± 1.4	0.509
Harmful–Healthy	5.2 ± 1.5	4.9 ± 1.7	5.4 ± 1.5	5.5 ± 1.4	0.364
Bad–Good	5.3 ± 1.5	4.7 ± 1.8	5.3 ± 1.5	5.4 ± 1.4	0.276
Artificial–Natural	4.9 ± 1.5 ^{ab}	4.4 ± 1.7 ^{b}	5.3 ± 1.3 ^{a}	5.1 ± 1.6 ^{ab}	**0.028**
Boring–Stimulant	4.9 ± 1.5	4.7 ± 1.6	4.9 ± 1.5	5.2 ± 1.4	0.305
Unsafe–Safe	4.7 ± 1.7	5.3 ± 1.5	5.0 ± 1.8	5.0 ± 1.6	0.307
Traditional–Modern	4.9 ± 1.6	4.6 ± 1.9	4.7 ± 1.4	5.0 ± 1.3	0.714
Known–Unknown	4.3 ± 1.7	4.6 ± 2.0	4.6 ± 1.4	4.5 ± 1.2	0.521
Cheap–Expensive	4.4 ± 1.6	4.2 ± 1.7	4.3 ± 1.4	4.1 ± 1.5	0.701
Common–Unique	3.7 ± 1.7	3.5 ± 1.8	3.6 ± 1.5	4.0 ± 1.6	0.420
Unpleasant taste–Pleasant taste	3.2 ± 1.3	3.5 ± 1.8	3.3 ± 1.4	3.1 ± 1.2	0.437

$^{a, b}$, Homogeneous groups according to a Kruskal–Wallis non-parametric test, at a 95% confidence level. Bold *p*-Value denotes a significant difference.

4. Discussion

The first study of the present work investigated the conceptualisation of the term circular economy and explored consumers' knowledge regarding the use of food industry by-products to obtain new products and/or new food ingredients. This analysis used free word association, a technique that allows for the verbalisation of the principles underlying the participants' reasoning [49]. This methodology allows unrestricted access to mental representations [50], including feelings, perceptions, motivations, and attitudes, which would be self-censored in a more structured approach, such as in individual questionnaires and personal or group interviews [51].

The results of the first question, concerning the concept of the circular economy, enabled the assessment that the dimension with the greatest impact and highest frequency of participants was Sustainability, representing, for this reason, greater importance in association with the concept in the consumers' minds [39]. According to the revision study of Geissdoerfer, et al. [52], the underlying interaction between the concept of the circular economy and sustainability is often ambiguous, and a circular economy is usually interpreted as a condition or sustainability and to have beneficial relationship with it. Moreover, according to Alonso-Almeida, et al. [53] and Khan, et al. [54], sustainability is one of the main factors for the acceptance of products and services coming from a circular economy policy, and thus a strong relationship between these two concepts prevails. Sijtsema, Snoek, Van Haaster-de Winter and Dagevos [9] used a qualitative approach and, through mapping using word cards to ascertain common people's ideas, associations, and perceptions withing the concept of the circular economy, also verified a relationship between the term sustainability and the concept of the circular economy. Through correspondence analysis,

it was also possible to observe that this dimension was significantly positively associated with the concept under study, mostly by young adults and female adults with a higher education. The concern for the environment and for a more sustainable planet on the part of a younger generation with some knowledge and a higher education places the results of this study in line with several other studies conducted so far, which indicate that although in practice this generation does not show consistency in their actions towards sustainable behaviours, the information, knowledge, and awareness are quite present in their minds [55,56]. A higher frequency of terms associated with the sustainability dimension by a mainly female adult audience may be explained by several studies that have already demonstrated a greater concern in this group for the environment and a greater knowledge and interest in sustainable consumption [57,58].

The second and third dimensions with the greatest impact in this study were the economy and the concept of circularity, together representing about one third of the associations announced by the participants. According to Fonseca, et al. [59], the circular economy is an economic system that replaces the end-of-life concept and allows us to reduce, reuse, repair, renew, recycle and recover materials and products in production, distribution, and consumption processes. The Ellen MacArthur Foundation, founded in 2011 with the aim of accelerating the transition from a linear to a circular economy, has also defined the circular economy as an industrial economy that is restorative, regenerative, and therefore relies on the circularity of all its constituent products. The lexical junction of these two dimensions gave rise to the word under study, and this is probably the main factor driving the description of terms related to these two concepts. As this is a rather logical and evident association, its negative associations with the concept of the circular economy by young adults without a higher education may suggest a lack of knowledge or information on this policy that would first enable them to relate the concept under study to other dimensions. The description of terms associated with their most literal meaning, and not considering the positive association of the terms, may demonstrate a lack of knowledge about the advantages and benefits of the circular economy.

Regarding the study on the use of food industry by-products, the results of the free word association showed a great lack of information and knowledge of the concept by the participants. By analysing Table 2 it is possible to see that more than half of the participants used terms associated with foodstuffs and only 27% correctly indicated food by-products used to obtain new products and/or new food ingredients. This second study was also the potential source of 67 incomplete questionnaires due to the participants' lack of knowledge or misinterpretation of the question asked. On average, it was also possible to observe large differences in the response time to the free word association questions, and participants took about twice as long to answer the second question on by-products (189.4 $\pm$ 13.8 s) compared with the first question on the circular economy (93.6 $\pm$ 6.3 s). These results are in line with the observations of Grasso and Asioli [35]. The authors, when studying consumer preferences for biscuits incorporating defatted sunflower seed flour, a by-product of the edible oil industry, found that the majority of consumers (85%) had never heard of the term "upcycled" in relation to a food ingredient. The remaining 15% of consumers who had heard of upcycled ingredients prior to the study had, on average, a knowledge score of 3.7 (rated on a 7-point scale anchored between 1—Low knowledge and 7—High knowledge). The difficulty in interpreting this study also lies in some specific socio-demographic characteristics of the participants. The correspondence analysis performed clearly shows a split between sociodemographic characteristics and the two most significant dimensions of the study. If, on the one hand, we can observe a strong relationship between the by-products dimension and people with a higher education, on the opposite axis we find the foods dimension to be associated with people with no higher education. This division may be related to the difficulty of people without a higher education to obtain information regarding this type of product, suggesting a weak dissemination of information by the entities responsible for this service.

Concerning the polarity of the terms elicited by the participants, most of them were described as positive (78%) or appealing (63%). To date, most studies aimed at exploring consumer perspectives and perceptions of the circular economy have focused primarily on specific solutions and have studied the acceptance of specific product types or functions [60]. A review of these studies showed that the acceptance of a circular economy model depends on personal values, products and service offerings, knowledge and understanding, experience and social aspects, perceptions of risks and uncertainty, benefits, and other psychological factors [60]. According to the same authors, the meaning of consumption has evolved, and consumers increasingly tend to adopt circular economy policies, reducing and refusing over-consumption, rethinking superfluous habits, and living with less [61]. Specifically, consumers show an increasing association of this concept with something advantageous, beneficial, and positive, thus allowing us to explain most of the positive polarities of the terms enunciated by the participants in this study. A possible cause for a non-appealing or non-positive association on the part of older or lower education participants may be related to their reluctance to try new food products and the new technologies that enable their development, as identified by Coderoni and Perito [37], which may lead to a lack of interest in seeking information on the use of food by-products or their incorporation in the industry and in their diet.

The main results of the qualitative study were supported by the quantitative study that allowed us to evaluate the attitudes of participants through the circular economy. From the PCA, four groups of attitudes were obtained. In all groups, the concept of sustainability—the main dimension associated with the concept of the circular economy in the qualitative study—was widely underlying in their characterisation. Thus, participants were divided between: (1) those who associated the circular economy with the broader and more general concept of sustainability, encompassing all interdependent variables that make up this concept; (2) those who did not clearly perceive an association between these two concepts; (3) those who mainly associated environmental sustainability with the concept of the circular economy; and (4) those who related the concept of the circular economy with sustainability, but did not understand nor verify any relationship to a food valorisation component in this relationship.

The results also showed that for the quantitative study, the sociodemographic variables analysed (sex, age, and level of education) were not significantly relevant in explaining different attitudes towards the circular economy and sustainability in the food chain. This finding is in line with the study by Akehurst, et al. [62], in which the authors concluded that there is often no significant distinction regarding socio-demographic characteristics with respect to ecologically conscious consumer behaviour. Some works also showed that it is difficult to identify a specific sociodemographic profile for the socially responsible consumer. The results are usually very diverse and contradictory, and sometimes no influence or link is observed with different behaviours [63,64]. For example, regarding gender, some studies showed that women may present a more pronounced behaviour of social responsibility, with strong environmental awareness and a more sustainable lifestyle [35,65–70]. On the other hand, some studies have also shown that there is no discrimination in this type of behaviour related to the gender of the participants [62,71]. The same is the case with age, where several studies report that it is young adults who present a more socially and ecologically conscious behaviour [55,69,70,72], while others say it is the older population that is the most aware [63,66,73,74] and others even identify no relationship between age and attitudes of participants [62]. Finally, regarding the level of education, the contradiction remains, with some studies pointing out greater ecologically conscious behaviour and social responsibility in people with a higher education [66,75], and others who are not identifying a significant relationship [62]. In turn, psychographic variables may be a more effective way to characterise ecologically conscious consumer behaviour. In future studies, measuring psychographic characteristics such as altruism, environmental concern, and perceived consumer effectiveness [62], may be of interest to

verify the existence of differences in groups of participants with different attitudes towards the concept of a circular economy and sustainability in the food chain.

Regarding the second question of the quantitative study, which aimed to assess consumer attitudes towards food products from the circular economy, it was possible to observe, in general, some positive attitudes, especially related to the advantageous environmental impact that these products can present and also in relation to their healthy character. This perception emphasises that the already existing institutional communication, as well as some marketing campaigns focusing on sustainability, have a positive impact on consumer perception. As such, these should continue to be fostered and disseminated to positively influence the willingness to consume and purchase these products [35]. Despite a positive evaluation with these attributes, there was a negative relationship regarding the expected taste, with many participants considering that these products may have an unpleasant taste. This devaluation may be strongly associated with the general lack of knowledge of food by-products [35], which may sometimes be associated with products composed of waste and therefore with less quality, and the subsequent risk of consuming them. This perception, as occurs with some novel or unfamiliar foods to the consumer, may result in a lower sensory performance expectation for this type of product [76,77]. These results also led to the conclusion that there are significant differences in the perception of the naturalness of food products from the circular economy between the two clusters. The environmental sustainability group perceived these products in a more natural way, without artificial or synthetic ingredients. This evidence is in line with the results of a special Eurobarometer developed by the European Commission with the aim of finding out which factors influence the European community's eating and food purchasing habits, and exploring how consumers perceive the concept of "sustainability", assessing what would help them adopt a healthy and sustainable diet. In the report, consumers who consider the "impact on the environment and climate" as one of the most important factors when buying food, were more likely to mention the environmental aspects of healthy and sustainable food and diets. They were also more likely to assume that sustainable food should have a low environmental and climate impact, and that food should be produced in a way that minimises waste, has minimal packaging and is organic [78]. On the other end, the unrelated-to-sustainability group perceived these foods in a more artificial and processed sense. These differences in consumer perception of novel functional foods with by-products may be a challenge because, as described above, these products may be perceived by some consumers to be less natural than traditional products, reinforcing the importance of the role of information provided by labelling and public campaigns [33].

It is important to mention that the questionnaire was initially planned as a whole, with the qualitative and quantitative parts being part of the same questionnaire. The preliminary one was carried out and was allowed to observe that most participants abandoned the questionnaire after or during the free word association task. It was also possible to ascertain that the time to perform this questionnaire as a whole was quite extensive. For this reason, the researchers decided to conduct both parts of the questionnaire—qualitative and quantitative—simultaneously. This way, although the final sample was different for both studies, the participants showed a greater involvement and enthusiasm in completing the task.

Finally, for both the qualitative and quantitative studies, some limitations were identified. The main one is related to the difficulty in accessing the responses from older consumers. This difficulty is related to a greater lack of knowledge on the part of these participants concerning the concepts under study and with the use of the technologies necessary to complete the questionnaire, which was only available in digital format. Furthermore, this study may not be considered as representative of the entire Portuguese population.

5. Conclusions

This study allowed us to assess consumers' perception and knowledge regarding the circular economy policy and the use and valorisation of food by-products. The results

demonstrated a greater knowledge on the part of the participants concerning the concept of the circular economy, in comparison to that of food by-products and their use in the food industry. This lack of knowledge was largely associated with the use of terms with little relation to the theme, as well as the high frequency of "blank" answers and successive interruption and non-submission of the questionnaire and the high response time associated with this question.

In practice, the lack of information on the use of by-products as ingredients in new food products, or in terms of the concept itself, may be a major obstacle to the promising solution found by the food industry to circumvent the problem of food waste production. However, for these products to be valued by consumers, it is essential to understand the corresponding perceptions about them, to diminish potential risks of unsuccessful launches, whether due to aversion or fear of consuming these products. Additionally, to tackle food waste at the consumption stage, it is necessary to actively involve consumers in decision-making and strategies related to the purchase and reuse of food. Government entities, educational establishments and the food industry should invest in awareness-raising and environmental education campaigns to increase consumer knowledge regarding circular economy policies, sustainable development, and behaviour, and especially regarding food industry by-products. These measures could generate trust, creating a positive impact in consumer attitudes, and subsequently in their behaviour, towards the purchase and consumption of these products.

Further work is needed to find the most appropriate way to communicate to consumers a link between the concept and policies of the circular economy and the food industry. Future work may focus in the study of the associations between possible reasons why consumers are unaware of the existence of agri-food by-products, the perceived benefits of their use, as well as possible applications for the development of value-added products. Exploring the variables generated as a theoretical framework, a more empirical approach may also be a potential avenue for future research. It would also be valuable to apply this approach in other EU countries in order to study cross-cultural differences in the conceptualisations of these two concepts. It is noteworthy that there is a relevance of generating larger knowledge and positive attitudes towards these concepts as a means to promote behavioural changes aiming at the reduction of food waste.

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