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Analysing the Social Acceptance of Bio-Based Products Made from Recycled Absorbent Hygiene Products in Europe

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Abstract: The acceptance of bio-based products by consumers is one of the fundamental pillars to achieve the integration of a circular economy model in society. This article analyses the results obtained in a large-scale survey on the social acceptance of bio-based products, especially those obtained from Absorbent Hygiene Products, where a statistical analysis of the data collected is performed to establish rules of thumb and conclusions on the factors considered most significant for consumers in their purchasing decisions. The study was carried out in four European countries, and the sample population covered different age ranges, genders and economic statuses. The main findings are that the most critical factors relate to price, quality and ease of use, but other factors, such as environmental benefits, composition and origin of materials, also affect bio-based products. In addition, this study concludes that most people do not understand some important aspects related to bio-based products, and product information and communication channels need to be improved. Therefore, purchasing strategies for bio-based products should focus on addressing these shortcomings, making the decision to buy bio-based products a quick and easy action.

Keywords: bio-based products; social acceptance; absorbent hygiene product; consumers

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1. Introduction

Climate change and material scarcity are global problems arising from existing patterns and policies that need to be solved by changes in production processes to make them more efficient [1]. These problems must be addressed not only from an environmental perspective, but also from a social and eco-economic one, to transform the current system into a circular economy [2,3]. In fact, these problems have generated in recent years a great concern for sustainability in society [4,5].

In the near future, it is essential to find alternative solutions to non-renewable resources that allow industrial processes to coexist in balance with the planet's ecological limits, e.g., by replacing fossil fuels with biomass or other renewable energy sources [6], reusing materials and waste [7,8] or optimizing water consumption [9,10]. The introduction of bio-based solutions might be a cornerstone for the adoption of a circular model of economy on a global scale [11–13].

However, it is necessary to involve society and especially consumers to learn from them about the social acceptance issues that might drive the change into this circular and bio-based way of production [3]. Further, learning about the social impact of products is useful for companies to generate more socially responsible products and processes [14]. Society is currently in the initial stages of a transition to the new circular economy model, as well as the standardisation of bio-based products. Understanding aspects related to social acceptance and consumer barriers to the consumption of bio-based products are essential in order to promote a rapid market penetration, meeting customer expectations [15] and overcoming the scepticism generated over the years by misuse of the term "bio" [3,16]. As consumers seems to be more susceptible to marketing campaigns than to their actual knowledge [17], companies might adopt greenwashing strategies, which refers to

adopting self-claimed sustainability practices or product properties that differ from the actual performance [18,19]. Overcoming this issue in favour of bio-based products might require the identification of the most trusted channels and the more reliable third parties by consumers, requiring an early involvement of stakeholders for the definition of future bio-based products.

In this sense, Absorbent Hygiene Products (AHPs), such as baby diapers, feminine hygiene products and adult incontinence products, present a challenge and an opportunity. On the one hand, AHPs improve living standards by providing a daily personal hygiene and health solution. AHPs are broadly use in Europe, accounting for up to approximately 2–7% of the total municipal solid waste, and are considered a non-recyclable fraction, which is usually incinerated or landfilled [20]. AHP components are generally not biodegradable, and inadequate end-of-life practices might lead to clogged piping systems and health issues for workers who deal with these wastes [21,22]. On the other hand, they can become a source of recyclable and bio-based materials, provided that appropriate technologies are available to allow their extraction and treatment. Within a circular approach, valorisation of the secondary raw materials is a promising field in continuous progress [17,18,20].

Within this context, the objective of this study is to identify which are the key factors that might increase the social acceptance of bio-based and recycled products made from recovered flows of AHP waste. As part of its contributions, the study aims to answer the following research questions around social acceptance factors affecting the market uptake for bio-based products:

- Which might be the key aspects for consumers when choosing a bio-based product?
- How do consumers stand with respect to products made with recycled or bio-based materials from the treatment of AHP waste?
- What might be the most efficient strategies to facilitate the placing on the market of this type of products?

The novelty of this article is the study of which factors can be used as a key to facilitate the social acceptance of bio-based and recycled products by studying the statistical relationships in the responses of a large survey on bio-based and recycled products. For this purpose, an analysis of the degree of social acceptance of recycled or bio-based products by European consumers is carried out. The questionnaire focuses on assessing general knowledge on bio-based products, but also includes questions on the five final products made from materials recovered from AHP waste treatment, within the scope of the EMBRACED project. These are: (i) caps and plastic bins for AHP collection made with recycled polypropylene/ polyethylene (PP/PE) plastic, (ii) underpads containing recycled Super Absorbent Polymers (SAP), (iii) medical devices made from bio-based polyhydroxybutyrate (PHB), (iv) packaging for absorbent products from recycled polyesters and (v) organic fertilizers.

The study is based on the responses from more than 1600 consumers in 4 EU countries, namely, Germany, France, Italy and Spain. These four countries are within the top five markets for baby diapers, towels/pads and panty liners in the EU over the last decade [23]. The sample size guarantees a confidence level of 95% and a margin error below 5%. The collected responses are evaluated through the application of qualitative methods to identify the most significant factors that could favour the integration and commercialization of bio-based products. The collection of consumer opinions is carried out within the framework of the European EMBRACED project, which aims to try to close the loop on AHP residues [21].

The structure of this study is as follows. First, there is the "Literature" section, which provides a literature review on the topics. Next, the "Materials and Methods" section explains the methodology used to conduct the survey and the statistical analysis, and how the information has been analysed and processed. The "Results and Discussion" section presents the results obtained, with figures and explanations. Finally, in the "Conclusions" section, the factors considered most critical for promoting the social acceptance of bio-based products are presented. In addition, there are three Appendices with additional information

to support data in the manuscript: Appendix A (Survey questionnaire), Appendix B (Survey results: supporting data) and Appendix C (Classification trees).

2. Literature

2.1. The Need to Effectively Implement a Bioeconomy That Is Based on the Reuse of Materials and That Helps to Achieve European Sustainability Goals

The 2018 EU bioeconomy strategy underlines that a sustainable economy is necessary to achieve the objectives and priorities related to climate targets, reduction of material consumption, reduction of waste generation and modernization of production processes [24].

Within Europe, the bioeconomy is progressively growing, and accounting is an important part of turnover, such as in the food and beverage market, the primary sector or forestry, representing a volume of more than EUR 2.4 billion in the European Union in 2017, and increasing by nearly 25% since 2008 [25]. The bio-based industry contributed approximately 30% of this percentage in sectors such as chemicals, plastics, pharmaceuticals, paper, biofuels, bioenergy, textiles and forestry [25,26]. Almost half of the turnover came from the beverage sector, followed by the primary sectors of forestry and agriculture [25]. The bioeconomy is essential to achieve the Sustainable Development Goals defined by United Nations, which are very ambitious (e.g., achieving climate neutrality by 2050) [27].

2.2. The Need to Successfully Introduce Bio-Based Products into the Everyday Life of Consumers

Many of the bio-based products on the market are still considered by consumers as a novel alternative because they have been on the market for only a short time, and therefore, consumers are often unaware of the conditions of the product [3].

In general terms, there is a lack of detailed knowledge on the overall consumer acceptance of bio-based products and the technologies and processes that generate them. Although several studies have been conducted on some related topics, they tend to refer to the consumption of specific products and not to a general overview of the variables that affect the purchase decision for bio-based products. Examples include studies on the purchase of organic food [28], bio-based packaging [29,30] or food made from insects [31].

Despite the above, and regardless of the composition or benefits that bio-based products may have over conventional ones, their purchase is affected by several factors that are not always linked to their characteristics. One example is the study by Verdurme et al. [32], where it is observed that the acceptance of bio-based products is associated with the acceptance of the technologies involved in their production processes. Sometimes, the purchase decision is also influenced by the brand name that launches it on the market, as can be seen in the study conducted by Chovanova et al. [33] and their research on the influence of brands on consumers' purchase decisions, where it was found that more than half of the 1250 respondents were influenced by the brand name in their purchase decisions for bio-based products. Other factors influencing decision making are price [34] and product performance, which may vary depending on the quality of the raw materials used [35,36]. There are also articles that point out the fact that the lack of consumer familiarity with the social acceptance of bio-based products may be a problem based on the definition of the term "bio-based" and its understanding by the consumer [37–39]. Recent studies have shown that 50% of consumers are aware of the existence of bio-based products, while only 12% have ever purchased such products [40,41].

In this sense, it is summarized that there is still a long way to go before social acceptance of bio-based products is complete. Brand owners can also play an important role in helping consumers to access products and can be key to the success of bioindustries, as large brands can champion a technology or product and drive its expansion into broad markets [42].

2.3. The Need to Address A Possible Outlet for the Treatment of Absorbent Hygiene Product (AHP) Waste

AHP products and wastes consist mainly of baby diapers, although other wastes, such as absorbent products for menstruation or urinary incontinence, are also included in this

category. Their generation depends on social and cultural parameters and the economic conditions of each country [22]. They are part of the regular shopping basket for most families, especially those with babies, and are considered indispensable in the daily lives of these stakeholders [43]. Despite being composed mainly of organic matter [44,45] (such as cellulose, faeces and urine), consumers tend to deposit them with the rest of the waste in the residual household waste fraction.

An estimated 30 million tons of AHP waste is generated worldwide annually, representing approximately 2–4% of total urban municipal waste [20,21], which often ends up in landfills or incineration plants. In the USA, AHP waste accounted for approximately 4100 tons in 2018 [46], representing 1.40% of total municipal waste generation in that country. In the European Union, it can account for as much as 15–25% of waste in some facilities [47].

When these products are used and transformed into waste, their management leads to a number of negative environmental impacts and repercussions, such as soil degradation, air and water pollution, soil erosion and greenhouse gas emissions [43]. In particular, most AHP wastes are usually landfilled or incinerated [48], thus generating the environmental impacts associated with this type of treatment:

- Landfills: methane emissions from the decomposition of organic matter, soil occupation and possible leachate from the landfill into groundwater, as well as noise and odours [49].
- Incineration: emission of polluting gases hazardous to health (NO_x, SO_2, HCl, particulates and dioxins) and generation of ashes with the presence of hazardous substances [49].

2.4. The Contribution from EMBRACED Biorrefinery Model

To address these needs, EMBRACED's contribution is based on a circular economy approach that combines the testing of technological approaches for the recovery of all AHP treatment's by-products, the involvement of end-users actively since the collection phase, and the design of final products useful for the care and health sector. The whole biorefinery concept is designed in order to enhance as much as possible the circularity of the proposed value chains and end-products.

At the technological level, a biorefinery model has been designed and tested for the treatment of AHP waste and the recovery of materials. As presented in Figure 1**,** the value chain is divided into six main phases [50]:

- AHP waste collection transport to the pre-treatment plant: carried out by waste operators testing different approaches to involve domestic users and commercial users from the care and health sector.
- Pre-treatment plant: cold storage of incoming waste, autoclave for sterilization, shredder, dryer, mechanical and optical separation. This pre-treatment allows the recovery of cellulose, PE/PP plastic and Super Absorbent Polymer (SAP).
- Value chain A: cellulose from the AHP pre-treatment is hydrolysed towards obtaining second-generation sugars. Sugars then feed a fermenter for producing bio-based building blocks that are used for producing bio-based polyesters.
- Value chain B: cellulose containing SAP and part of the plastic fraction undergo a gasification process targeted at producing gas (CO_2 and H_2). The cleaned gaseous stream is then fed to a bioreactor for producing bio-based polyhydroxybutyrate (PHB) and Protein Hydrolysates (PH) via fermentation with selected microorganisms.
- Recovery of all by-products: plastic and SAP fractions obtained upstream from the AHP waste pre-treatment are also valorised, while the nutrients extracted from wastewaters are recycled, and the cells recovered from the fermentation broths are further valorised into bioenergy and fertilizers.
- Final application: production of the bio-based materials and products.

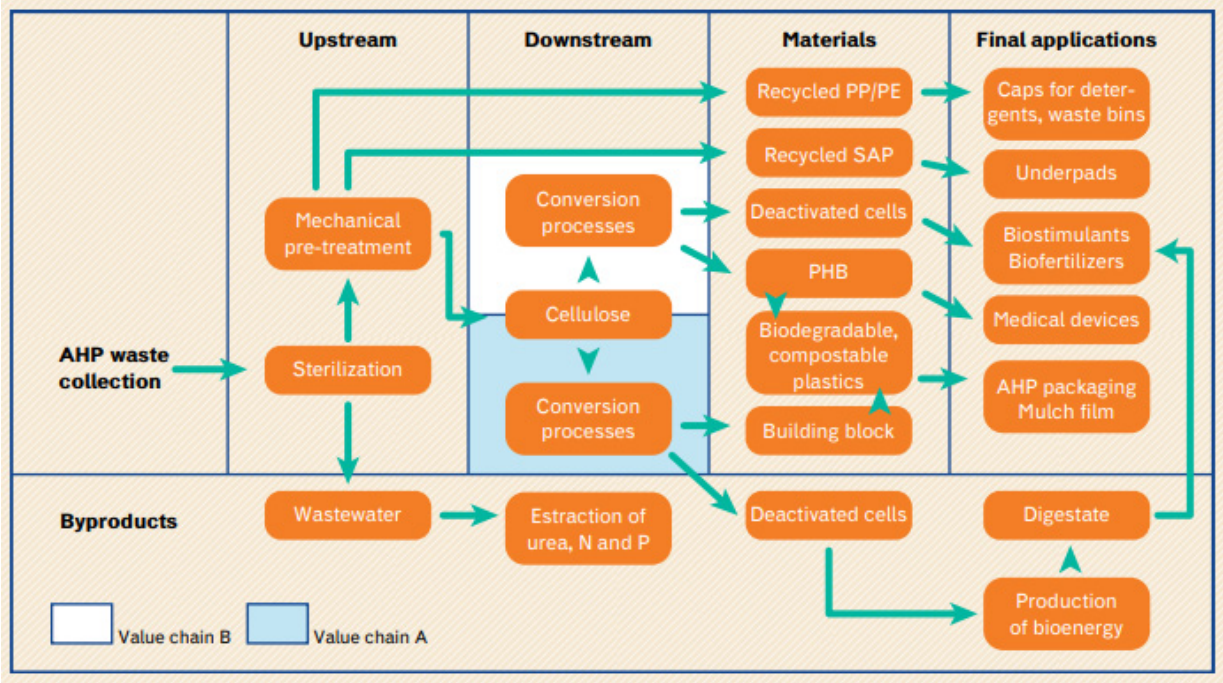

Figure 1. EMBRACED biorefinery model [50].

The biorefinery model is tested to achieve the treatment of 10,000 ton of AHP waste per year. Among the technical barriers encountered for the re-entering of AHP waste into this innovative value change are highlighted the following. First, an initial deficit for the collection of the required testing volumes from domestic users, which is compensated by collecting directly from commercial users, such as hospitals, nurseries and nursing homes. Involving this type of user also ensured a high-quality separation, with an impurity margin of less than 2%. To address domestic users, two approaches are tested: door-to-door collection and smart bins located in kindergartens and supermarkets. Both tests result in positive numbers. To further promote the collection, an app connected to the smart bins is tested to reward participants with vouchers for purchasing new AHP or prizes made with the recycled materials. Up to 6 tons per week are collected through the smart bins [50].

Second, the transport and storage of AHP waste initially produced Malodour impacts that are quickly corrected. The main solutions applied are to store the AHP waste in 6-ton refrigerated containers at 4 degrees before transportation, and the location of the pre-treatment plant in a site where municipal solid waste is treated already, avoiding any additional impact. Regarding other safety and health issues, none are encountered during the collection. Once AHP waste arrives at the pre-treatment plant, sterilization is carried out within the autoclave, a jacketed metal tank where the combined action of rotation and temperature produces the total sterilization. This is a patented process that does not require the pre-opening of the bags. Final tests on recovered materials demonstrate the compliance of the most stringent health and hygiene criteria [51].

Finally, the final applications are designed to close the loop from waste generation to material recovery. The most illustrative example is the production of underpads from recycled SAP, a useful product for nursing homes and hospitals. Recycled plastic is also intended to re-enter into the life cycle of AHP, whether as packaging of absorbent products or as bins for the collection of diapers by domestic users. Similarly, bio-based PHB is destined as a 3D-printing material for medical applications (i.e., bone implants). EMBRACED final products present a better life cycle performance than that observed for the corresponding benchmarks, in terms of global warming potential and use of resources. The CO_{2eq} emissions of the process amount to 66 kg per ton of AHP waste, and the saving versus the landfill/incinerator scenario are equal to −270 $kgCO_{2eq}$ [50].

3. Materials and Methods

The methodology followed in this article consists of three main steps. Firstly, the Data Collection phase, during which a consumer survey collects information on consumer awareness, potential barriers and opportunities related to the social acceptance of recycled/bio-based products from AHP waste treatment. Second, the Exploratory Data Analysis phase, during which the databases are prepared, and the initial descriptive statistics are performed. Finally, the Data Mining phase that involves the application of Classification Tree Analysis (CTA) and Association Rules (AR).

3.1. Data Collection (Consumers Survey)

Given that consumers may have different socioeconomic profiles, the scope of the survey is set to have a broad sample of participants in order to have a more objective view on the topic. The data collection takes place in 4 European countries (Italy, France, Germany and Spain) during 2019. The survey is conducted online, and a total of 1602 surveys are completed. The consumer survey template can be found in Appendix A.

The questionnaire is divided in three main sections. The first one, a general section containing questions about the key aspects that consumers evaluate in every product, as well as awareness-related questions to establish the level of understanding about the term bio-based and what is considered as a bio-based material or product.

After a brief but clear explanation of what is a bio-based product, the second section examines the consumers' perception about the factors that could influence their preference (or not) for bio-based products. Accessibility to information and availability in local shops, as well as product aspects, such as quality, environmental performance and price, are asked to better understand the consumer's perspective.

The final section focuses on the evaluation of the five final products of the EMBRACED project, made from recycled or bio-based materials recovered from the treatment of AHP waste. Consumers are asked to evaluate each of these innovative alternatives in comparison with conventional ones made from non-recycled fossil-based materials.

In the case of underpads, an exclusive question is included to determine if the final tone, which could vary from white to a light ochre, could affect the product acceptance by consumers. PHB's bio-based medical devices, such as bone implants, which are not products usually purchased by the public, but consumed through hospital-related services, are examined through two additional questions aimed at determining whether consumers would express a preference or satisfaction knowing that their designated hospital use these innovative products.

Additional questions to establish the socioeconomic profile of the respondent are also included, such as gender, age and financial situation.

3.2. Exploratory Data Analysis

Once the data collection is completed, an individual assessment per question is carried out to process the data and classify the results according to the profile of the participants. A similar approach is made for each question, generating descriptive statistics and graphs by gender, age, country and household economic status. A comparative analysis is made based on this to identify initial trends and conclusions. Participant profile attributes is shown in Table 1.

3.3. Data Mining

First, the database from the survey is prepared for the application of the selected Data Mining Techniques (DMTs). Data preparation is a key step towards any data-based analysis, given that a carefully prepared database ensures a more efficient use of the information during assessment and modelling steps [52]. Inconsistencies in the database (missing or outlier values and false values of zero) are resolved, and those variables and records that are not relevant to achieving the goal are discarded.

Table 1. Consumer survey respondent profile.

Profile	
Gender	50.62% female 49.38% male
Age	31.17% aged 18–34 years 67.33% aged 35–64 years 1.50% aged >65 years
Economic situation	3.68% very difficult situation 13.84% difficult situation 53.55% situation sufficient to make ends meet 26.56% comfortable situation 2.37% very comfortable situation
Education level	9.91% Primary education 18.83% Secondary education 29.68% Technical/Occupational education 41.58% Higher education
Location	50.84% Cities 32.81% Towns and suburbs 16.34% Rural areas

Besides descriptive statistics, two DMTs are selected, with the objective of exploiting the information collected through the survey to better understand how consumers stand with respect to bio-based products. These DMTs are classification trees and association rules.

On one hand, the classification tree is a multivariate technique that segments a given database into multiple dichotomies or branches representing attributes. Each of the branches represents a prediction of how the dependent variable would be classified, according to whether or not the binary decision of each dichotomy is met. In other words, the algorithm repeatedly selects a value attribute, such as level of environmental awareness, that could divide the database into two groups, maximising intergroup difference and minimizing the intragroup variability. This process is repeated to explain the dependent variables, such as the preference of selecting a bio-based product over a conventional one [53].

On the other hand, the rules of association method are employed to analyse the prevalent trends among consumer responses. This method searches for interesting relationships among items that might result in a rule. Rules of association identify frequent associations between objects. These associations are represented under a structure that can be read as "if 'Antecedents (A)', then 'Class (C)'", in which A are the required causes for C, the consequences, to happen. Rules are composed also by the support of the rule (s%) and the confidence of the rule (c%). The support and confidence of the rules are indicators of the certainty of the discovered rules. The s% value represents the percentage of registers containing both A and C over the total number of registers. In contrast, c% represents the percentage of the registers containing both A and C over the number of registers containing A. These objective measures attempt to analyse the structure of the rules, their predictive performance and statistical significance, mainly based on support and confidence values. Finally, rules are considered interesting if they meet a minimum support and confidence threshold. However, as many of the rules that meet this requirement are expected or obvious associations, further evaluation is necessary. The objective is to determine how interesting a rule is according to subjective approaches, such as the lack of predictability in terms of rules that were previously unknown or that contradict prior knowledge, or objective ones, such as how actionable the rule is given the benefit that produce the obtained information. This method is known as Analysis of Interest [54,55].

In this sense, two types of databases are created according to the requirements of the different DMTs and the specific needs of this research. The first one, by transforming the

original responses into dummy and factor variables as required for the classification. The second one, by converting the survey responses into a relational table, which consists of N cases described by different attributes [56].

4. Results and Discussion

4.1. Descriptive Statistics

All the information described in this section is based on the data included in Appendix B.

In regards to the most influential aspects that consumers evaluate about any product (see Figure 2), the survey shows that quality, price and ease of use are always at the top, regardless of the approach (e.g., by gender, by age or by nationality). However, and taking into account the information shown in Figure A1, people in Germany seem less interested in competitive pricing. Environmental benefits and the composition and origin of materials seem to be closely related, but the former is slightly less valued, especially in Spain and Germany. Both aspects increase in acceptance with the age of the respondent. For the younger group, brand reputation is just as important as benefits and origin. The influence of all aspects declines if the economic situation worsens: competitive price value might drop 15 points if the situation of the household is very difficult.

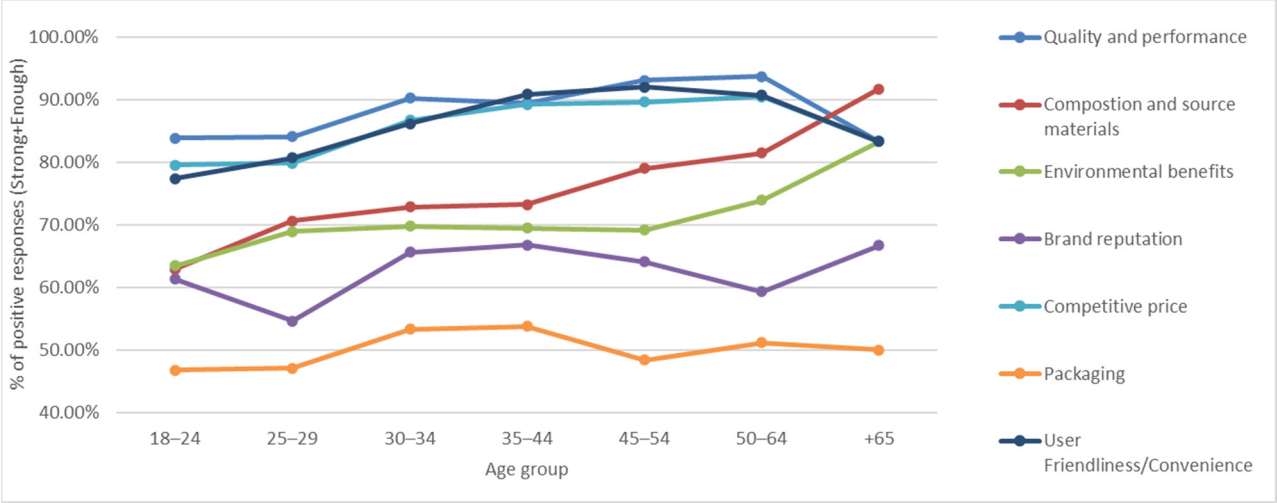

Figure 2. Consumers' influential aspects for the purchase of a product.

This result suggests, as other studies also indicate [3,57], that environmental awareness is not enough by itself to ensure market openness: consumers will always look for quality and attractive pricing. On the question of how much should products made from alternative materials cost in comparison with the conventional ones (Figure A2), half of respondents state they should cost the same, whereas 20% think they should cost more.

Furthermore, the survey shows that 5% of the participants are completely reluctant to change their behaviour, despite the potential environmental benefits from the bio-based/recycled versions (Figure A3). This trend can be seen in all ages and increases up to 10% in the German case. This tendency is very localized among the less well-off, as 25% of them would not make changes just because of better environmental qualities.

However, 74% of people seem to be open to trying more sustainable products, almost without any conditions. A considerable exception is those over 65, as 42% of them would need additional aspects to make the shift. France is the country that follows this trend the most. About these other aspects that influence the decision, again, competitive price (Spain) and quality (Germany) are the most important ones.

With respect to the awareness level towards the bio-based concept (Figure A4), a general misunderstanding of the term is found, given that about 50% of interviewed say that they can identify only "some" characteristics of a bio-based product. This might be related to the overuse of the prefix "bio", which might provoke consumers to confuse it

with organic or biodegradable, for example [57,58]. Other cause might be that the word "bio-based" is inexistant in some languages, such as Spanish and Italian. In terms of gender, a large percentage of both men and women are unclear about the identification of bio-based products (37% of women and 32% of men).

To increase awareness and trust over products (Figure A5), consumers demand more and clearer information [59]. In general, information related to health benefits is more attractive to consumers, up to 15 points higher than environmental aspects, such as organic, recyclable or biodegradable properties. These characteristics seem to be grouped in the same package, perhaps reflecting a tendency to consider everything together as "green solutions". Awareness of social impact is less important, especially when the financial situation is more difficult. As can be seen in Figure 2, information demand increases with age, as young people seem to be less interested, except for health benefits.

Additionally, survey respondents are consulted about their level of agreement about some statements related to the purchase of bio-based products, as shown in Table 2 (additional information in Figure A6). Besides finding these products at competitive prices, people seem keen to find products at their local stores, but will prefer to have a straightforward shopping without having to spend too much time evaluating which is the best option. A marketing strategy might be, for example, local store's staff serving as advisors to buyers about what is a bio-based product and the benefits of those available in-store, facilitating the evaluation of alternatives and the purchase decision [60]. This would require a capacity building for sellers.

Table 2. Level of agreement about statements related to bio-based products' purchase.

	Answers Distribution [%]						**Country (Strongly + Agree) [%]**			
	Strongly + Agree	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**FR**	**DE**	**IT**	**ES**
If I knew that bio-based products were available through a local store, I would be interested enough to look at it.	74	26	49	19	4	2	72	67	81	76
I would only consider buying bio-based products if the price is competitive with conventional ones.	72	25	47	20	6	2	69	67	81	70
I think that there is too much information to be analysed to know which is the best purchasing choice.	76	22	54	17	5	2	82	67	83	71
I make shopping with a lot of time to make a thoughtful choice of the products I am buying.	70	21	49	22	7	1	77	58	76	69
Price is a mean of simplifying complicated purchasing choices.	69	20	49	21	8	2	74	65	62	74
Products I am used to buy make shopping quicker and easier.	66	16	50	28	4	2	71	63	64	67
Labels are simple and understandable.	44	10	34	29	22	5	43	45	49	39
I know how to learn if a product is bio-based.	39	8	32	32	21	7	35	43	46	34
I believe my friends/family/colleagues would like me to buy bio-based products.	36	9	27	43	11	10	27	33	43	42

In a second level, consumers seem to value the possibility of making less effort-demanding purchases. For this, price is usually used as one of the main criteria for product selection, whereas using labels seems to be avoided unless their design is clear and understandable. The lowest scores are related to proactivity to learn about bio-based products and recognition by relatives.

When asked exclusively about preferences regarding products made from recovered materials from AHP waste treatment (Figure A7), consumers seem to start valuing the composition and source of the materials very similar to how they did with price, quality and user-friendliness. Environmental benefits are also better valued if compared to the response given towards products in general. This is the case of Spain (from 64% to 74%) and Germany (from 66% to 74%). Consumers' perception about final cost is the same as that explained before.

Regarding the preference of the five products tested in EMBRACED against conventional alternatives, people show a clear tendency to prefer recycled/bio-based products over non-recycled/bio-based products, as Figure 3 shows. Younger people (under the age of 34) choose recycled/biologically based options at a higher percentage than those over the age of 44, despite being less interested in receiving related information, as previously commented. In terms of gender (Figure A8), women tend to rate recycled/bio-based products more positively than men (in some cases by at least five points).

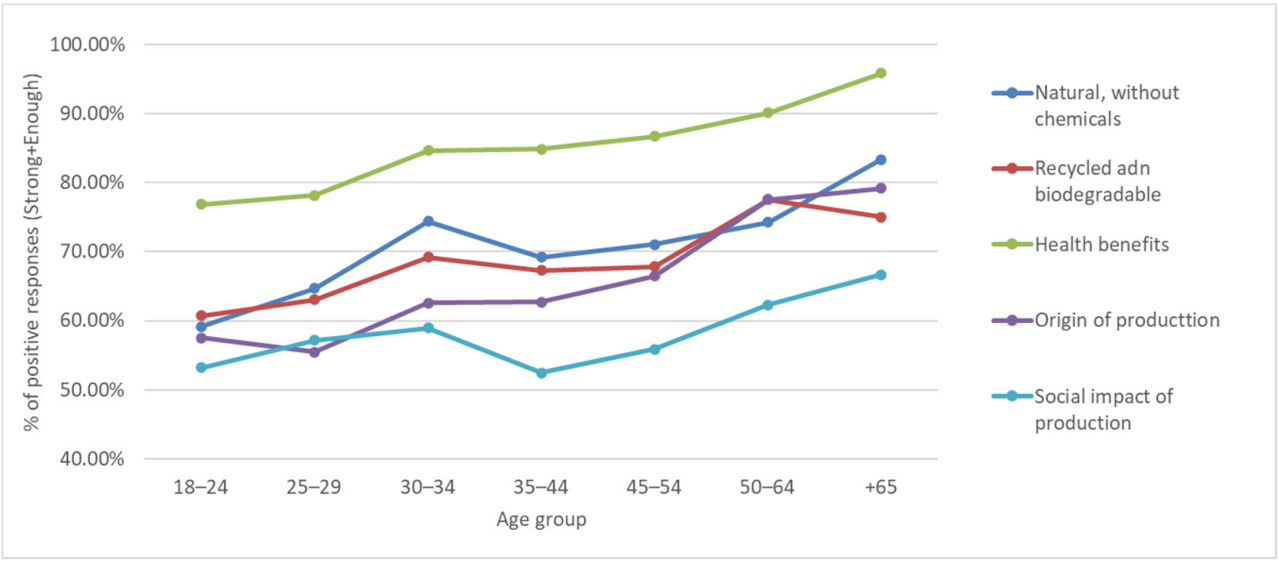

Figure 3. Product information more interesting for consumers.

Although all products have a similar acceptance among consumers, absorbent pads seem to generate less satisfaction than the others (Figure 4). This difference appears when people are asked about how comfortable they will be using these products (Figure A9). People seem to be more open to try packaging and fertilizers than a hygienic product like the underpads. By country, people in France and Germany seem to be more reticent than those in Spain and Italy, as well as men compared to women. Younger people also show lower satisfaction overall. The values between 30 and 64 years of age are similar.

Another clear distinction for underpads can be seen in that the influence of the final colour of the product might affect the purchasing decision of consumers (Figure A10). In this case, if the final tone slightly varies from white to an ochre colour, as the one associated to recycled paper, 37% of people would be very influenced (valued over 7 out of 10) to change their purchasing decision by declining the product if it were ochre. Moreover, product aesthetics could be a considerable barrier for half of the consumers given that the mean value is 5.3. Still, there is a large variability among the responses, and the standard deviation is high at 2.7.

Finally, for the case of medical devices from bio-based PHB (Figure A11), such as bone implants, specific questions are designed to evaluate the consumer perception in case their designated hospital would use this bio-based alternative. In general, acceptance is above 70%, with no major differences between the analyses. However, most of the people who might be interested would prefer to know exactly which product has biological content.

Interestingly, 30% of respondents would prefer it "in any case". This value is higher for people over 65 years of age (38%) and for people with a "very comfortable" economic situation (45%).

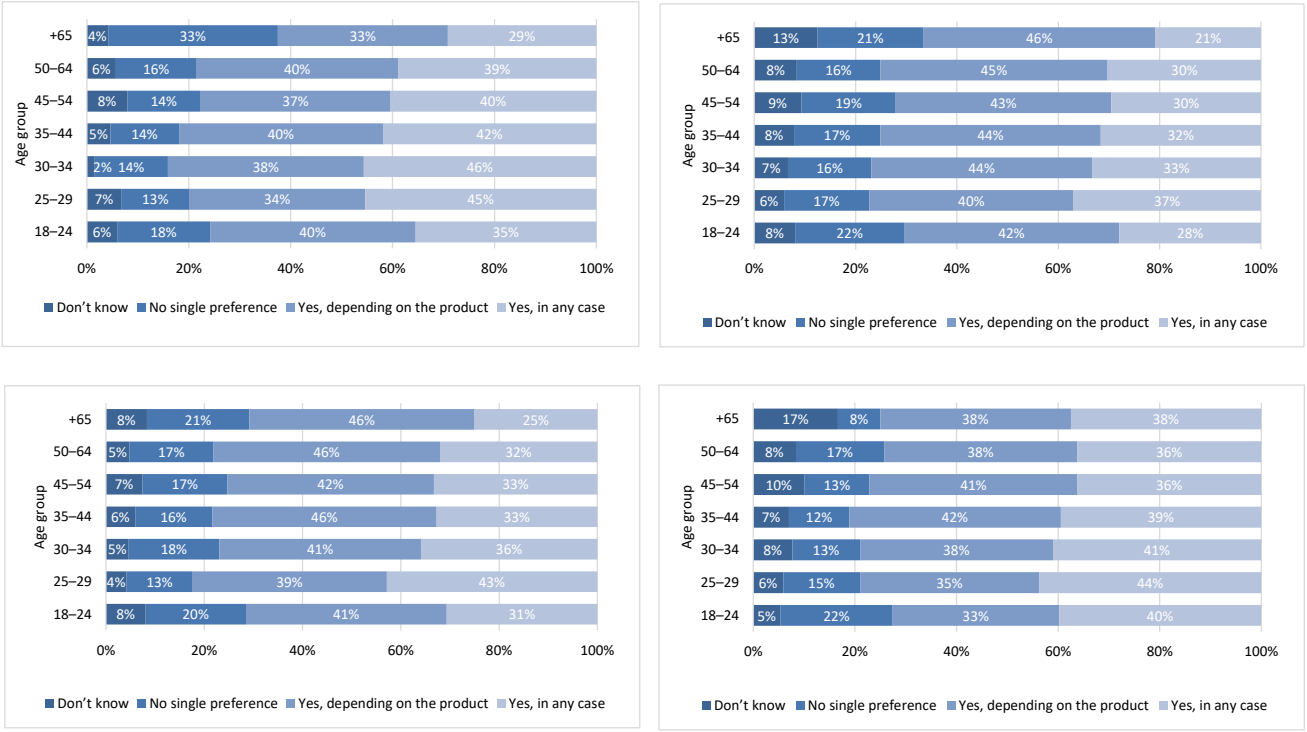

Figure 4. Consumers' preference of recycled/bio-based alternative over conventional ones.

4.2. Classification Trees

For the decision trees, the declared preference of consumers with respect to each of the bio-based products is defined as the dependent variable. The complete classification trees can be found in Appendix C. Based on Q9, a dummy variable was built based on a positive ("Yes, in any case" or "Yes, depending on the product") or negative and neutral preference ("No single preference" and "I don't know"). To avoid redundancy, responses from Q11 and Q12 were avoided, as well as the stated preference over the rest of the products. This is done for each of the products to generate 5 trees, using 70% of the database as the training set and 30% for validation, although the objective is to further identify key factors influencing the consumers' preferences, rather than to create a classification model. Table 3 shows that the resulting trees are consistent. The visualization of the trees is shown in Figure A12 for caps and bins, Figure A13 for underpads, Figure A14 for secondary packaging, Figure A15 for Fertilizers and Figure A16 for medical devices.

As a result, the trees for Underpads and Medical Devices ended up being more simple ones, with 4 to 6 levels, if compared to those for Packaging, Caps and Bins and Organic Fertilizers. This result was consistent in the first case given that the main dichotomy for the recycled Underpads was the influence of the final colour of the product. Consumers that valued this between 3 and 8 were directly classified as to reject the recycled alternative (67% of the cases), and only those who seemed to value more the environmental benefits and receiving information about the social impact of the production were classified positively. Similarly, the Medical Devices' tree presents that only those with a satisfaction level of 9 or 10 regarding the usage of these devices in their local health centre might end up preferring the alternative product over the conventional one, whereas the rest, 75%, would not.

In the case of Recycled Caps and Bins, the tree's first segmentation is based on consumer's given importance of the environmental benefits. From this point, the complexity of the tree increased given that there were not clear paths to establish a confident classification.

Those with lower interest towards environmental benefits might prefer the alternative version of the product if it is available in local stores, and if their expectation about receiving the product's safety information is completely fulfilled. On the other side, it seemed that people under 60 would prefer this new version if the same quality is assured over a competitive price.

Finally, the first node of the Packaging tree and the Organic Fertilizer tree presented a clear segmentation among those who totally agree with the statement "I would be interested if available in a local store" and the rest. Although this condition is true for 26% of the cases, only around 60% of them might prefer the bio-based version if the final cost is less compared with a conventional option or if the consumer shows a tendency to value the environmental benefits as highly. The other 74% of cases might be slightly influenced by price.

Table 3. Classification trees' confusion matrix.

	Cases (Validation)	True Negative	True Positive	False Negative	False Positive	*p*-Value
Recycled Underpads	481	282	54	88	57	4.727×10^{-7}
Bio-based Packaging	481	269	56	96	60	9.228×10^{-6}
Medical devices	481	311	63	79	28	2.902×10^{-20}
Recycled Caps and Bins	481	214	90	113	64	7.484×10^{-7}
Organic Fertilizers	481	235	72	63	111	1.605×10^{-5}

4.3. Rules of Association

Finally, the DMT of rules of association is performed with the aim of identifying some trends related to the profile of respondents. For this, gender, education level, household size and economy, location (cities, towns or rural) and the country are set as the pivotal points of the Analysis of Interest by the authors.

For generating the rules, the minimum support and confidence limits are determined at 10% and 85%, respectively. The result is the generation of 1456 rules, most of them already identified in the previous phases of the evaluation or of no use. Table 4 presents the five most interesting rules identified from the survey.

Regarding the importance of environmental benefits that a bio-based product might contribute to, the rule with the highest s% and c% is selected. According to rule number one, these benefits are important to people who are keen on receiving clear information about the safety and end of life properties of a given product, and that also value the composition of bio-based ones. This might indicate that consumers are interested in how the product affects their daily life: if it is safe for their health or how they might be actively involved in recycling or composting, for instance. Giving clear information on how a bio-based product successfully addresses circularity and safety issues may be a good practice to promote.

Rules 2, 3 and 4 are selected as they give an indication of specific opinions of urban consumers. Rule number 2 confirms the importance of addressing the triangle price-quality-user's friendliness, whereas rule number 3 gives an idea of other issues consumers are interested in cities. Urban citizens seem to search for a balance among acquiring products that reduce the environmental and social impact of their purchase, but at the same time they tend to rely on well-known products to make a quick and less effort-demanding shop. So, the window of opportunity to influence urban consumers on buying bio-based products over conventional ones might be too short. This might be addressed, whether by informing consumers about the existence of these innovative products via advertisement prior to the purchase, or by placing quick and clear messages inside stores, for example. This idea seems to be strengthened by rule number 4, given that most European citizens open to trying fewer impacting products would prefer to find them locally.

Finally, rule number 5 shows an interesting result, as people that stated that their economy is "enough to make ends meet", this is, 54% of the survey's participants correctly identified the bio-based definition, avoiding its misconception with other definitions, such as biodegradable or ecologic. Being that most of European citizens might identify with this

wellbeing level, the market opportunity of bio-based products should be remarkably high due to the awareness level shown in the survey.

Table 4. Most interesting rules identified from the survey.

No	Antecedent (IF)	Consequent (THEN)	Support (%)	Confidence (%)
1	Rates 5 on receiving information about products' end of life, AND rates 5 on receiving information about products' safety, AND rates 5 the importance of the composition of a bio-based product	Rates 5 the importance of the Environmental benefits of a bio-based product	10.34	90.21
2	Lives in city, AND rates 5 the importance of the price of a product, AND rates 5 the importance of the friendliness of a product	Rates 5 the importance of the quality of a product	10.47	85.23
3	Lives in city, AND rates 5 on receiving information about products on social impacts, AND selects products that make the shopping easier and quicker	Is open to try an alternative version by its environmental benefits	10.97	89.79
4	Lives in city, AND has a medium level of knowledge about bio-based products, AND is interested in acquiring alternative version on local stores	Is open to try an alternative version by its environmental benefits	10.72	89.11
5	Household Economy declared as Enough, AND knows that biodegradable is not the same as bio-based, AND Knows that biodegradable is not the same as ecologic, AND Knows that biodegradable is not the same as recycled	Knows what the bio-based concept means	14.02	100

5. Conclusions

The consolidation of a circular economy in Europe and the introduction of more sustainable products, as recycled or bio-based ones, faces both economic opportunities and social barriers [11–13,25]. This statement is true for materials recovered from the treatment of AHP waste, in terms of the elevated rate of waste production, its potential for industrial purposes [20,61] and consumers' perception with respect to these single-use hygiene products. In this context, this study contributes with an assessment of social acceptance factors that could be synergistic for future market acceptance [3]. The followed methodology allows gaining further insights about consumer perceptions. The combination of descriptive statistics and DMTs could be a useful approach to be replicated by other studies working on complex social issues based on data collection techniques such as surveys.

Although the survey results vary significantly by gender, age or economic status, the main findings are shown below:

In terms of what might be the key aspects for consumers when choosing a bio-based product, interviewed consumers tend to confirm that attractive price [34], quality and ease of use [35,36] are the most important factors. However, survey insights suggest that environmental benefits might be a useful factor during the purchase process if understandable information is clearly delivered to consumers, as 74% of respondents indicated. The most valued benefits seem to be related to health and safety, sustainable end-of-life of products and natural origin and properties.

This might be even more accurate for bio-based products made from AHP waste, as consumers would value the composition and origin of materials in much the same way as they do price and quality. Environmental benefits are also more highly valued when compared to general products. Compliance with consumers' expectations might increase the chances of making bio-based products an attractive option. As the classification trees indicate, this could be necessary in the case of underpads and medical devices, as

specific factors, such as the final colour for the latter or a positive predisposition towards environmental benefits for the former, seem to be a must-have to support the purchase.

Another key insight is that environmental awareness might not be influential enough towards a market uptake of bio-based products. This could be related to the excessive use of the prefix "bio", which could confuse consumers with other terms, for example, organic or biodegradable. Another reason could be that the word "bio-based" does not exist in some languages. Addressing issues such as greenwashing marketing [17] and an overwhelming use of terms, such as "bio" or "green" [3,16], is required to overcome the current tendency between a medium level of knowledge about bio-based alternatives and a low actual product purchase [40,41].

Regardless of language and terminology issues, consumers are most interested in how the product affects their daily lives, especially if it is safe for their health and how they can actively participate in its end-of-life (e.g., recycling). Therefore, it is crucial to provide clear information on how a bio-based product successfully addresses circularity and safety issues, and this should be a good practice to promote. However, depending on the product, there are some aspects that can significantly affect the purchase decision, such as aesthetic, which could be a considerable barrier for some consumers.

Finally, and in relation to what could be the most efficient strategies to facilitate the marketing of this type of products, people seem to be willing to acquire products in their local stores, especially in the case of packaging and fertilizer, as the classification trees suggest. This availability should be complemented with a purchase process that reduces the effort and time spent during the assessing of the best choices. In this sense, consumers demand more and clearer information on bio-based products, and products should match the level of information on health benefits to other information. In fact, this study shows that information channels should be evaluated in terms of their effectiveness, and improvements in the labelling system have been identified as important.

Specially in the case of urban citizens, they seem to be looking for a balance between buying products that reduce the environmental and social impact of their purchase, but at the same time, they tend to rely on familiar products for quick and less effort-demanding shopping.

To advance with this line of research, the authors propose to update the data collected from consumers, which currently depicts the perception and opinions before the COVID-19 Pandemic, especially to confirm if people maintain the same key aspect, or if environmental aspects might have been replaced by health and safety issues. Furthermore, this methodological approach could be replicated in different type of products, or even extended to include a life cycle perspective with the conduction of Social Life Cycle Assessments [14].

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Institutional Review Board Statement: Ethical review and approval were waived for this study due to the fact that the participants in the article have carried out their research tasks in compliance with the Organic Law 3/2018 of 5 December 2018, on the Protection of Personal Data and guarantee of digital rights and the Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of individuals with regard to the processing of personal data and on the free movement of such data and repealing Directive 95/46/EC (General Data Protection Regulation), also following the internal procedures of their organization (CIRCE) regarding the

respect and management of personal data. In addition, the project's certificate of ethical compliance during its activities is available.

Informed Consent Statement: Patient consent was waived since the survey was conducted by an expert company in the field, subcontracted by CIRCE. All survey participants are anonymous, and their personal data have been treated under the confidentiality commitment of the company that conducted the survey (attached link: https://www.ipsos.com/sites/default/files/2018-04/ipsos_commitment_to_privacy_and_data_protection.pdf (accessed on 25 January 2023)).

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the detailed information on the survey results is confidential (only for members of the consortium, including the Commission Services), as stated in agreement no 745746.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Survey Questionnaire

Please, take 15 min to let us your thoughts on the purchasing of products through more sustainable means, using less resources and generating less waste.

Let's start with some simple questions about your preferences.

Q1. In your opinion, how influent are the following aspects when evaluating a product? Please, answer in a scale from 1 (not important) to 5 (very important).

	No Single Influence				Strong Influence	
	1	2	3	4	5	Don't Know
Quality and performance						
Composition and source materials						
Environmental benefits						
Brand (reputation)						
Competitive price						
Packaging						
User friendliness/convenience						

Q2. Please, indicate how much do you agree with the following statement in respect of each of the product characteristics on the list below? Please answer in a scale from 1 (strongly disagree) to 5 (strongly agree).

When I purchase products, I give importance to information related to . . .

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
	1	2	3	4	5	Don't Know
. . . their percentage of bio-based content.						
. . . their CO_2 footprint/energy savings.						
. . . their compostability/recyclability/biodegradability.						
. . . their health/safety benefits.						
. . . their origin and production process.						
. . . their social impact of production.						

Q3. If you received accessible, understandable information about certain benefits for the environment, would you be willing to try a more sustainable product?

- No, these kind of benefits are not in my priorities
- Yes, it would be an attractive quality for me for trying a more sustainable product.
- Yes, but depending on other aspects such as (please, mark which ones):
  - Quality and performance
  - Composition and source materials
  - Environmental benefits
  - Brand (reputation)
  - Competitive price
  - Packaging
  - User friendliness/convenience

Q4. Please indicate how much do you agree with the following statement in respect of each your knowledge about bio-based products? Please, choose one option.

- I can recognize bio-based products among other competing products
- Some characteristics of bio-based products come to my mind quickly
- I have difficulty in imagining bio-based products in my mind.

Q5. In your opinion, which of the following definitions could be part of the concept "bio-based product". Select more than one, if necessary.

- Products or materials that are made avoiding the use of man-made chemical substances.
- Products or materials that have been recuperated from waste through a transformation process that make them adequate to be used again.
- Products and materials from biological and renewable sources, such as plants. Raw materials like minerals and fossil fuels, despite being extracted from earth, are not considered in this category given the long period their production takes (i.e., beyond a century).
- Products or materials that are rapidly decomposed/disintegrated by microorganisms under natural conditions, reducing their environmental impact after disposal (i.e., in landfills).

Bio-based Product Specific

Regarding the last question, the most suitable definition of bio-based product is "Products and materials from biological and renewable sources, such as plants. Raw materials like minerals and fossil fuels, despite being extracted from earth, are not considered in this category given the long period their production takes (i.e., beyond a century)". This means that a plastic made out from petroleum is not bio-based, where as a plastic made from vegetable oils is indeed a bio-based product. Nylon, for example, is a plastic that can be produced from both sources. Even recycled Nylon is also considered bio-based if originally made from vegetable oils.

In this sense, we would like to know your opinion about bio-based products in general.

Q6. If compared with products made of non-bio-based materials, do you think a bio-based product should cost:

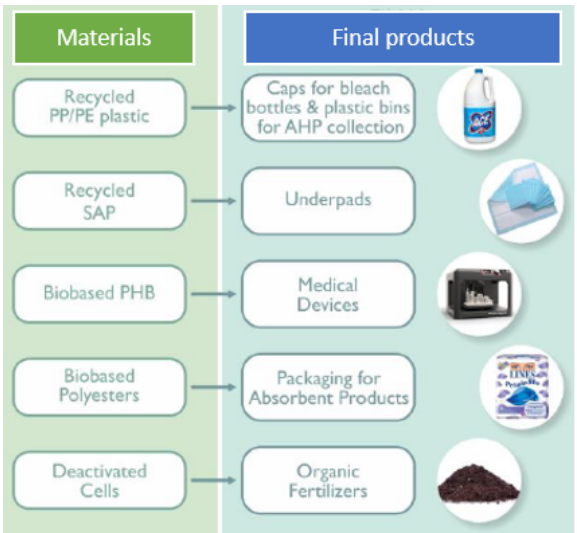
- The same.
- Less. Please, specify in percentage: _____%
- More, Please, specify in percentage: _____%

Q7. Please indicate how much do you agree with the following statements? Please answer in a scale from 1 (strongly disagree) to 5 (strongly agree).

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
	1	2	3	4	5	Don't Know
If I knew that bio-based products were available through a local store, I would be interested enough to take a look at it.						
I would only consider buying bio-based products if the price is competitive with conventional ones.						
I know how to learn if a product is bio-based.						
I make shopping with a lot of time to make a thoughtful choice of the products I am buying						
I think that there is too much information to be analysed in order to know which is the best purchasing choice.						
Price is a mean of simplifying complicated purchasing choices.						
Purchasing products I am used to buy makes shopping quicker and easier.						
Labels are simple and understandable.						
I believe my friends/family/colleagues would like me to buy bio-based products						

EMBRACED Product Specific

In the case of the EMBRACED project, researchers are developing the proper technologies to make the most of Absorbent Hygiene Products (AHP), such as diapers, in order to keep recycling the useful materials, with the aim of using less resources and generating less waste. As a result, the project will generate new materials that will be used to made the following final products:



In order to respond to the consumer's requirements, the project assures that:

- These materials were already evaluated from Competent Authorities as safe for health and environment;
- No difference in quality and functionality is expected with respect to similar products made of virgin materials. Minor variations may occur, such as the final colour, that

could be different in the following final products: caps for bleach bottles, plastic bins for AHP collection, underpads, and packaging for absorbent products.

After this brief introduction, we would like to know your opinion about each of this final products.

Q8. How much of an influence does each of the following factors have on your decision to prefer recycled products over non-recycled ones? Answer from 1 no single influence) to 5 (Strong influence).

	No Single Influence				Strong Influence	
	1	2	3	4	5	Don't Know
Quality and performance						
Composition and source materials						
Environmental benefits						
Brand (reputation)						
Competitive price						
Packaging						
User friendliness/convenience						

Q9. If available, I prefer products using recycled Plastic Caps over non-recycled options.

- Yes, in any case.
- Yes, depending on the product.
- No single preference.
- I don't know

Q10. If compared with Plastic Caps made of non-recycled materials, do you think this new recycled plastic cap should cost:

- The same.
- Less. Please, specify in percentage: _____%
- More, Please, specify in percentage: _____%

Q11. Please indicate how proud would you feel buying a product with recycled plastic cup in comparison with non-recycled alternatives. Answer from 1 to 10:

Q12. Please indicate how comfortable would you feel using one of a product with recycled plastic cup in comparison with non-recycled alternatives. Answer from 1 to 10

Q9. If available, I prefer products using Underpads recycled material over non-recycled options.

- Yes, in any case.
- Yes, depending on the product.
- No single preference.
- I don't know

Q10. If compared with Underpads made of non-recycled materials, do you think this new Underpad with recycled material should cost:

- The same.
- Less. Please, specify in percentage: _____%
- More, Please, specify in percentage: _____%

Q11. Please indicate how proud would you feel buying one of Underpad with recycled materials in comparison with non-recycled alternatives. Answer from 1 to 10:

Q12. Please indicate how comfortable would you feel using one of a Underpad with recycled materials in comparison with non-recycled alternatives. Answer from 1 to 10

Q13. If we focus on Underpads (mattress protectors) and packaging for absorbent products, how would your purchasing decision be influenced if the final tone would vary from a white to an ochre color (of the recycled paper)?

Q14. If available, I prefer products using Medical Devices with bio-based materials over non-bio-based options.

- Yes, in any case.
- Yes, depending on the product.
- No single preference.
- I don't know

Q15. Please indicate how comfortable would you feel using a Medical Devices with bio-based materials in comparison with non-bio-based alternatives. Answer from 1 to 10

Q16. If available, I prefer products using bio-based packaging non-bio-based options.

- Yes, in any case.
- Yes, depending on the product.
- No single preference.
- I don't know

Q17. If compared with packaging made of non-bio-based materials, do you think this new bio-based packaging should cost:

- The same.
- Less. Please, specify in percentage: _____%
- More, Please, specify in percentage: _____%

Q11. Please indicate how proud would you feel buying a product with bio-based packaging in comparison with non-bio-based alternatives. Answer from 1 to 10:

Q12. Please indicate how comfortable would you feel using one of buying a product with bio-based packaging in comparison with non-bio-based alternatives. Answer from 1 to 10

Q9. If available, I prefer products using this bio-based organic fertilizer over non-bio-based options.

- Yes, in any case.
- Yes, depending on the product.
- No single preference.
- I don't know

Q10. If compared with bio-based organic fertilizer made of non-bio-based sources, do you think this new bio-based organic fertilizer should cost:

- The same.
- Less. Please, specify in percentage: _____%
- More, Please, specify in percentage: _____%

Q11. Please indicate how proud would you feel buying bio-based organic fertilizers in comparison with non-bio-based alternatives. Answer from 1 to 10:

Q12. Please indicate how comfortable would you feel using bio-based organic fertilizers in comparison with non-bio-based alternatives. Answer from 1 to 10

Questions related to Profiling

1. Your gender:

   1 = female
   2 = male
   Your age:

2. What is the highest level of education you have completed?: [Indicate the level that you fully completed (until now)]

   1 = university or college or equivalent
   2 = intermediate between secondary level and university (e.g., technical training)
   3 = secondary school
   4 = primary school only (or less)

3. Your household composition:

   Nr. of adults (including yourself)
   Nr. of persons 12–17 years old
   Nr. of persons 4–11 years old
   Nr. of persons < 4 years old

4. Your financial situation:

   1 = very difficult
   2 = difficult
   3 = sufficient to make ends meet
   4 = comfortable
   5 = very comfortable

5. Type of area where you live:

   1 = urban/in a city
   2 = semi-urban/city suburb
   3 = rural/small town or village

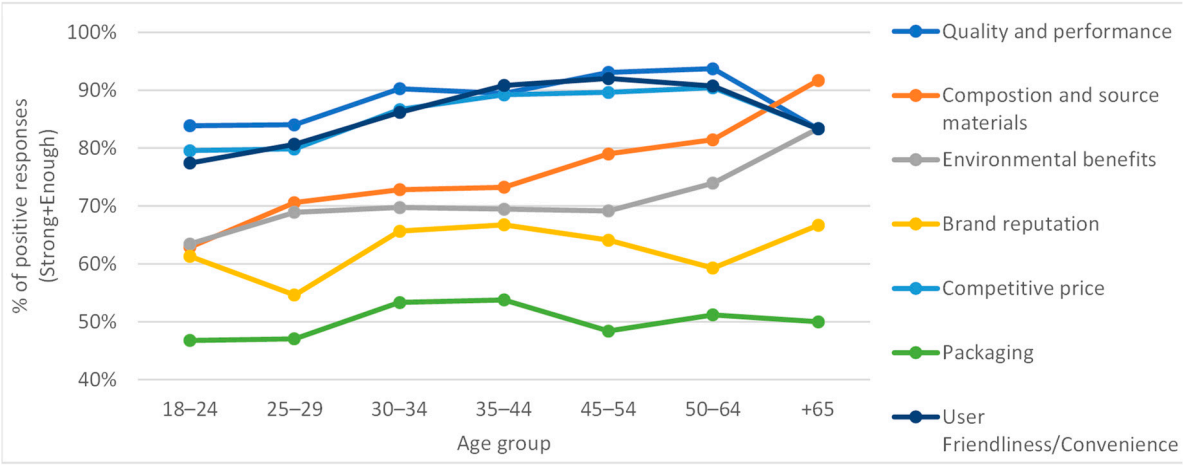
6. Your postal code/province:

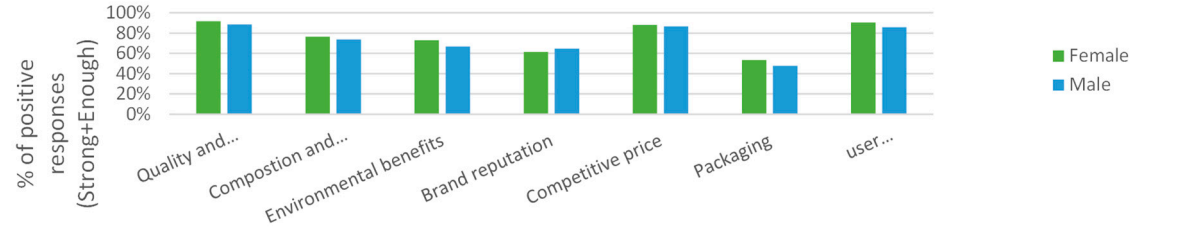
   Thank you very much for your collaboration.

Appendix B. Survey Results: Supporting Data

Q1. In your opinion, how influent are the following aspects when evaluating a product? Please, answer in a scale from 1 (not important) to 5 (very important).

	Answers distribution [%]						Country (Strongly + Agree) [%]			
	Strongly + Agree	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	FR	DE	IT	ES
Quality and performance	**90**	58	32	7	1	2	87	88	92	94
Composition and source material	**75**	33	42	19	4	2	77	62	85	76
Environmental benefits	**70**	29	41	22	5	3	72	66	78	64
Brand (reputation)	**63**	20	43	25	8	4	67	50	74	61
Competitive price	**87**	48	39	10	1	2	90	77	90	92
Packaging	**51**	14	37	33	12	4	44	57	45	56
User friendliness/convenience	**88**	43	45	10	1	1	86	84	93	89





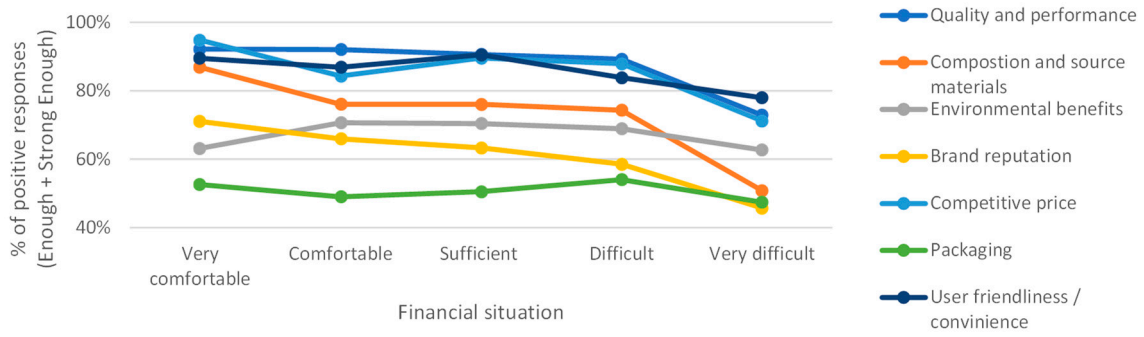


Figure A1. Consumers' influential aspects for the purchase of a product.

Q6. If compared with products made of non-bio-based materials, do you think a bio-based product should cost . . .

	Answers distribution	Country			
	[%]	[%]			
		FR	DE	IT	ES
The same	50	53	58	41	50
Less than one made with non-biobased materials	31	33	22	34	33
More than one made with non-biobased materials	19	14	20	25	17

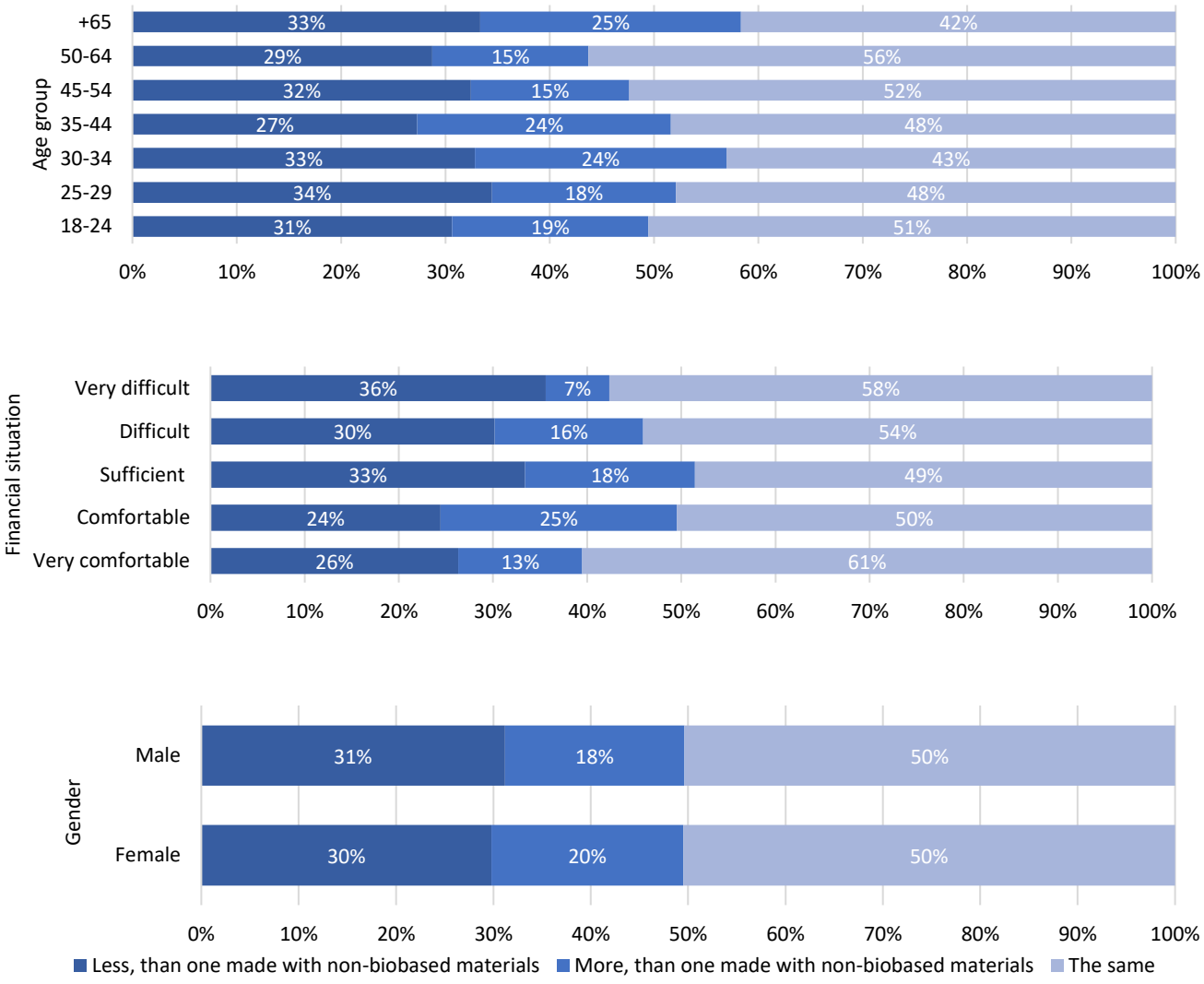


Figure A2. Consumers' expected cost of a bio-based product compared to traditional ones.

Q3. If you received understandable information about certain benefits for the environment, would you be willing to try a more sustainable product?

	Answers distribution	Country			
	[%]	[%]			
		FR	DE	IT	ES
No, these kinds of benefits are not in my priorities	5	6	9	4	2
Yes, it would be attractive quality for me trying a more sustainable product	74	67	73	80	76
Yes, but depending on other aspects such as (please, mark which ones):	21	27	18	16	22
Competitive price	74	73	60	71	88
Quality and performance	65	52	82	59	72
User friendliness / convenience	43	40	57	35	39
Composition and source materials	36	39	29	33	40
Environmental benefits	23	21	32	19	22
Brand (reputation)	17	14	21	27	11
Packaging	12	7	19	5	16

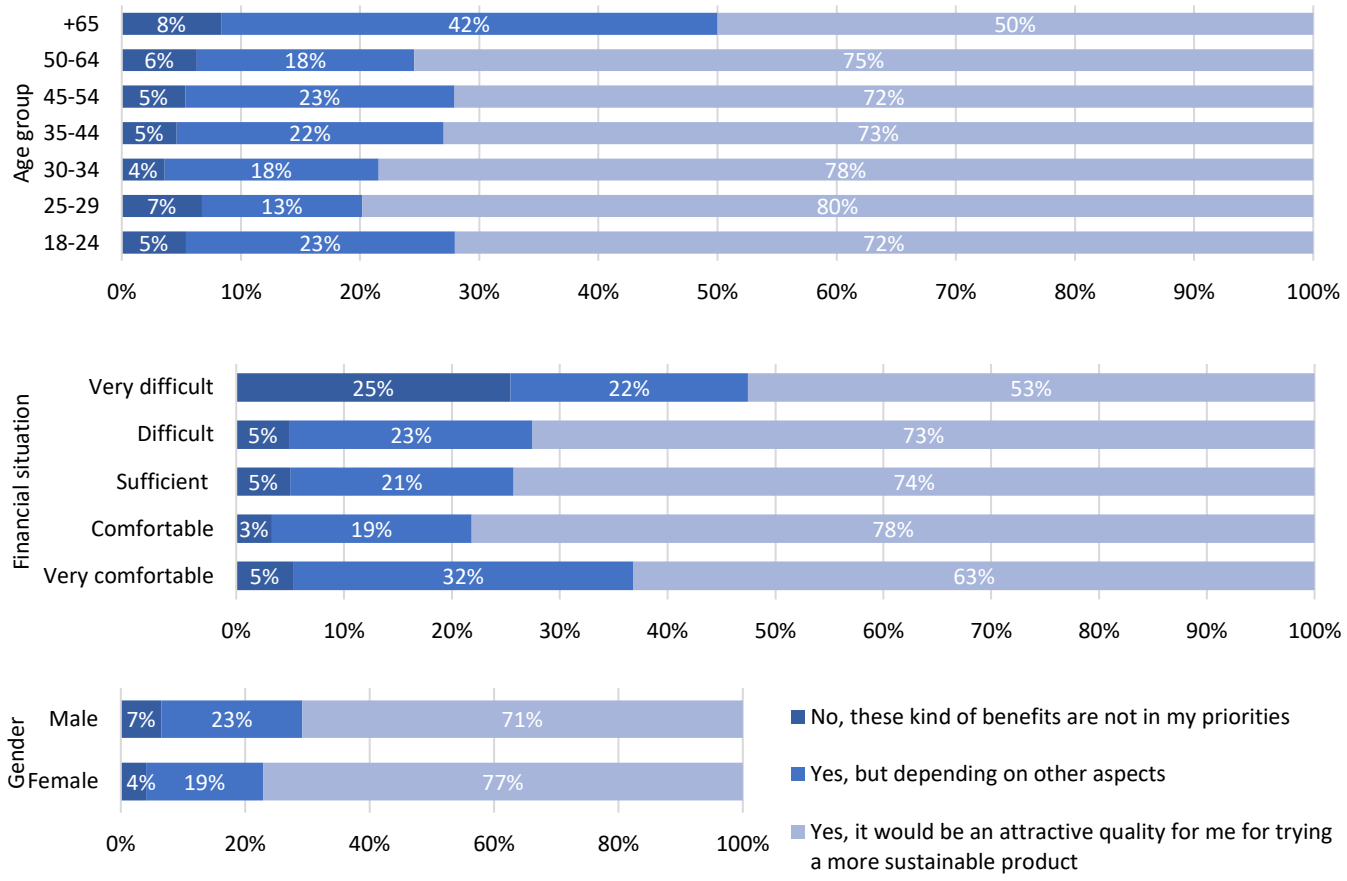


Figure A3. Consumer's willingness to try products based on environmental benefits.

Q4. Please, indicate how much do you agree with the following statement in respect of each your knowledge about bio-based products? Please, choose one option.

	Answers distribution	Country			
	[%]	[%]			
		FR	DE	IT	ES
I can Identify bio-based products among other competing products	16	13	19	22	9
I can Identify some characteristics of bio-based products	50	43	59	55	43
I have difficulty in imagining bio-based products.	34	44	22	24	49

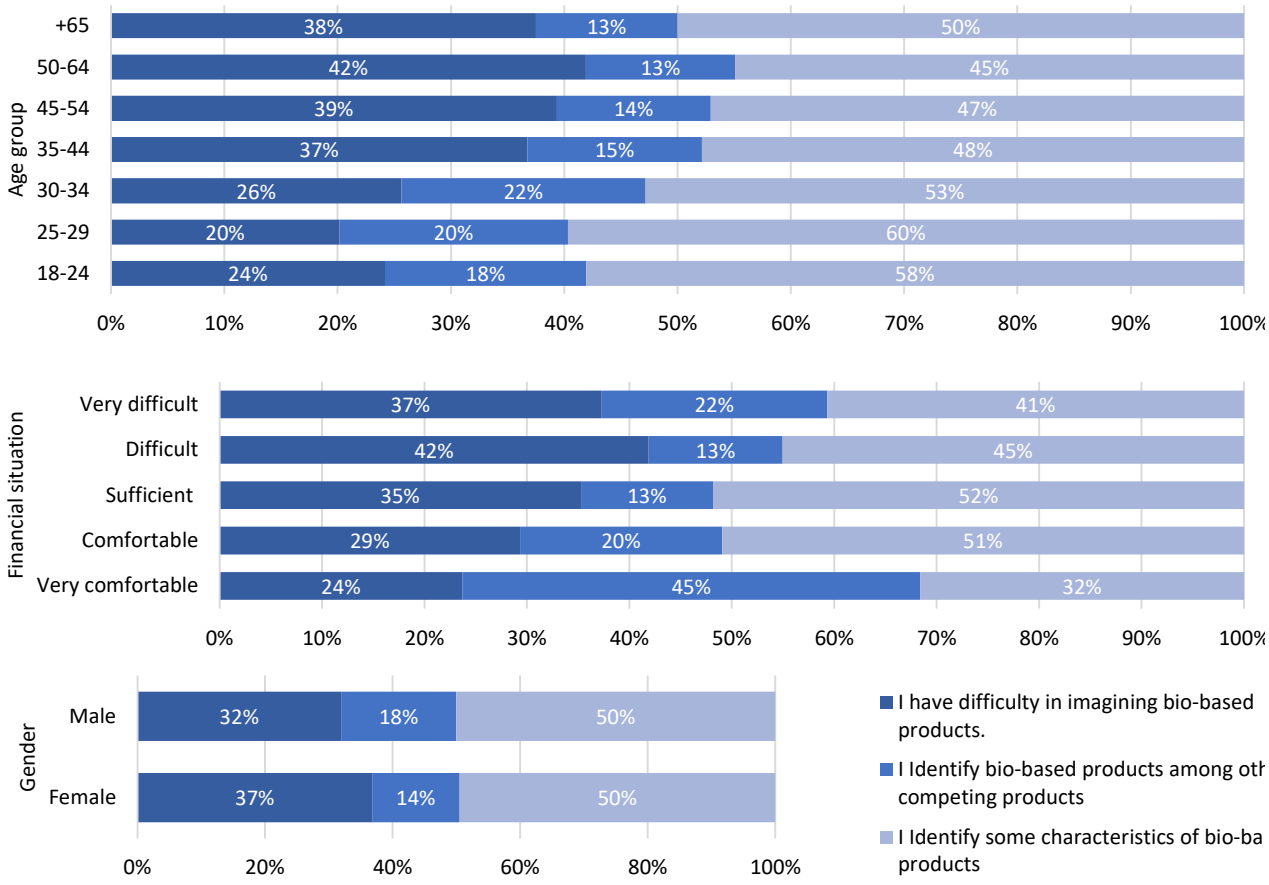


Figure A4. Consumer's stated level of awareness towards bio-based products.

Q2. When I purchase products, I give importance to information related to . . .

	Answers distribution [%]						Country (Strongly + Agree) [%]			
	Strongly + Agree	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	FR	DE	IT	ES
If it is natural, bio, without chemicals	**70**	29	41	22	5	3	71	69	74	67
If it can be recycled, if it is biodegradable	**69**	25	44	23	5	3	67	62	76	70
Their health /safety benefits	**85**	41	45	11	2	1	87	74	91	89
Their origin and production process	**66**	22	44	26	5	3	71	56	75	62
Their social impact of production	**57**	17	40	32	7	4	57	49	63	59

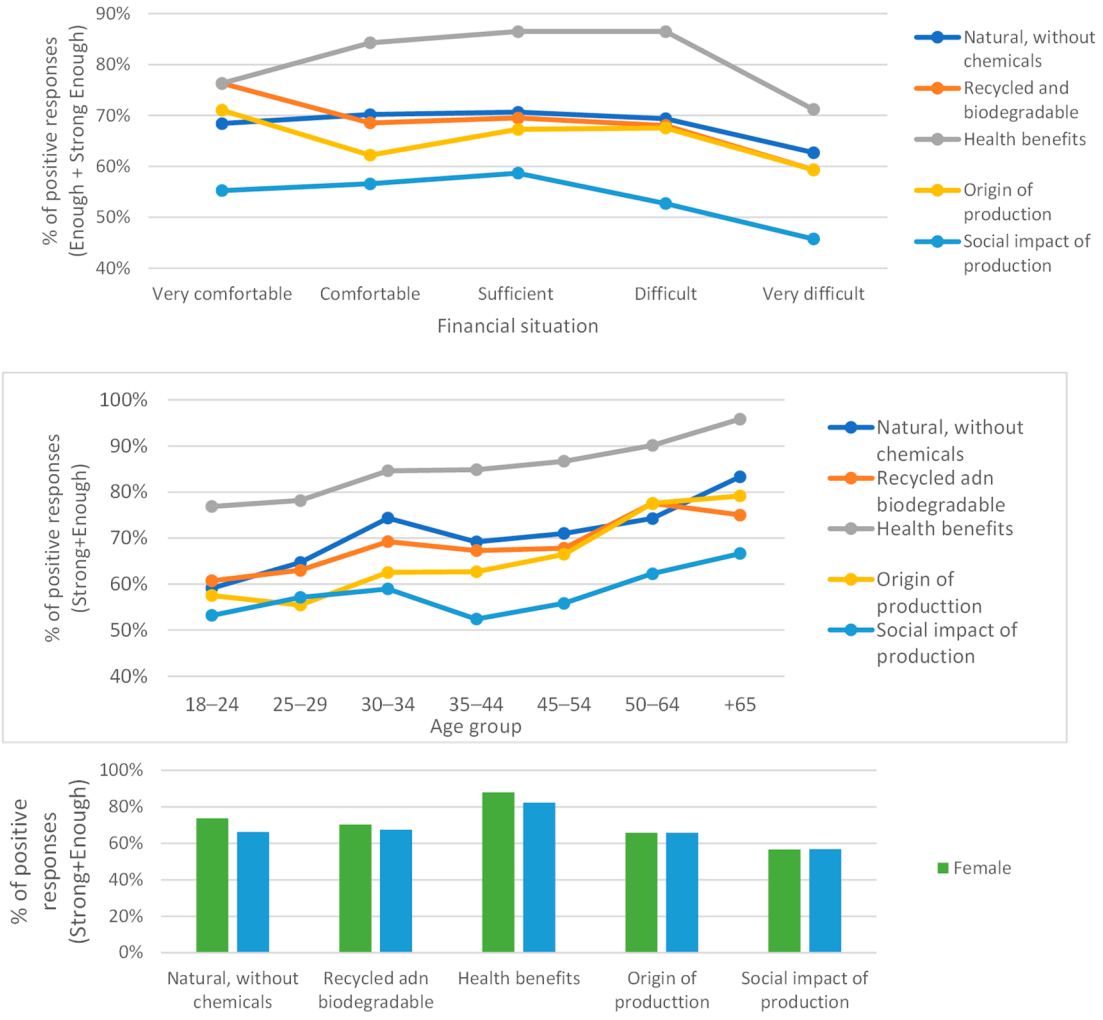


Figure A5. Product information more interesting for consumers.

Q7. Please, indicate how much do you agree with the following statements.

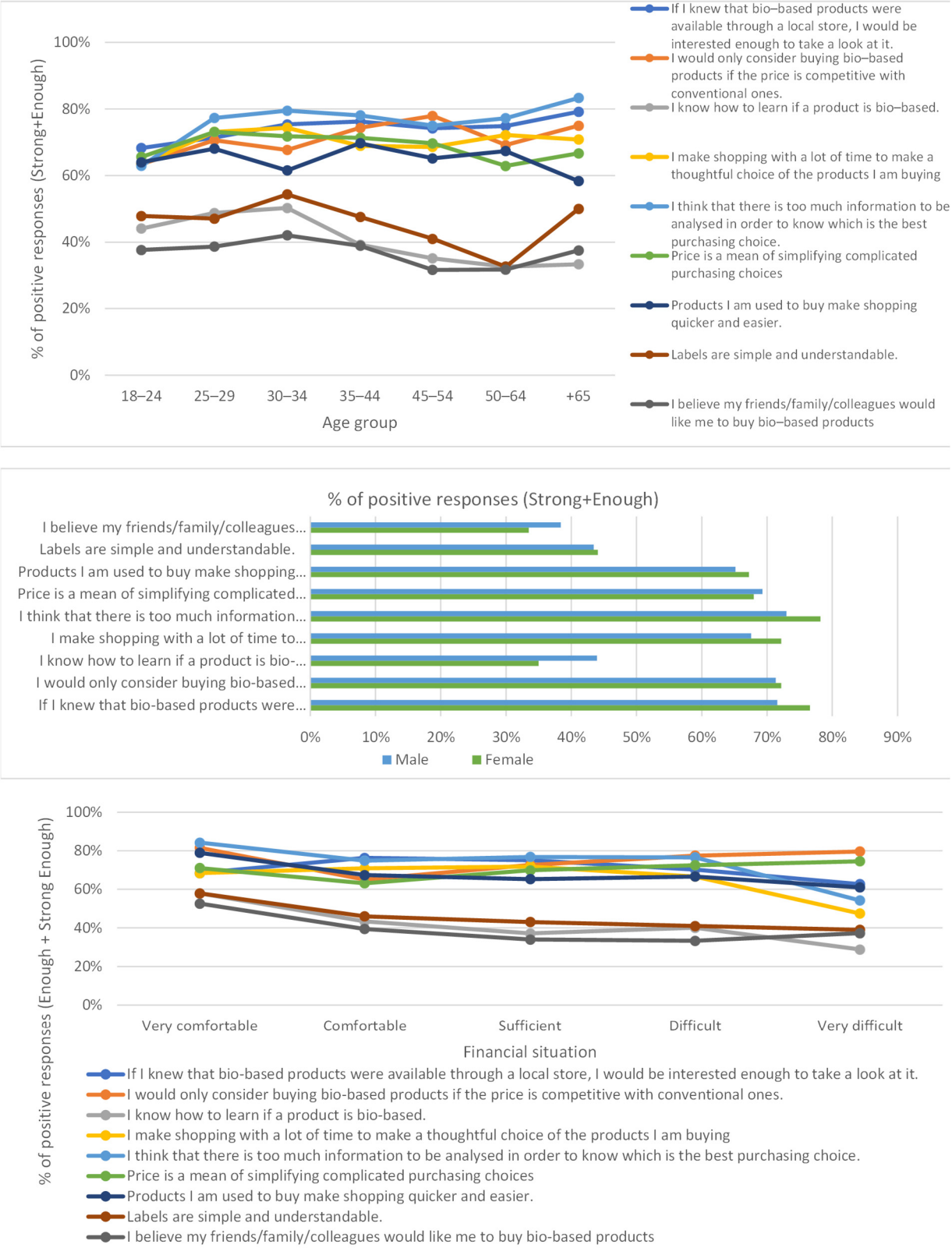
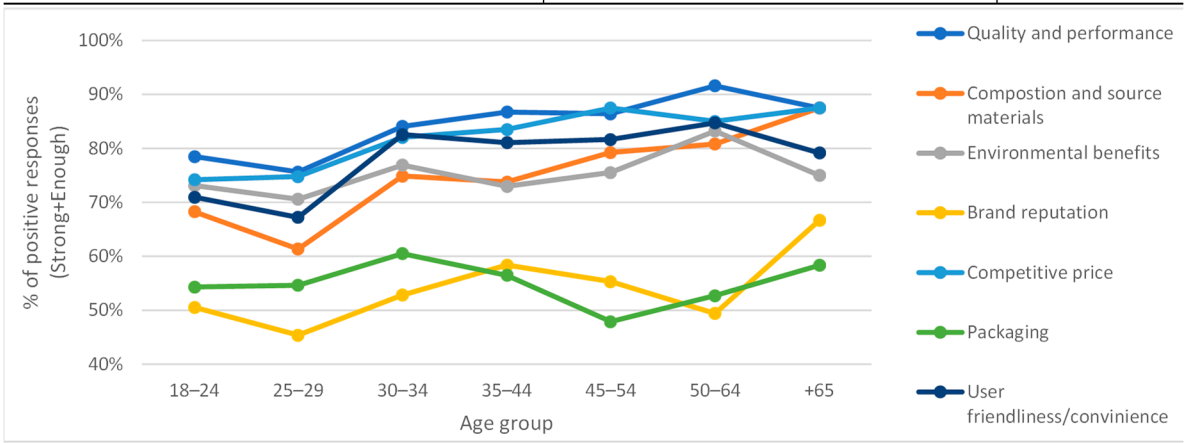
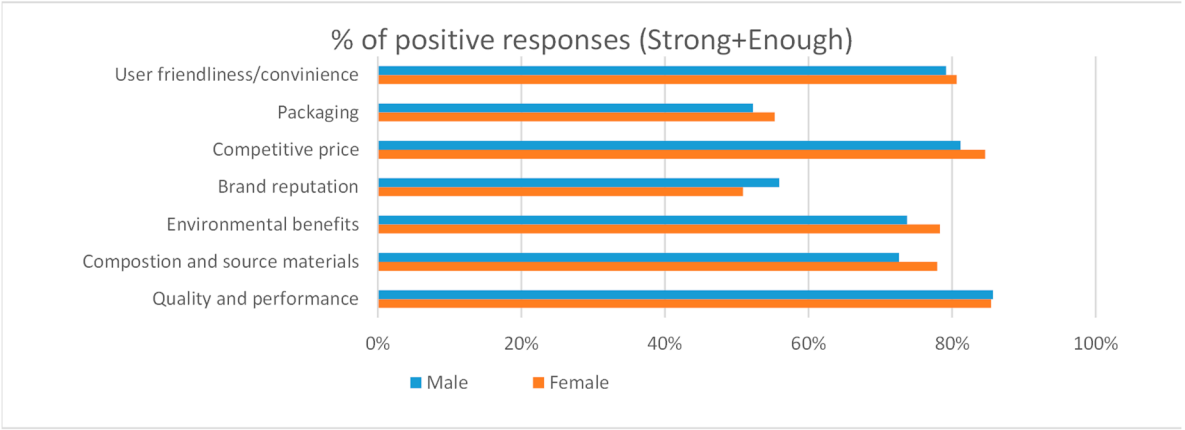


Figure A6. Level of agreement about statements related to bio-based products purchase.

Q8. How influent are the following aspects when evaluating a product made with bio-based materials compared to non-bio-based ones?

	Answers distribution [%]						Country (Strongly + Agree) [%]			
	Strongly + Agree	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	FR	DE	IT	ES
Quality and performance	**86**	40	46	12	1	1	79	86	89	88
Composition and source materials	**75**	30	46	19	4	1	77	66	84	72
Environmental benefits	**76**	35	42	19	4	0	77	74	79	74
Brand (reputation)	**53**	14	39	32	10	5	56	40	67	51
Competitive price	**83**	37	46	14	2	1	87	78	83	84
Packaging	**54**	15	39	33	9	4	48	53	56	58
User Friendliness / Convenience	**80**	27	53	16	3	1	81	77	83	80





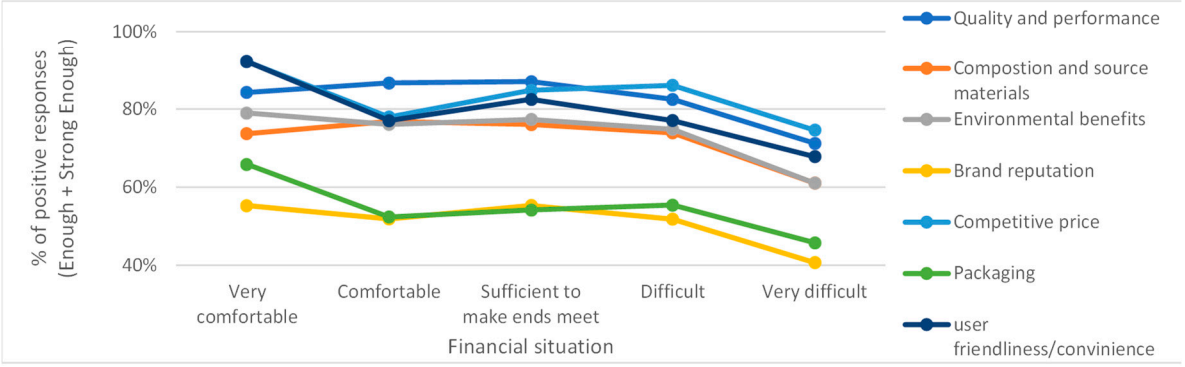


Figure A7. Consumers' influential aspects for the purchase of a bio-based product compared with a non-bio-based one.

Q9. If these final products were available, would you prefer products made with recycled/bio-based materials or non-recycled/non-bio-based options?

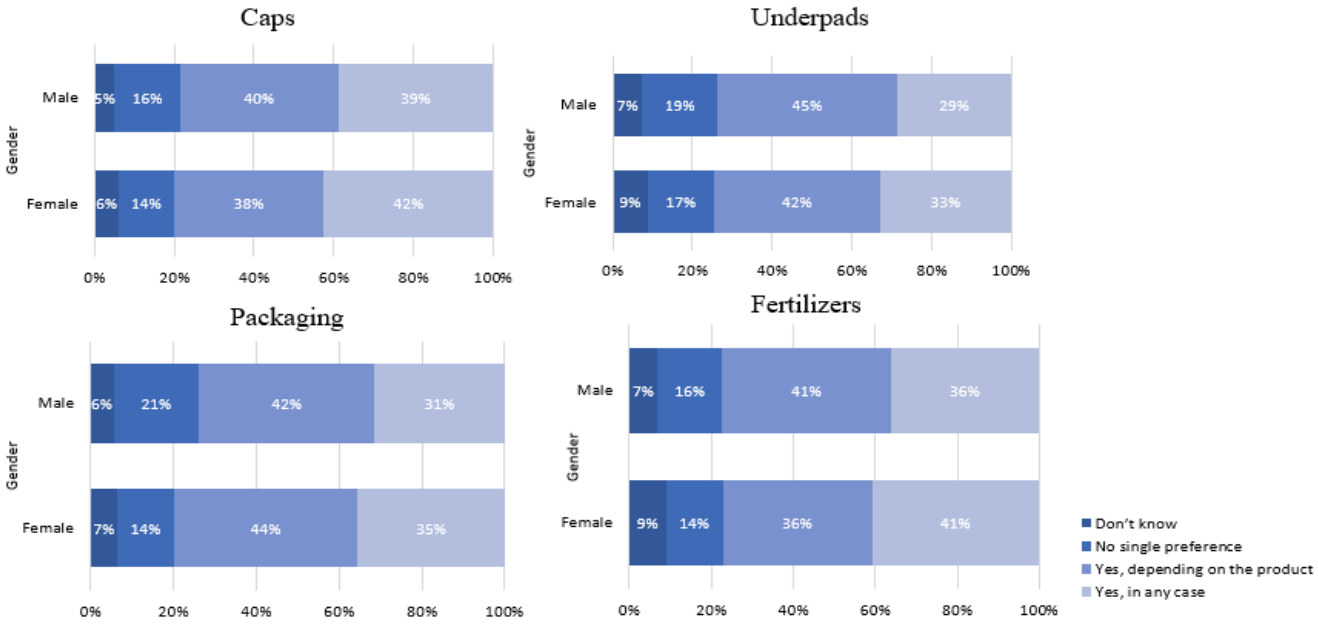


Figure A8. Consumers' preference of recycled/bio-based alternative over conventional ones.

Q12. Please indicate how comfortable would you feel using a product with recycled/bio-based materials compared to non-recycled/non-bio-based alternatives.

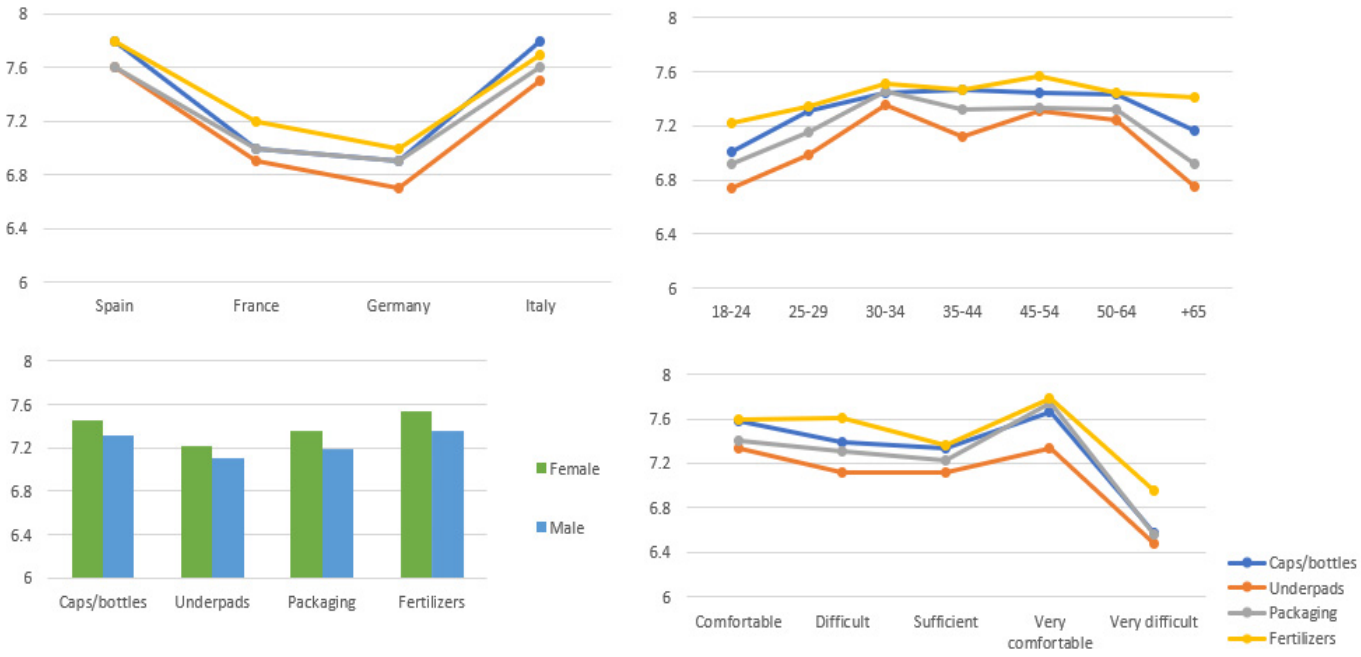


Figure A9. Consumer's stated comfort if using a recycled/bio-based product.

Q13. If we focus on Underpads (mattress protectors) and packaging for absorbent products, How would your purchasing decision be influenced if the final tone would vary from a white to an ochre color (of the recycled paper)?

	Average (all)	Average per Country			
		FR	DE	IT	ES
From 1 (very little influence) to 10 (very influenced)	5.3	4.8	5.5	5.8	5.1

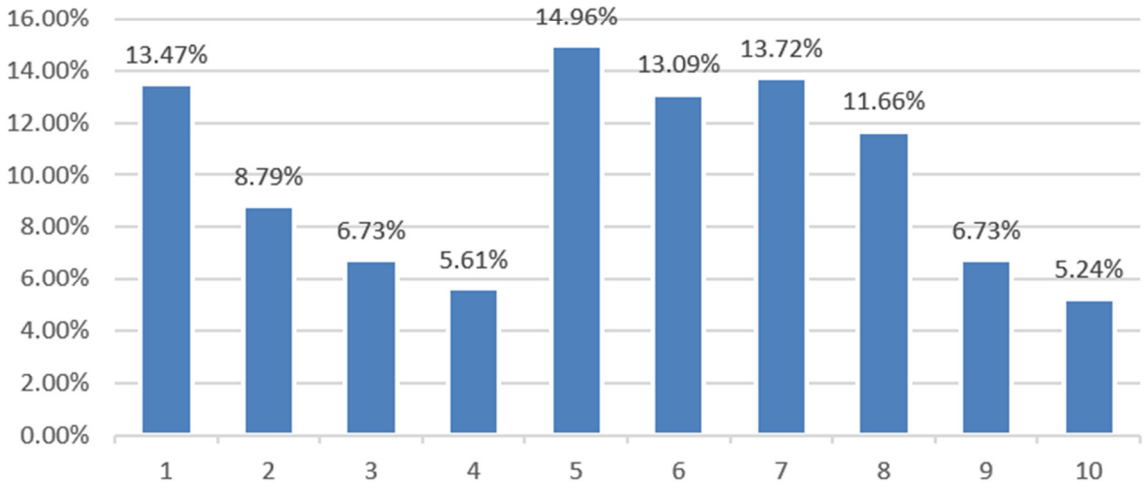


Figure A10. Final colour, from white to ochre, influence on consumer's purchasing decision.

Q14. If this product was available, would you prefer that your designated hospital would use this type of device made with recycled/bio-based materials compared to non-recycled/non-bio-based options?

	Answers distribution	Country			
	[%]	[%]			
		FR	DE	IT	ES
Yes, in any case	30	25	23	38	32
Yes, depending on the product	46	42	48	48	47
No single preference	14	17	18	7	12
Don't know	10	16	11	8	9

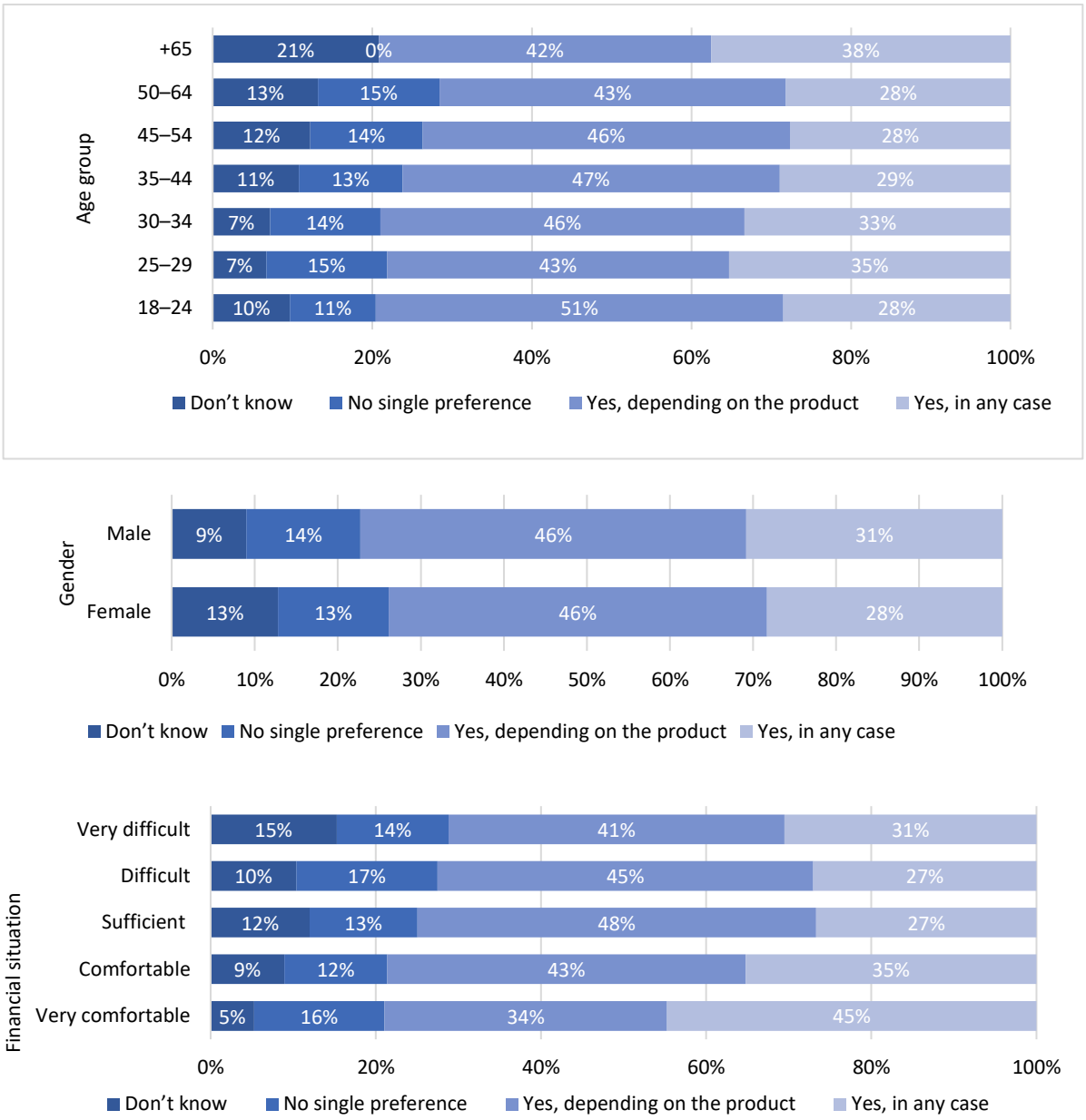


Figure A11. Consumer's preference about their designated hospital to use medical devices made with recycled/bio-based materials compared to non-recycled/non-bio-based options.

Appendix C. Classification Trees

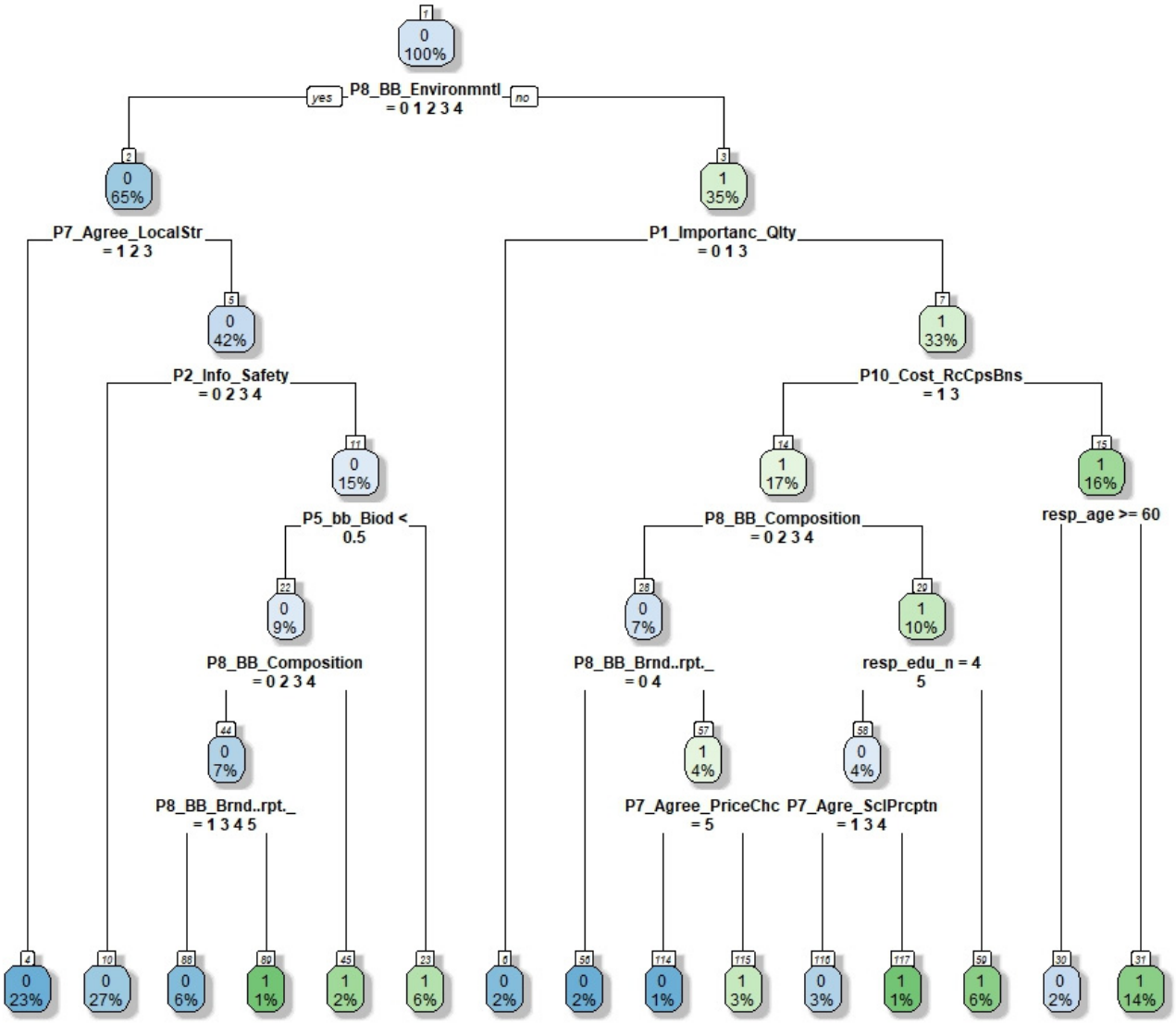


Figure A12. Decision Tree—Cap Bins.

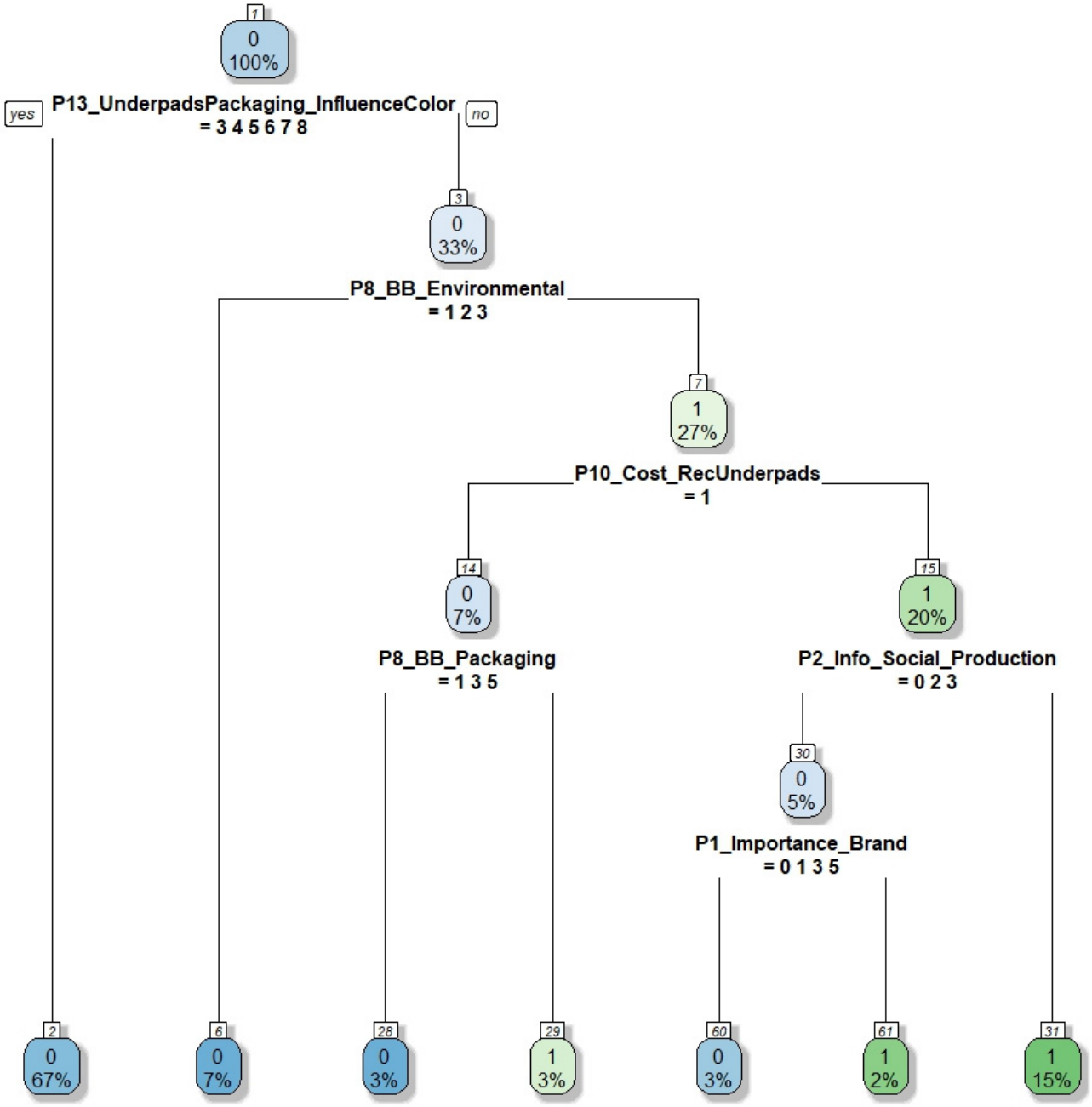


Figure A13. Decision Tree—Underpads.

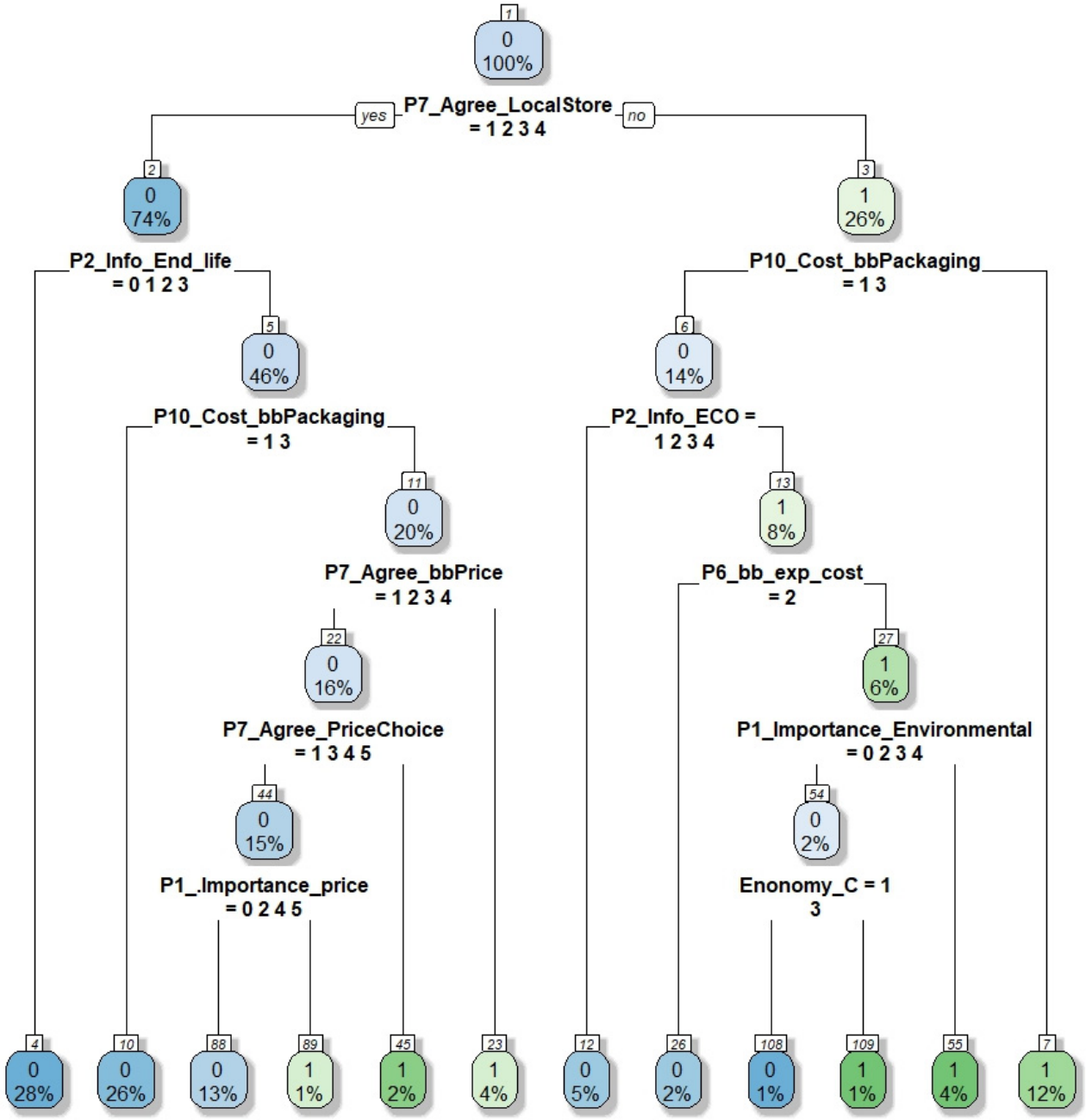


Figure A14. Decision Tree—Packaging.

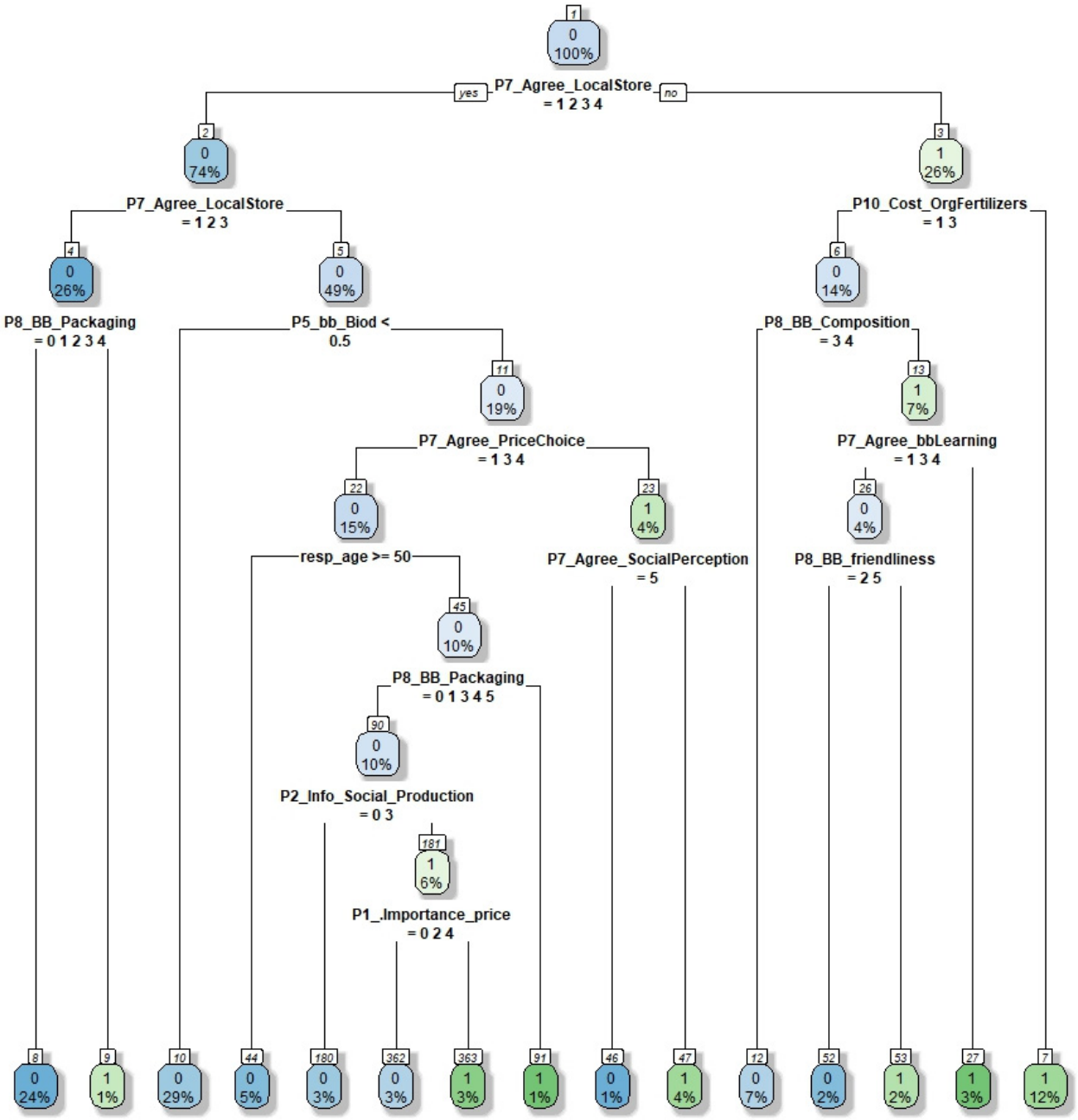


Figure A15. Decision Tree—Organic Fertilizers.

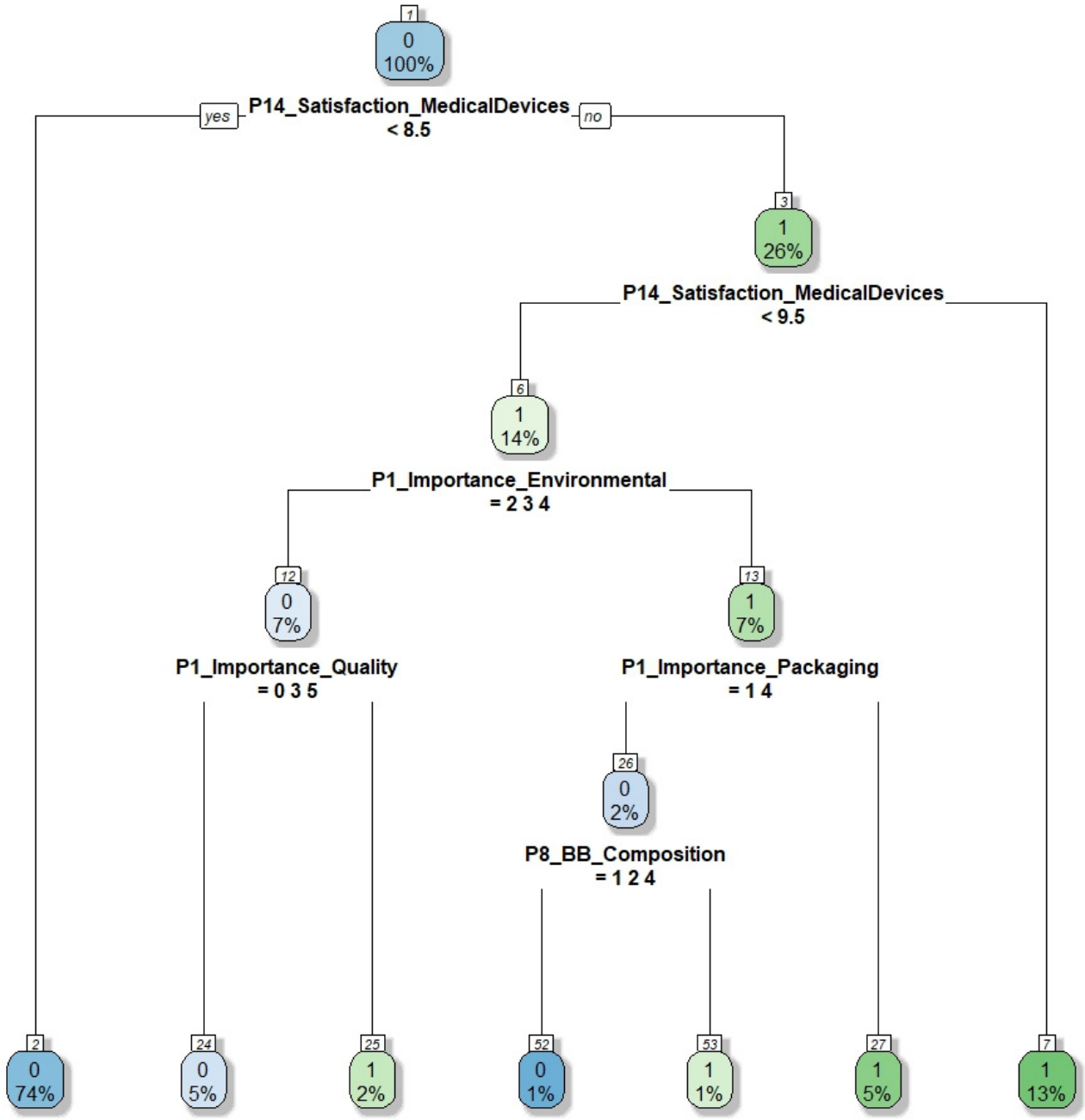


Figure A16. Decision Tree—Medical Devices.

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