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Behaviours and attitudes of consumers towards bioplastics: An exploratory study in Italy

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Abstract: Bio-based and biodegradable plastics produced from wood residues can have a positive impact on the environment by replacing conventional plastics. However, the current bioplastics market is held back by a lack of available information and weak marketing activities aimed at final consumers. To increase the available information, the present study investigated the consumers' attitudes and behaviours towards bioplastic products. A web-based survey was conducted on a sample of potential consumers in Italy. 1 115 consumers filled out the questionnaire with a dropout rate in compilation of 14%. The results showed that the environmental characteristics of bioplastics (lower impact on climate change and renewable sources used to produce them) are considered more important by respondents than the non-environmental characteristics (technical properties, origin of raw material, potential trade-off between bioplastics and food production). The results highlighted that the most important behavioural factor is the purchase intentions, followed by control of perceived cost and subjective norm. It is interesting to emphasize that the cost of bioplastics compared to conventional plastics is a key variable in the choices of many Italian consumers. The results provided can be useful to the manufacturing industries to better understand the consumers' attitudes towards bioplastics.

Keywords: bio-based plastics; biodegradable plastics; innovative forest-based products; theory of planned behaviour; wood residues

Worldwide, the annual global production of fossil fuel plastics – also known as conventional or petroleum-derived plastics – attained 367 Mt in 2020 and the trend has continually grown over the past 70 years (PlasticsEurope 2021). The year 2020 was an exception to this trend with a decrease of one million tons caused by the COVID-19 pandemic. In this context, Geyer et al. (2017) estimated that approximately 6 300 millions t of plastic waste have been generated throughout the history of this material (79% ended up in landfills or in the environment, 12% was destined for incinerators, while only 9% of total plastic waste was recycled). Since the 2000s, plastics accounted for between 60% and 80% of global waste (Derraik 2002) with a further increase in 2020–2021 due to single-use plastics (e.g. face masks, surgical masks, face shields) production to counter the spread of the COVID-19 pandemic (Shams et al. 2021). Historically, the use of petroleum-derived plastics has caused some environmental problems, such as carbon dioxide (CO_2) emissions and the long-term accumulation of non-biodegradable materials in the environment (Nielsen et al. 2020). Therefore, the need to identify appropriate alternatives to petroleum-derived plastics that are ecologically sustainable – e.g. bioplastics – is one of the target objectives for the European Union (EU) policy makers to achieve the target established by the Paris Agreement on Climate Change (2015) and the European Green Deal (Emadian et al. 2017; Di Bartolo et al. 2021).

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In 2015, the European Commission (EC) proposed the full legislative package on waste aimed at achieving huger harmonization and simplification of the legal framework on by-products and end-of-waste status (Scarlat et al. 2019). The waste legislative package revised the Waste Framework Directive (2008/98/EC) stressing the circular nature of bioplastics and the potential of bio-based compostable plastic packaging to foster an EU circular economy (Briassoulis 2019). The main objective of a circular economy is to have minimal input and production of system "waste" by redesigning the life cycle of the "product" (Biancolillo et al. 2019). In this context, the role of bioplastics to minimize the environmental and climate impacts of petroleum-derived plastic packaging and in reducing the dependence of EU member countries on imported raw materials was emphasized (Fornabaios et al. 2019). In other words, the EU legislators recognized that bio-based and recycled materials can play a key role in the transition from the "linear economy" to a "circular economy" paradigm in Europe by replacing fossil fuels with renewable resources and by increasing reusing and recycling (Hetemäki et al. 2020; Tamantini et al. 2021).

From a terminological point of view, plastic material can be defined as bioplastic if it is bio-based, biodegradable or if it has both properties (European Bioplastics 2020). Based on the EU Standard EN 16575 (2014), bio-based products are products wholly or partly derived from biomass – materials of biological origin such as sugar cane, starch from maize or potatoes, cellulose and plant oil – through a physical, chemical or biological treatment of the biomass itself. Among the various feedstocks available, wood-based biomass is an important source for producing bio-based plastics in forest biorefineries (Kangas et al. 2011). Forest biorefineries can use multiple feedstocks – such as pulpwood, harvesting wood residues, recycled paper and industrial wastes – in order to produce both low value-high volume and high value-low volume products (Näyhä et al. 2014). In the diversification of the product portfolio related to the opportunities provided by forest biorefineries, bio-based plastics are among the most attractive options due to the growing demand for these products (Biancolillo et al. 2019). In fact, in bio-based plastics are included bio-based polypropylene (PP), and polyethylene terephthalate (PET) (De Marchi et al. 2020). Biodegradability (or compostability) can be defined as the inherent ability of a material to decompose under microbiological activity into naturally occurring substances, for example, CO_2 and water (Lucas et al. 2008). Polybutylene adipate terephthalate (PBAT) is included in biodegradable but not bio-based plastics, while some bioplastics even possess both characteristics such as polylactic acid (PLA) (Jiménez et al. 2019). This crucial distinction between bio-based and biodegradable plastics, also as environmental impacts and benefits, is not always perceived by consumers (Ansink et al. 2022).

Currently, the bioplastics market represents one of the fastest growing markets; IFBB (2019) estimated the average growth in 2023 compared to 2018 at 72.8% for biodegradable and 62.4% for bio-based plastics. This growth trend should lead to a production capacity of 1.8 million t for biodegradable plastics and 2.6 million t for bio-based plastics in 2023 (Döhler et al. 2020). Bioplastics can be used in several industrial processes, mostly packaging, but also in electronics, agriculture, medical and health applications, toys and automotive. However, currently, the global production of bioplastics still consists of less than 1% of total plastics production worldwide, and therefore it can be considered a niche market (European Bioplastics 2020). High prices, low availability, poor marketing activities, and lack of product information are the main obstacles to the demand increase for bioplastics products (Iles, Martin 2013; Lettner et al. 2017).

In the international literature, studies mainly focused on bioplastic product development and environmental impact (Tsiropoulos et al. 2015; Koch, Mihalyi 2018; Benavides et al. 2020; Atiwesh et al. 2021), while few studies focused on consumers' perspectives and opinions towards some specific bioplastic products (Lynch et al. 2017; Scherer et al. 2018; Ketelsen et al. 2020; Klein et al. 2020). To overcome this knowledge gap, the objective of this study is to investigate consumers' attitudes and behaviours towards bioplastics. From a theoretical point of view, the study was developed following the principles of the theory of planned behaviour (TPB) by Ajzen (1985). The premise of the TPB – an attitude-behaviour relationship model able to predict and explain consumer behaviour (Ajzen 1993) – is that behavioural decisions are not made spontaneously but are influenced by attitudes, norms, and perceptions of control over the behaviour. According to this theory, attitude, subjective norms, and perceived behavioural control influence behaviour primarily through their impact on behavioural intention (Smith et al.

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2008). In environmental issues, interest in the TPB theory has grown (Grilli, Notaro, 2019) as it has proved adequate for the explanation of environmentally friendly behaviors (e.g. Kaiser, Scheuthle 2003; López-Mosquera, Sánchez 2012). From a practical point of view, the attitude-behaviour relationship can be measured through the principle of compatibility so defined by Ajzen and Fishbein (1977): verbal and non-verbal indicators of a given attitude are compatible with each other to the extent that their action is assessed at identical levels of generality or specificity. Taking into account these principles and practical aspects, the research questions analysed within this study are the following: How do consumers value different environmental and non-environmental characteristics of bioplastic products? What are the most important behavioural factors influencing consumer choices toward bioplastics? Could the socio-demographic characteristics of consumers influence preferences for bioplastics?

MATERIAL AND METHODS

Consumer behaviours and attitudes towards bioplastics were analysed using the same questionnaire that Notaro et al. (2022) employed to estimate hypothetical willingness to pay (WTP) for different selected characteristics of two bioplastic products. The questionnaire was administered online to a sample of consumers in Italy. A preliminary version of the questionnaire was pre-tested through in-depth face-to-face interviews with 10 consumers to verify its accuracy and adequacy.

The questionnaire was arranged in four thematic parts, but this paper focuses only on the three parts concerning the key aspects related to the TPB: the first investigated the knowledge and attitudes of respondents towards bioplastics and their environmental and non-environmental characteristics (e.g. technical properties, origin and type of raw material, climate impacts of the production process), the second focused on consumer buying behaviour, while the third considered the socio-demographic characteristics of the respondents. In the preliminary part of the questionnaire, the concept of bio-based and biodegradable plastics was introduced and explained with special regard to the possible feedstocks used to produce them such as potato starch and wood residues. The first group of questions (from Q1 to Q4) focused on consumers' previous experience and familiarity with the concept of bioplastics. To this end, in the first question (Q1) consumers indicated whether they had already heard of bioplastics in the past, while the second question asked whether they bought bioplastic products in the past (Q2). The next two questions investigated the reasons for the past purchase (Q3) or no-purchase of bioplastics (Q4) considering the set of options shown in Table 1.

The following four questions (from Q5 to Q9) focused on consumers' attitudes towards the main characteristics of bioplastic products. For each characteristic considered in the survey, the respondents assigned the degree of importance using a 5-point Likert scale format (from 1 = not at all important to 5 = extremely important). For this purpose, two environmental and three non-environmental characteristics of the bioplastics have been selected and thus described:

– bioplastics must have the same technical properties – e.g. impact resistance, durability, stiffness – as conventional plastics (PROPR);

– bioplastics must have a lower climate impact generated by the production process compared to conventional plastics (CLIM);

– bioplastics must not be produced from fossil sources and must not take 100 to 1 000 years to decompose (FOSSIL);

– bioplastics must be produced from domestic (Italian) crops rather than foreign crops (ORIGIN);

– bioplastics can be produced from organic sources (i.e. maize and potatoes) but without di-

Table 1. Reasons for purchase (Q3) or no-purchase (Q4) of bioplastic products considered in the survey

Reasons for past purchase	Reasons for past no-purchase
product quality (QUALITY)	difficulty to find bioplastic products on the market (MARKET)
convenient price (CONV)	
brand (BRAND)	difficulty to distinguish bioplastic products from non-bioplastic ones (DIFFER)
clear ecological information about bioplastics (ECOL)	
clear information about product disposal at the end of the life cycle (DISPOS)	too high costs of bioplastics (EXPEN)
impact on human health (HEALTH)	I am not interested in bioplastics (INTER)
impact on environment (ENVIRON)	–

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minishing the availability of these sources for food use. In other words, there must be no trade-off between bioplastics production and food production (FOOD).

In the second part of the questionnaire, the three behavioural factors of the TPB were considered and thus defined (Cialdini et al. 1991; Smith et al. 2008; Chen et al. 2020): (*i*) purchase intentions (the tendency, plan, desire and possibility of buying a product or service), (*ii*) perceived behavioural control (the perceived control over the performance of the behaviour which can have a direct effect on behaviour and an indirect effect via intention), and (*iii*) subjective norm (the perceived social pressures from family, partners, friends to perform the behaviour). In particular, the consumers expressed their level of agreement or disagreement with certain statements using a 5-point Likert scale format (from 1 = strongly disagree to 5 = strongly agree). Questions Q10 and Q11 focused on the general purchasing intentions of consumers (PI) considering two key aspects in accordance with the method proposed by Klein et al. (2019): (*i*) the option to pay more attention to bioplastic products in the future purchasing decisions (FUTUR); (*ii*) the option to choose a plastic product made of renewable raw materials rather than a plastic product made of conventional raw materials (e.g. petroleum) (RENEW).

The following three questions (from Q12 to Q14) described respondents' control over the perceived cost of bioplastic products (CPC) based on some key aspects formulated by Ajzen (1991) and Maloney et al. (2014) and thus synthesizable:

– I can afford to buy bioplastic products (AFFORD);

– I am willing to pay a higher price for a bioplastic product (WTP);

– if the cost of bioplastic products was the same as the cost of a conventional plastic product, I would be more likely to buy the bioplastic one (COSTS).

The last question of the second part (Q15) considered consumers' subjective norms (SN) through the following statement (Ajzen 1991; Klein et al. 2019): "People close to me (partners, children, parents, friends) expect me to buy products made of bioplastics rather than of petroleum-based plastics".

Finally, the third part of the questionnaire focused on personal information of respondents such as gender, age (considering six age classes: less than 25 years old, 25–34, 35–44, 45–54, 55–64, and more than 64 years old), annual income (distinguishing among seven classes: no income, less than EUR 10 000, EUR 10 000–19 999, EUR 20 000–29 999, EUR 30 000–39 999, EUR 40 000–60 000, more than EUR 60 000, and degree of education (distinguishing among elementary/middle school degree, high school degree, university/post-university school degree).

During the second phase of this study, the data was collected through a web-based survey targeting Italian consumers aged 18 years and more. The questionnaire was written in the Italian language and developed using the EUSurvey platform. From November 2020 to January 2021, the final version of the questionnaire was distributed following the method proposed by Yao et al. (2019). Specially, a snowball sampling method was applied using a preliminary list of names provided by many public institutions and private organizations located throughout Italy. Then, the questionnaire link was posted to several social network sites (e.g. Facebook, Twitter, LinkedIn) to further recruit respondents from non-institutional and private organizations.

In the last phase, the collected data were processed to produce the main descriptive statistics (mean, median and standard deviation) for the data collected using the Likert scale format, percentage of frequency distribution (%) for Q1. Besides, for questions from Q2 to Q11 the non-parametric Kruskal-Wallis and Mann-Whitney tests were performed using the XLStat 2020 software (Version BASIC, 2020). The non-parametric tests were applied rather than the parametric tests because the assumption of normality was violated (Shapiro-Wilk test: $P < 0.0001$, $\alpha = 0.01$; Anderson-Darling test: $P < 0.0001$, $\alpha = 0.01$).

The Kruskal-Wallis test ($\alpha = 0.01$) was used for data collected through a Likert scale format with the aim to underline differences between three or more groups of respondents with different socio-demographic characteristics (age, degree of education, income).

The Mann-Whitney test ($\alpha = 0.01$) was used through a Likert scale format with the aim to highlight differences between two groups of respondents with different socio-demographic characteristics (gender).

Finally, the chi-square (χ^2) test was applied to analyse the group differences when the depen-

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dent variable is measured at a nominal level like our questions about the reasons for purchase or non-purchase of bioplastic products (Q3 and Q4).

RESULTS

Socio-demographic characteristics of consumers. A total of 1 296 Italian consumers opened the questionnaire link and 1 115 of them completed the survey (dropout rate in the compilation of 14.0%).

The sample is mainly composed of females (67.8% of total respondents), while the remaining 32.2% are males. In the sample, people under the age of 34 (50%) and between the ages of 35 and 54 (31%) prevail, as well as well-educated people (64.3% have a university or post-university degree). With regard to the annual income, the majority of respondents have an annual income between EUR 20 000 and 39 999 (33.2%), but it is interesting to emphasize that 26.3% of total respondents have no income because they are mainly university students.

Characteristics of bioplastics. The results show that 81.6% of respondents declared that they had heard of bioplastics in the past, while 18.4% had never heard of these products. Especially, males have slightly higher knowledge of bioplastics compared to females as well as people over 64 years old compared to the other age classes. Conversely, the results show that the degree of education does not influence the level of knowledge of bioplastics: 83.3% of respondents with an elementary/middle school degree heard of bioplastics before, compared to 78.9% of respondents with a high school degree, and 82.2% with a university/post-university degree.

The results point out that 76.3% of respondents bought bioplastics in the past (11.5% of consumers often bought these products, 56.7% sometimes, and 8.1% once), while the remaining 23.7% of respondents have never bought bioplastic products despite knowing them.

Therefore, the results highlight that our sample of consumers has a high level of knowledge of bioplastics both from a theoretical (heard/read about bioplastics) and practical (purchased bioplastics) point of view.

The results about the reasons that led to the purchase of bioplastics show the following order of priority (Figure 1): impacts on the environment (ENVIRON), impacts on human health (HEALTH), clear ecological information about bioplastics

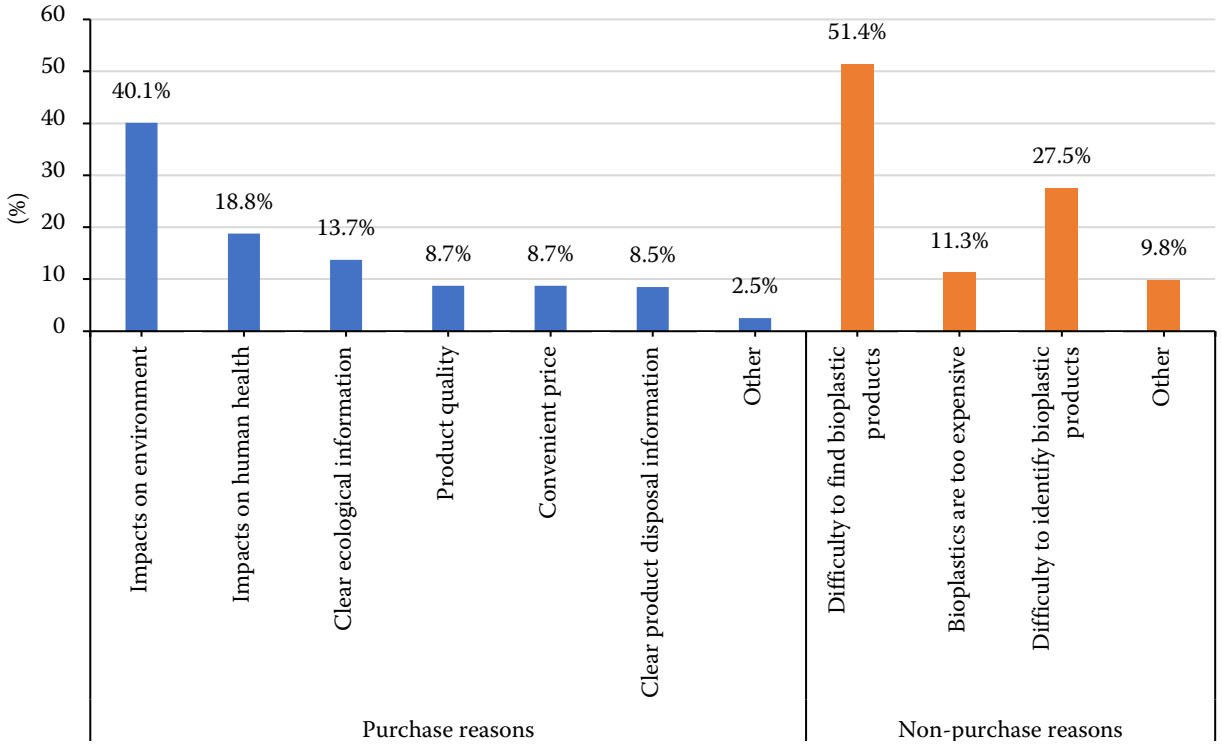

Figure 1. Importance of the reasons for purchasing or no purchasing bioplastic products (% of respondents)

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(ECOL), product quality (QUALITY), convenient price (CONV), and clear information about product disposal at the end of the life cycle (DISPOS). Accordingly, there is consumer awareness of the negative impacts of petroleum-derived plastics on both the environment and human health compared to bio-based and biodegradable plastics.

Regarding the reasons why bioplastic products were not purchased, the most important are as follows (Figure 1): difficulty to find bioplastic products on the market (MARKET), difficulty to distinguish bioplastic products from non-bioplastic ones (DIFFER), and bioplastic products are too expensive compared to conventional plastics (EXPEN), while 9.8% of respondents indicated other reasons among which none exceeds 1%. These results show that only a minority of respondents report the higher cost of bioplastics compared to conventional plastics as a reason for the no-purchase of these more sustainable products. Conversely, the importance of making more information on the quality of bioplastic products and the environmental impacts available for consumers are two key aspects highlighted by our results. In particular, it is of key importance to be able to find and easily recognize bio-based and biodegradable plastics from conventional ones. The label of bioplastic products must summarize the main characteristics such as the type and origin of raw material used, and possibly the time of biodegradability.

Observing the data by socio-demographic characteristics, the results show that the females assigned higher importance to ENVIRON and HEALTH compared to the males within purchase reasons. Conversely, males emphasized two other reasons more than females: CONV and QUALITY. Regarding the no-purchase reasons, females highlighted more than males the importance of MARKET, while males emphasized more than females the importance of DIFFER. However, the χ^2 test did not show any statistically significant differences between males and females both for purchase (P = 0.943) and no-purchase (P = 0.837) reasons. With regard to age, the results highlight that young people less than 25 years old assigned higher importance among the reasons for purchasing bioplastic products to ECOL compared to the other age classes. Instead, older people more than 64 years old emphasized more than young people the importance of QUALITY and DISPOS. Even for age, the χ^2 test did not show any statistically significant differences between age classes for pur-

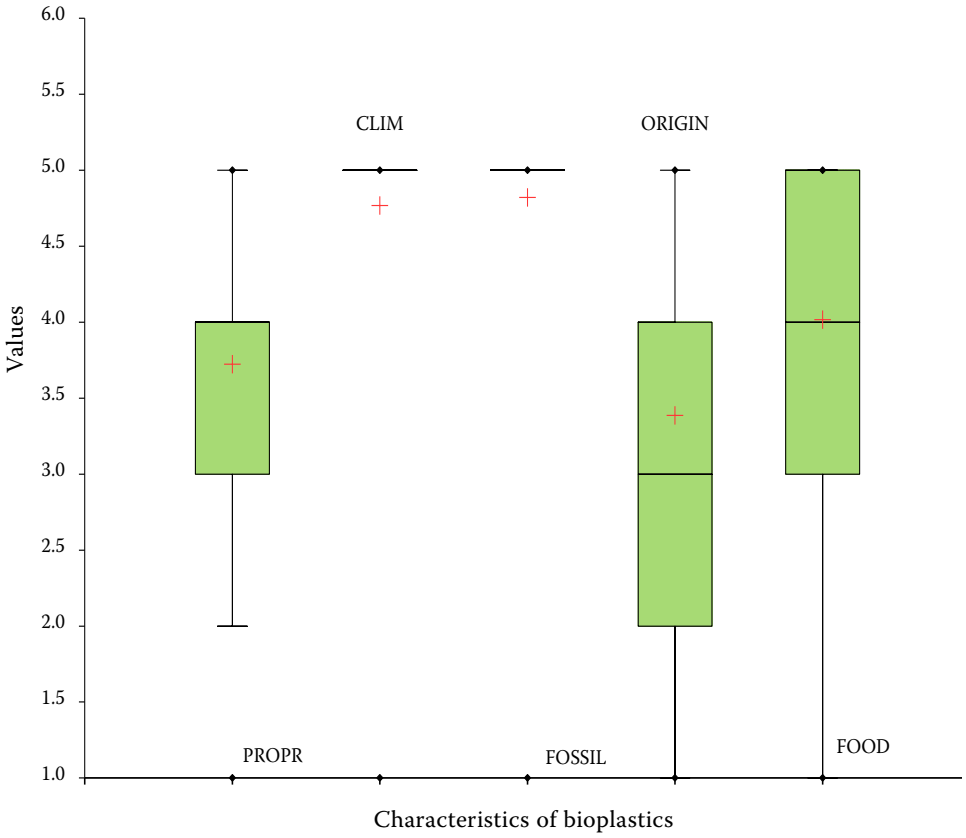

Figure 2. Box-plots for the importance of the characteristics of bioplastics

PROPR – technical properties; CLIM – lower climate impact; FOSSIL – not produced from non-renewable sources; ORIGIN– produced from domestic crops; FOOD – not produced using sources for food purpose

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chase reasons (P = 0.873), while there were statistically significant differences between age classes for non-purchase reasons (P = 0.001). Within the reasons for bioplastics purchase, the results highlight that respondents with a low level of education emphasize more the importance of ENVIRON than respondents with a high level of education. Within the reasons for the non-purchase of bioplastics, it is interesting to highlight that respondents with a high level of education assigned higher importance to QUALITY and MARKET compared to the others. Conversely, respondents with a low level of education assigned higher importance to DIFFER. However, the χ^2 test did not show any statistically significant differences between respondents with different levels of education either for purchase (P = 0.828) or no-purchase reasons (P = 0.554).

The environmental characteristics of bioplastics (FOSSIL and CLIM) have higher average importance to consumers than the non-environmental characteristics (FOOD, ORIGIN and PROPR). In particular, 86.2% of respondents declared that it is really important that bioplastics will not be produced from non-renewable sources and will not require long decomposition times (FOSSIL), and most respondents (82.2%) think that it is very relevant that bioplastics have a much lower impact on climate change than petroleum-derived plastics (CLIM). The results show the following mean values for the first two factors (Figure 2): FOSSIL and CLIM. In addition, the results highlight that the origin of raw material used to produce bioplastics (ORIGIN) has the lowest mean value of all other characteristics.

Considering the respondents' characteristics (Table 2), the results show that females assigned higher importance to all characteristics of bioplastics than males except for the technical properties of bioplastics compared to conventional plastics (PROPR). However, the Mann-Whitney non-parametric

Table 2. Importance assigned to the characteristics of bioplastics by consumers

Socio-demographic characteristics	PROPR	CLIM	FOSSIL	ORIGIN	FOOD
Gender					
Male	**3.80 ± 0.98**	4.70 ± 0.72	4.77 ± 0.62	3.19 ± 1.19	3.98 ± 0.96
Female	3.69 ± 0.95	**4.78 ± 0.51**	**4.84 ± 0.45**	**3.50 ± 1.17**	**4.03 ± 0.92**
Age (years)					
< 25	3.83 ± 0.87	4.76 ± 0.63	4.75 ± 0.63	3.24 ± 1.17	3.90 ± 0.92
25–34	3.77 ± 0.96	4.72 ± 0.60	4.80 ± 0.53	3.26 ± 1.16	3.89 ± 0.95
35–44	**3.87 ± 0.89**	4.79 ± 0.52	4.83 ± 0.49	3.39 ± 1.29	4.14 ± 0.92
45–54	3.60 ± 0.98	4.75 ± 0.56	4.84 ± 0.47	3.62 ± 1.12	4.11 ± 0.94
55–64	3.64 ± 1.08	4.80 ± 0.60	4.90 ± 0.36	3.55 ± 1.22	**4.26 ± 0.81**
> 64	3.42 ± 1.03	**4.83 ± 0.56**	**4.92 ± 0.28**	**3.69 ± 1.09**	3.83 ± 1.02
Degree of education					
Elementary/middle school degree	3.56 ± 1.17	4.54 ± 0.91	4.59 ± 0.85	**3.69 ± 1.06**	3.95 ± 0.97
High school degree	3.72 ± 0.99	4.72 ± 0.65	**4.83 ± 0.51**	3.60 ± 1.19	**4.11 ± 0.92**
University/post university degree	**3.74 ± 0.94**	**4.79 ± 0.53**	4.82 ± 0.48	3.29 ± 1.18	3.97 ± 0.93
Income (EUR)					
No income	3.84 ± 0.88	4.77 ± 0.55	4.79 ± 0.52	3.24 ± 1.19	3.93 ± 0.91
< 10 000	3.68 ± 0.93	4.75 ± 0.57	4.82 ± 0.50	3.37 ± 1.08	3.89 ± 0.95
10 000–19 999	3.61 ± 0.97	4.73 ± 0.64	4.74 ± 0.67	3.57 ± 1.22	4.12 ± 0.93
20 000–29 999	3.67 ± 1.01	4.77 ± 0.51	4.85 ± 0.44	3.47 ± 1.22	4.02 ± 0.94
30 000–39 999	3.77 ± 1.03	4.73 ± 0.71	4.84 ± 0.47	3.31 ± 1.12	4.06 ± 0.98
40 000–60 000	3.74 ± 1.03	**4.87 ± 0.40**	**4.94 ± 0.24**	**3.61 ± 1.13**	**4.18 ± 0.85**
> 60 000	**3.94 ± 0.93**	4.55 ± 0.96	4.77 ± 0.50	3.32 ± 1.28	4.13 ± 0.85

Bold – the highest value for each factor; PROPR –technical properties; CLIM – lower climate impact; FOSSIL – not produced from non-renewable sources; ORIGIN – produced from domestic crops; FOOD – not produced using sources for food purpose

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test shows statistically significant differences only for one of all characteristics of bioplastics: ORIGIN ($P < 0.0001$).

With regard to age, the results highlight that older respondents assigned higher importance to three of the four characteristics of bioplastics compared to the other age classes: CLIM, FOSSIL, and ORIGIN. Contrariwise, for technical properties of bioplastics (PROPR) the highest values are assigned by the respondents between 35 and 44 years of age, while for the impact on food availability (FOOD) they are assigned by the respondents between 55 and 64 years of age. Also, it is interesting to highlight that young people assigned less importance than other age classes to two of the five characteristics of bioplastics: FOSSIL and ORIGIN. The Kruskal-Wallis non-parametric test shows statistically significant differences only for two non-environmental characteristics: ORIGIN ($P = 0.0004$) and FOOD ($P < 0.0001$).

Regarding the degree of respondents' education, the results show that two characteristics of bioplastics (PROPR and CLIM) are considered more important by respondents with a higher degree of education (university/post-university degree) compared to those with a lower degree of education. Conversely, respondents with an elementary/middle school degree attached more importance to the Italian origin of raw materials (ORIGIN) compared to the other groups of respondents. However, the Kruskal-Wallis non-parametric test shows statistically significant differences only for the geographical origin of raw material – ORIGIN ($P = 0.0003$), while there are no statistically significant differences for the other characteristics.

Taking into account the income of respondents, the results evidence that people with the highest annual income (between EUR 40 000 and 60 000, and more than EUR 60 000) emphasized more than other income classes the importance of all characteristics of bioplastics, but with limited differences. For this reason, the Kruskal-Wallis non-parametric test shows no statistically significant differences for all characteristics considered in the survey.

Behavioural factors. The results of the behavioural factors are shown in Figure 3. Purchase intentions (PI) are characterized by the highest mean value, followed by control on perceived cost (CPC) and subjective norm (SN). In particular, in the PI both sub-factors have a similar level of importance (FUTUR and RENEW), while for the CPC, the results show that the most important sub-factor is related to the costs of bioplastics compared to the conventional plastics (COSTS), while the other two sub-factors are considered less important (WTP and AFFORD).

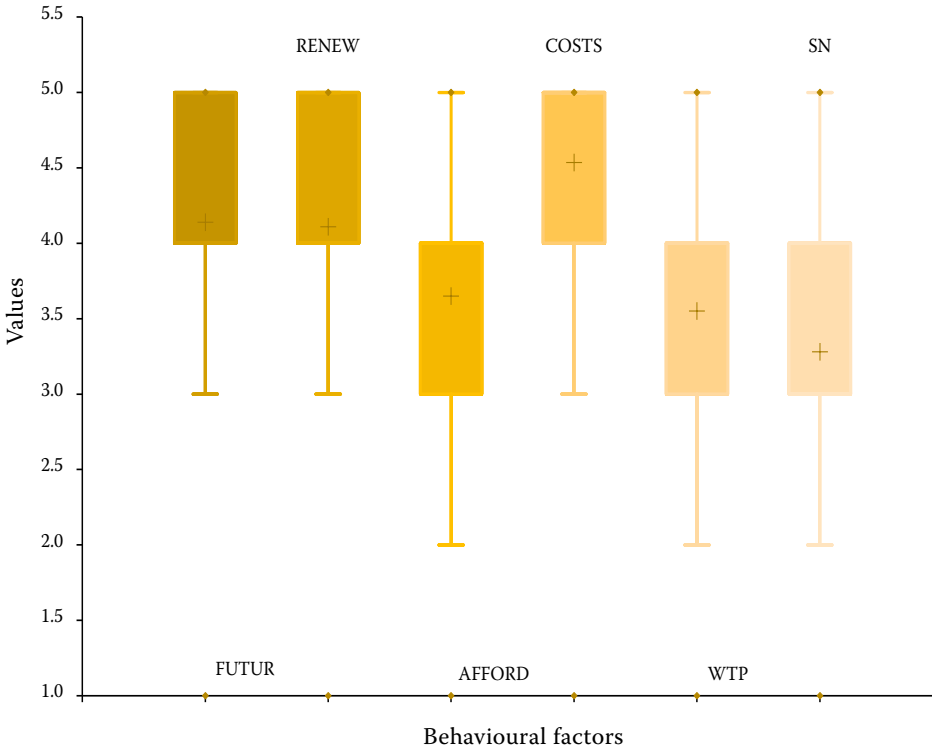

Figure 3. Box-plots for the behaviour factors related bioplastics

SN – subjective norms; FUTUR – future purchasing decisions; RENEW – plastic product made of renewable raw materials; AFFORD – afford to buy bioplastic products; WTP – willing to pay a higher price for a bioplastic product; COSTS – cost of bioplastic products

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The results show that socio-demographics influence the purchasing behaviour of consumers (Table 3). Females seem to have higher purchase intentions (PI) than males as confirmed from the statistical point of view by the non-parametric Mann-Whitney test ($P = 0.0037$). Older generations stated higher values for all three behavioural factors. Especially, people over 64 years old assigned higher importance to two CPC sub-factors (AFFORD and WTP) and one PI sub-factor (RENEW) compared to the other five age classes. Moreover, it is interesting to emphasize that people under 24 years old assigned particularly low importance to SN. The non-parametric Kruskal-Wallis test confirmed that there are statistically significant differences between the six age classes in five of the six sub-factors: FUTUR ($P < 0.0001$), RENEW ($P = 0.001$), AFFORD ($P < 0.0001$), WTP ($P = 0.001$), and SN ($P < 0.0001$).

With regard to the degree of respondents' education, the results show that people with an elementary/middle school degree stated higher SN, while CPC and PI are higher for people with a high school degree. In particular, the latter group of respondents emphasizes three sub-factors more than the other groups: FUTUR, WTP, and COSTS. However, the non-parametric Kruskal-Wallis test showed statistically significant differences between respondents with different degrees of education only in three sub-factors: AFFORD ($P < 0.0001$), WTP ($P < 0.0001$), SN ($P < 0.0001$).

Finally, consumers with lower income showed a lower level of agreement with all three behav-

Table 3. Importance assigned to the behavioural factors by consumers

Socio-demographic characteristics	PI		CPC			SN
	FUTUR	RENEW	AFFORD	WTP	COSTS	
Gender						
Male	4.03 ± 0.69	4.03 ± 0.80	**3.69 ± 0.81**	3.52 ± 0.82	4.47 ± 0.82	3.26 ± 1.00
Female	4.19 ± 0.63	4.15 ± 0.70	3.57 ± 0.83	**3.55 ± 0.80**	**4.57 ± 0.72**	**3.27 ± 0.93**
Age (years)						
< 25	4.03 ± 0.71	4.06 ± 0.80	3.50 ± 0.87	3.42 ± 0.83	4.59 ± 0.68	2.92 ± 0.96
25–34	4.07 ± 0.64	4.04 ± 0.74	3.35 ± 0.90	3.47 ± 0.82	4.53 ± 0.76	3.02 ± 0.96
35–44	4.24 ± 0.67	4.05 ± 0.76	3.73 ± 0.76	3.56 ± 0.75	4.58 ± 0.78	3.21 ± 0.81
45–54	4.19 ± 0.64	4.12 ± 0.69	3.67 ± 0.74	3.56 ± 0.81	4.49 ± 0.83	3.51 ± 0.85
55–64	**4.27 ± 0.52**	4.27 ± 0.66	3.95 ± 0.65	3.74 ± 0.70	**4.58 ± 0.68**	3.79 ± 0.78
> 64	4.23 ± 0.75	**4.44 ± 0.62**	**4.00 ± 0.55**	**3.79 ± 0.77**	4.35 ± 0.86	3.85 ± 0.88
Degree of education						
Elementary/middle school degree	4.03 ± 0.81	**4.13 ± 0.66**	**3.67 ± 0.93**	3.41 ± 0.82	4.26 ± 1.02	**3.59 ± 0.97**
High school degree	4.16 ± 0.65	4.13 ± 0.76	3.64 ± 0.80	**3.56 ± 0.84**	**4.54 ± 0.73**	3.36 ± 1.00
University/post university degree	4.05 ± 0.65	4.09 ± 0.74	3.61 ± 0.82	3.54 ± 0.82	4.48 ± 0.80	3.21 ± 0.88
Income (EUR)						
No income	4.06 ± 0.66	4.04 ± 0.76	3.42 ± 0.91	3.45 ± 0.82	4.58 ± 0.72	2.93 ± 0.95
< 10 000	4.09 ± 0.62	4.09 ± 0.78	3.35 ± 0.77	3.44 ± 0.78	4.56 ± 0.69	3.16 ± 0.89
10 000–19 999	4.07 ± 0.74	4.09 ± 0.74	3.55 ± 0.86	3.45 ± 0.84	4.37 ± 0.88	3.31 ± 1.00
20 000–29 999	4.23 ± 0.62	4.12 ± 0.74	3.70 ± 0.76	3.55 ± 0.81	4.56 ± 0.73	3.38 ± 0.90
30 000–39 999	4.16 ± 0.66	4.18 ± 0.67	3.80 ± 0.72	3.70 ± 0.69	**4.63 ± 0.70**	3.50 ± 0.91
40 000–60 000	4.29 ± 0.51	**4.29 ± 0.57**	4.09 ± 0.57	**3.85 ± 0.65**	4.58 ± 0.73	**3.69 ± 0.82**
> 60 000	**4.32 ± 0.60**	4.19 ± 0.91	**4.10 ± 0.60**	3.74 ± 0.93	4.55 ± 0.77	3.58 ± 0.89

Bold – the highest value for each factor; PI – purchase intentions; CPC – control on perceived cost; SN – subjective norms; FUTUR – future purchasing decisions; RENEW – plastic product made of renewable raw materials; AFFORD – afford to buy bioplastic products; WTP – willing to pay a higher price for a bioplastic product; COSTS – cost of bioplastic products

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ioural factors (PI, CPC, and SN), but the non-parametric Kruskal-Wallis test revealed statistically significant differences only in CPC ($P < 0.0001$) and SN ($P < 0.0001$).

DISCUSSION

The present study provides a preliminary overview of the behavioural factors that influence the purchasing decisions toward bioplastics based on the responses of a sample of Italian consumers. Our sample of respondents is mainly composed of females (67.8% of the total) as well as the distribution at the national level but with more marked differences (Istituto Nazionale di Statistica 2021): 51.8% of females and 48.2% of males. With regard to age, our sample has a higher percentage of young respondents and a lower percentage of older respondents compared to the Italian population characterized by 8.2% of people between 18 and 24 years old and 27.6% over 64 years old. In addition, our sample is overrepresented by people with a university degree (17.9% of the Italian population), while it is underrepresented by people with an elementary/middle school degree (38.7%) (Istituto Nazionale di Statistica 2021).

The results point out that the most important characteristics of bioplastics for our sample of consumers are related to the environmental aspects of the product. First of all, a bioplastic product must be produced from renewable resources (e.g. wood, algae, maize, sugar cane) rather than from non-renewable sources (e.g. petroleum), and it must be produced with a low impact on climate change. This result is congruent with the international literature which shows a reduction from –50% to –70% of GHG emissions in the use of PLA rather than conventional petroleum-derived plastics (Atiwesh et al. 2021), while other studies highlighted that substituting maize-based PLA bioplastics for conventional petroleum-derived plastics can reduce GHG emissions by 25% (Sabbah, Porta 2017). Therefore, these two environmental characteristics of bioplastics are closely interrelated. Our results show that consumers are aware of the importance of using renewable resources rather than fossil fuels also with the aim to reduce the negative impacts of the production process on climate. This is in line with the findings of other researchers on consumer preferences for products with low carbon emissions (Yue et al. 2010; Scherer et al. 2017; De Marchi et al. 2020). In summary, we can assert that the majority of consumers would shift their choices from conventional plastics to bioplastics mainly for environmental reasons related to climate change. Conversely, the other three characteristics of bioplastics evaluated in this study – technical properties, the origin of raw material, the trade-off between food and bioplastics production – are considered less important by our sample of consumers. Particularly, technical properties do not have a direct effect on environmental and climate impacts, but they are linked to the intrinsic characteristics of the product influenced by the type of raw material (Kadtuji et al. 2021). Contrariwise, the importance of the origin of raw material used for bioplastics production is related to two aspects: the first one is due to a greater trust in domestic products than in those of foreign origin, while the second one includes environmental reasons due to the greater environmental and climate impacts of the transport phase compared to the other production phases. With regard to the first aspect, consumer preferences for foreign and domestic products could be influenced by trust in foreign firms and consumer ethnocentrism (Kaynak, Kara 2002; Jiménez, San Martín 2010). Trust in firms is related to their country-of-origin reputation to manufacture goods with specific characteristics, while consumer ethnocentrism is a belief held by consumers in the appropriateness and indeed morality of purchasing foreign-made products (Shimp, Sharma 1987). The combination of these two aspects can induce consumers to prefer domestic products rather than foreign products in particular low-cost products produced by low-reputation countries such as plastic products. Regarding the second aspect, many studies have emphasized the high environmental impacts of the transport phase in the production process due to the long distances travelled (Manfredi, Vignali 2014; Notaro, Paletto 2021). For this reason, environmentally friendly consumer preferences are directed towards local or national products characterized by limited travel distances.

Other international studies have pointed out comparable results with those provided by our study. In a study carried out in the Netherlands, Lynch et al. (2017) showed that consumers prefer bioplastics rather than fossil fuel plastics because they believe that these biomaterials have a more positive impact on the environment and that pur-

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chasing bioplastic products contributes to a green lifestyle. In a choice-based conjoint analysis conducted in Germany, Scherer et al. (2018) highlighted a consumer preference for a bio-based plastic bottle and running shoes with a biopolymer sole compared to conventional plastics. Those authors also showed that the origin of the raw materials (i.e. cultivated in Germany) was the most important factor in purchasing choices (Scherer et al. 2018). In another more recent study carried out in Germany, Klein et al. (2020) found that consumers with no previous experience with bio-based products preferred not to purchase the bio-based product. The results provided by those authors suggested that consumer "green" values and attitudes toward bioplastics are influencing factors for purchasing decisions. Again with reference to the German context, Rumm (2016) analysed consumer preferences for bio-based shopping bags and disposable cups highlighting that the reduction of the dependence on crude oil and carbon dioxide emissions of bio-based alternatives over the production of conventional plastics was a particularly positive aspect during the purchasing decision process. With regard to the information to be provided on bioplastics to consumers, Kainz et al. (2013) highlighted that for German consumers the most important types of information concerning bioplastics are: the type and origin of raw material used to produce them (43% of total respondents) and the effects of bioplastics on environment and climate (36%). Conversely, other types of information – such as areas of application (24%), price (16%), and product characteristics (7%) – are considered less important by the sample of consumers involved in that study. In another study conducted in Italy, Banterle et al. (2012) showed that consumers emphasized the lack of information on sustainability, recyclability and reusability of packaging, noting that they would be interested in having such additional information about the environmental characteristics of these products.

The present study also reveals the importance of the behavioural factors influencing consumers' purchasing decisions toward bioplastics. From this point of view, our results are consistent with the TPB by Ajzen (1985, 1993), who highlighted that positive behavioural intentions increase the probability of carrying out the actual behaviour. In the international literature, other studies investigated drivers of purchase intentions and purchasing behaviour towards bio-based and environmentally friendly products. In accordance with the theoretical principles of TPB, the results of those studies confirmed that for consumers the most important influencing factors are: purchase intentions (Osburg 2016), attitudes towards bioplastics, including the reduction of environmental and climate impacts (Osburg 2016; Scherer et al. 2017), perceived control (Maloney et al. 2014; Osburg 2016), and subjective norm (Osburg 2016; Onwezen et al. 2017). In addition, the results of our study highlight the importance of the purchase costs of a bioplastic product compared to an equivalent conventional plastic product. A high number of consumers are willing to buy bioplastics only if the costs of these are not higher than those of conventional plastics.

Finally, some socio-demographic characteristics of respondents are shown to have a significant impact on consumer preferences. Our results show that females assigned greater importance to all environmental characteristics of bioplastics – use of renewable resources and low impacts on climate – compared to males who emphasize more the technical properties of the products than females. In the international literature, some studies have shown that females have a more positive attitude than males towards environmental protection (Hirsh 2010) and towards bioplastics purchase (Yue et al. 2010; Kainz 2016; Scherer et al. 2018). Besides, our results highlight that people with a higher degree of education assigned higher importance to the environmental characteristics of bioplastics as well as older people. With regard to the influence of consumers' age on preferences for bioplastics some international studies have highlighted conflicting results (Yue et al. 2010; Scherer et al. 2018), while in the literature a high degree of education is normally associated with environmentally friendly consumers (Finisterra do Paço et al. 2009).

Considering the potential growth of the bioplastics market in the coming decades, it is important that the forest-based sector can supply quality raw materials with low environmental impacts (Jonsson et al. 2021). To make this possible, it is first of all necessary to enhance the wood residues deriving from silvicultural interventions and from the woodworking process rather than realizing *ad hoc* plantations for woody biomass production (Schnabel et al. 2020). The valorisation of wood residues could have low environmental impacts as required by final consumers and could have competitive advantages compared to other biomass also used for

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food purposes (e.g. sugar cane, starch from maize or potatoes). The use of wood residues for the production of bio-based products would be an efficient way to economically exploit this by-product of the forest-based sector as emphasized by many authors (Tamantini et al. 2021; Paletto et al. 2022). However, this innovative use of wood residues should not decrease the availability of raw materials for traditional uses such as bioenergy production (potential trade-off between bio-based products and bioenergy production). In Italy, the results of some forecast models show a theoretical wood biomass potential capable of satisfying a growing demand for bioenergy and bio-based products in the coming decades (Panichelli, Gnansounou 2008; Sacchelli et al. 2013). Nevertheless, the wood biomass potential from forests would only be available if the price of the raw material is higher than the harvesting and transport costs to supply it.

From a methodological point of view, the main strength of this study is the large sample size (more than a thousand respondents) and the distribution of respondents by socio-demographic characteristics which permitted a comparison between different potential groups of consumers. The web-based dissemination of the survey has accelerated and facilitated the data collection compared to the other administration systems such as face-to-face, mail, and phone surveys. Instead, the main weakness of the study is related to the snowball sampling techniques used to identify potential consumers to be involved in the survey. In the snowball sampling techniques, the sample may depend on the initial contacts; therefore, it can be characterized by a potential bias. Here, an attempt was made to overcome this weakness by distributing the questionnaire link on many social networks and web pages. An additional weakness concerns the underrepresentation of some categories of respondents – people with an elementary/technical school degree and people over 64 years old – due to the administration system used. Usually, older and low-educated people are the least likely to fill in online questionnaires for a gap and mistrust in the use of new technologies.

CONCLUSION

The results provided by this study can contribute to supporting decision makers (policy makers and entrepreneurs) to address suitable strategies toward a zero-emission economy and to replace conventional petroleum-derived plastics with environmentally friendly materials (e.g. bio-based plastics). Likewise, the present study can contribute to filling up the knowledge gap on consumers' behaviours and attitudes towards bioplastic products and the key factors influencing purchasing decisions. For this reason, the results provided can be useful to increase the information on bioplastics from a consumer perspective and, consequently, to identify new marketing strategies capable of increasing the market penetration of bio-based and biodegradable plastics.

With regard to the three research questions, the results of this study highlight that consumers assign higher importance to the environmental characteristics of bioplastic products compared to the non-environmental ones. Besides, the most important behavioural factor influencing consumer choices toward bioplastics is the origin of raw materials used (renewable raw materials rather than conventional raw materials). Finally, the socio-demographic characteristics of consumers are an important explanatory factor for consumer choices. Considering bioplastic products, females and more educated people are the types of consumers most inclined towards these environmentally friendly products.

Future research could provide insights into consumers' behaviours, attitudes and preferences toward specific bioplastic products with different environmental characteristics (raw material used in the production process, bioplastics percentage, biodegradability) and investigate the importance of environmental characteristics for low, medium and high-end bioplastic products.

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