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SHORT COMMUNICATION

Consumer Preferences in Greece for Bio-Based Products: a Short Communication

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Abstract
This study examines consumer preferences for bio-based products. Drawing from a sample of Greek consumers ($n = 533$) and the use of self-reported scales, we assess the effects of individuals' characteristics such as innovativeness, trust in science and technology, environmental concern, and previous experience with bio-products on consumer preferences, i.e., willingness to pay (WTP) for (a) a bio-nylon jacket, (b) a pack of bio-based breadsticks, and (c) a bioplastic bottled water. Findings indicate that certain consumer- and product-specific attributes may influence WTP for the three bio-based products included in our study and offer insights on the extent to which such characteristics may shape purchase decisions for products of this growing market. In this respect, the results encapsulate managerial/practical and policy implications toward the development of appropriate advertising messages and awareness-raising campaigns and indicate the need to further explore consumers' attitudes and purchase decisions for bio-based products in Greece.

Keywords Consumer preferences · Willingness to pay · Bio-based products · Greece

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Introduction—Background

The bio-based industry is one of the fastest-growing sectors worldwide [1–3]. The European Commission is actively supporting bio-based production, confirmed by the decision to invest €3.8 billion during the 2014–2020 period in boosting bio-based processes and related innovation systems [4]. Bio-based products are defined as products derived (wholly or partially) from renewable biomass materials, i.e., plants, trees, or animals. They are generally considered more environmentally friendly compared to respective "conventional" ones [5], but much debate still remains about their exact environmental footprint and impact [6]. Nevertheless, the environmental attributes of bio-based materials are improving and considerable growth is expected over the following decade [7, 8].

Despite the growing interest in the use of bio-based materials, ingredients, and additives, it is only a small number of studies that have, so far, focused on consumer attitudes and purchase decisions in relation to bio-based products [9–11]. Our knowledge of the reactions and acceptability that consumers may demonstrate toward bio-based materials and/or final products is still thin on the ground despite being of paramount importance [12]. Moreover, prior findings from different national terrains on consumers' WTP for eco-friendly products and underlying explanatory factors have been ambiguous and far from conclusive [13–16], which is in sheer contrast to the cost-intensive launches of new "green(er)" products companies plan and implement.

Numerous parameters have been identified as possible determinants shaping consumers' decisions for eco-friendly products, including those having bio-based characteristics. Demographics (in terms of gender, age, education, and income) have been widely employed in market segmentation and for profiling pro-environmental consumer behavior, but the results of related studies are to a certain degree conflicting and far from consistent [17–19]. Environmental concern to local and/or global issues is identified in the literature as a key explanatory variable of consumer behavior affecting conscious green consumption decisions [20–23] and explaining why individuals are willing to pay a premium price for these products [24–26]. Klein et al. [10, 18] and Stahl et al. [11] provide supporting arguments on the influence of consumers' attitudes and purchase intentions toward bio-based materials, along with their relative interest in as well as previous experience of bio-based products, in shaping purchase preferences. Consumer altruism, indicating prosocial behavioral patterns, has been identified as a precursor to environmentally conscious consumption [27, 28]. Likewise, the tendency of consumers to demonstrate innovativeness through their purchase decisions, e.g., by choosing newly released eco-friendly or bio-based products, is reported to have a positive impact on green consumption and the relative WTP for sustainable, innovation-oriented, goods, and services [9, 10, 29–32]. Additionally, product labeling and certification reduce information asymmetry between producers and consumers [33] and can potentially shape informed consumer choices for sustainable and bio-based products [34]. In a similar vein, trust in science and in new, innovative, technological advancements entering the market (along with the reported socioeconomic and environmental benefits they encapsulate) has been stressed as of critical importance in the acceptability of sustainability transitions, including products with a low environmental footprint in terms of resources, processes, and materials used [35–38].

Against this background, and as application areas and market penetration of bio-based materials are both increasing, this study examines Greek consumers' willingness-to-pay for bio-based products. To achieve this, we opted for a diverse set of products and attempt to shed light on factors explaining such purchase decisions. Next, the materials and methods

are outlined, followed by the results of the study. The final section provides some concluding remarks.

Material and Methods

The findings of this study rely on a sample of 553 consumers aged between 16 and 60 years (51% are female) that participated in our survey, which took place during July–September 2021 using a structured questionnaire. Participants were instructed to answer a battery of self-reported statements using a 5-point agreement scale that measures aspects of their personal beliefs, perceptions, and attitudes along with their WTP for:

(i) Breadsticks fortified with phenolic extracts from olive mill wastewater;
(ii) A jacket made from bio-nylon, i.e., produced using renewably sourced and plant-based textiles;
(iii) Bottled water in a bioplastic bottle made from polyhydroxyalkanoate (PHA) biopolymer which is produced by a variety of microorganisms through bacterial fermentation.

Dependent Variable

Willingness to pay (WTP) for the above bio-products is measured using the following three items:

(a) an open-ended question asking respondents how much more would they be willing to spend in euros for the bio-based product if the respective general/conventional one was priced at €*X* (where *X* is €4 for the breadsticks, €1 for the bottled water and €120 for the nylon jacket), i.e., how much compared to the cost of the conventional product would they pay for the bio-based product by entering euros amount of €0 and above (and this allowed us to quantify WTP in the three substudies);
(b) two 5-point Likert scale items with a scale ranging from strongly disagree to strongly agree adopted and revised from Laroche et al. [39] and Schniederjans and Starkey [40]: "*I am willing to pay a higher price for this 'bio-based product' than for a respective regular one*" and ''*Even if the 'regular product' is priced lower, I will still buy the "bio-based' product.*"

Independent Variables

Altruism (ALTR), denoting prosocial behavioral intentions, is measured using an adapted scale drawn from Price et al. [41].

Consumer innovativeness (INNOV), denoting the consumer's attraction to novelty of new products, is assessed using a reformulated scale developed by Tellis et al. [29] and also applied in the study of Scherer et al. [9] assessing consumer preferences for bio-based plastic products.

Trust in science (TRUSTSCI), denoting consumers' perceptions of science and technology advancements, is measured through the standardized items previously identified by Miller et al. [35] and Miller and Kimmel [42].

Product labeling (PRODLAB) is operationalized using a common factor of four standardized items measuring consumer choices based on information provision, reflecting agreement with the following statements: *"An important criterion when I choose a product is: (i) the information on the label regarding the product's country of origin, (ii) the information on the label regarding the certification of the product's production methods, (iii) the information on the label regarding the raw materials used to produce it, and (iv) the information on the label regarding the origin of key ingredients/main raw materials*."

Lack of environmental concern (ENVCONC), reflecting negative attitudes toward environmentally responsible behaviors, i.e. the likelihood to engage in pro-environmental behaviors [43] (Paul et al. 2016) is measured (using reverse scored items) through an adapted version of the scale identified by Ellen et al. [44] and Schwepker and Cornwell [45].

Attitude toward bio-products (ATTITOBIO), interest in bio-products (INTINBIO), purchase intention for bio-based products (PURCHINT), and previous experience with bio-products (PRODEXP) are operationalized using the scales drawn from Klein et al. [18].

Sociodemographic descriptors in terms of *gender*, *age*, *education*, and *income* were employed as categorical variables.

Model Specification and Statistical Analysis

In order to examine the dependence of the response variable of the WTP factor on the explanatory variables described above, we opted for multiple regression modeling approaches [46]. In this respect, linear regression estimation and inference were performed assuming the following model Eq. (1):

$$\begin{aligned} \mathrm{WTP} &= b_0 + b_1{}^*[\mathrm{INTINBIO} = \text{Not at all}] + b_2{}^*[\mathrm{INTINBIO} = \text{A little}] \\ &+ b_3{}^*[\mathrm{INTINBIO} = \text{Fairly enough}] + b_4{}^*[\mathrm{INTINBIO} = \text{A lot}] \\ &+ b_5{}^*\mathrm{PRODEXP} + b_6{}^*\mathrm{PRODLAB} + b_7{}^*\mathrm{ALTR} + b_8{}^*\mathrm{INNOV} \\ &+ b_9{}^*\mathrm{ENVCONC} + b_{10}{}^*\mathrm{TRUSTSCI} + b_{11}{}^*\mathrm{ATTITOBIO} \\ &+ b_{12}{}^*\mathrm{PURCHINT} + b_{13}{}^*[\mathrm{GENDER} = \text{male}] + b_{14}{}^*[\mathrm{AGE} \\ &=< 19\text{yrs}] + b_{15}{}^*[\mathrm{AGE} = 20 - 29\text{yrs}] + b_{16}{}^*[\mathrm{AGE} = 40 - 59\text{yrs}] \\ &+ b_{17}{}^*[\mathrm{INCOME} =< 1000] + b_{18}{}^*[\mathrm{INCOME} = 1001 - 2000] \\ &+ b_{19}{}^*[\mathrm{INCOME} = 2001 - 3000] + b_{20}{}^*[\mathrm{EDU} = \text{primary}] \\ &+ b_{21}{}^*[\mathrm{EDU} = \text{secondary}] + b_{22}{}^*[\mathrm{EDU} = \text{graduate}] \\ &+ b_{23}{}^*[\mathrm{EDU} = \text{postgraduate}] + \varepsilon \end{aligned} \tag{1}$$

where b_0 is the intercept and $b_j (j = 1, .., 23)$ are the regression coefficients of the continuous and categorical explanatory variables. The error term (ε) is used for measuring the unexplained variance in the dependent variables due to covariates, and is distributed as a Gaussian random variable with zero mean and constant variance. For estimating the regression model parameters in the three different fitted models (substudies), the ordinary least squares (OLS) method was employed due to that all three dependent factors for WTP for breadsticks, jackets, and bottled water were examined (Kolmogorov–Smirnov test for normality) and found to follow the Gaussian distribution, whereas selection of the best-fitted model in each case that includes only statistically significant explanatory variables was performed by utilizing the backward elimination selection technique. The latter approach for covariate selection is chosen in order to account for potential correlation among all the covariates under consideration (i.e. the full model) and to finally derive the best-fitted

regression model to the collected data. Goodness of fit for all models was assessed by the coefficient of determination, R^2. Data were fitted to the three linear regression models via the use of SPSS 21.0 statistical software [47]. Lastly, to ensure the validity and reliability of the regression modeling, including as dependent variable and covariates certain latent factors, the percentage of variance explained and Cronbach's α values were extracted [48] for each of the latent factors utilized as dependent and independent variables in the regression models.

Findings

Table 1 reports the percentage of variance and Cronbach's α values for the three dependent latent variables (WTP) and the explanatory latent constructs.

According to the validity and reliability tests, the dependent variables and covariates, which are factors, are suitable for further analysis through regression modeling since the obtained factors explain the largest proportion of the variance in the initially selected items and, in general, values are over 50%, while the items are reliable, as revealed by the generally high Cronbach alpha values (above 0.6).

Table 2 presents the overall significant effects of the covariates in the three regression models, along with goodness of fit in the form of R^2 values. In particular, Table 2 presents the statistically significant explanatory variables as were selected by the application of the backward selection technique. Different explanatory variables are found to be statistically significant for each of the three regression models (bio-based products), with only the explanatory factor of [ATTITOWBIO] being a statistically significant explanatory variable in all three WTP models/substudies. Among the remaining statistically significant factors, we observe that [INNOV] and [PURCHINT] are statistically significant predictors in two of the three models (i.e., INNOV is significant for breadsticks and bottled water and PURCHINT is significant for the jacket and bottled water). The factors of [ALTR], [PRODLAB], and [ENVCONC] have a negative effect in only one out of three dependent factors.

It is also of interest to note that no demographic effects have been found to be statistically significant in all three examined regression models.

In terms of model fit, the R^2 values range between 0.174 (breadsticks) and 0.327 (bionylon jacket), indicating a moderate fit for the fitted models. This indicates that there is still

Table 1 Validity and reliability measures for the dependent and independent variables included in the regression models

Factor	% of variance explained	Cronbach's α
WTP (breadsticks)	91.88	0.915
WTP (jacket)	89.07	0.871
WTP (bottled water)	94.03	0.922
ALTR	62.48	0.868
INNOV	63.86	0.769
TRUSTSCI	56.78	0.693
PRODLAB	72.98	0.869
ENVCONC	51.16	0.751
PURCHINT	85.22	0.801
ATTITOBIO	50.04	0.829

Table 2 Test of statistically significant effects for the models' covariates

	Breadsticks					Jacket					Bottled water				
Source	Type III sum of squares	df	Mean square	*F*	*P*-value	Type III sum of squares	df	Mean square	*F*	*P*-value	Type III sum of squares	df	Mean square	*F*	*P*-value
Intercept	0.182	1	0.182	2.100	n.s	0.017	1	0.017	0.024	n.s	0.432	1	0.432	0.506	n.s
INTINBIO	2.117	4	0.529	0.613	n.s	10.597	4	2.649	3.764	0.005	3.548	4	0.887	1.038	n.s
PRODEXP	0.321	1	0.321	0.372	n.s	0.130	1	0.130	0.184	n.s	1.523	1	1.523	1.782	n.s
PRODLAB	4.572	1	4.572	5.294	0.022	0.743	1	0.743	1.055	n.s	2.260	1	2.260	2.645	n.s
ALTR	0.047	1	0.047	0.054	n.s	0.207	1	0.207	0.294	n.s	4.440	1	4.440	5.196	0.023
INNOV	9.515	1	9.515	11.018	0.001	0.020	1	0.020	0.029	n.s	11.881	1	11.881	13.905	<0.001
ENVCONC	2.841	1	2.841	3.290	0.07	4.728	1	4.728	6.718	0.01	0.200	1	0.200	0.234	n.s
TRUSTSCI	0.182	1	0.182	0.211	n.s	0.419	1	0.419	0.595	n.s	0.033	1	0.033	0.039	n.s
ATTITOWBIO	9.390	1	9.390	10.872	0.001	11.991	1	11.991	17.037	<0.001	11.007	1	11.007	12.882	<0.001
AGE	3.972	3	1.324	1.533	n.s	0.266	3	0.089	0.126	n.s	6.375	3	2.125	2.487	n.s
INCOME	2.157	3	0.719	0.832	n.s	0.796	3	0.265	0.377	n.s	0.792	3	0.264	0.309	n.s
PURCHINT	3.170	1	3.170	3.671	0.056	6.642	1	6.642	9.438	0.002	5.467	1	5.467	6.399	0.012
Error	455.128	527	0.864			370.891	527	0.704			450.284	527	0.854		
Total	551.000	552				551.000	552				551.000	552			
Corrected Total	551.000	551				551.000	551				551.000	551			

a. Breadsticks model: R-squared = 0.174 (adjusted R-squared = 0.136); b. Jacket model: R-squared = 0.327 (adjusted R-squared = 0.296); c. Bottled water model: R-squared = 0.183 (adjusted R-squared = 0.146)

considerable variation in the dependent variables that is not explained by the current covariates. However, since the purpose of our study is confirmatory instead of explanatory, in the sense that we seek to examine certain hypotheses concerning the potential effects of specific explanatory variables and factors on the dependent factors of WTP instead of the estimation or prediction of WTP based upon the regression model, we present our results upon the three estimated models to determine which of the hypothesized predictors are significant for WTP.

Table 3 includes the parameter estimates for the three WTP regression models, along with the respective statistical significance (p-value) and the corresponding 95% confidence intervals for each of the parameters. The obtained results are outlined in brief for each one of the fitted models after covariate selection as follows.

Substudy 1 Findings: Breadsticks

A total of 63% of respondents said that they would be willing to pay for a pack of breadsticks that include phenolic extracts from olive mill wastewater as an ingredient (mean WTP: €3.91). Among those, 47% would be willing to buy the product at a premium price (WTPm) compared to the conventional one (WTPm ranges from €4.2 to €10 with mean WTPm being €5.51). Those not willing to buy the product pointed out doubts over the ingredients and its production methods (53%), the actual environmental benefits it may offer (16%), as well as perceived quality-reliability concerns (29%). Factors of [INNOV] and [ATTITOBIO] positively affect the WTP for breadsticks at the 1 and 10% significance level, respectively. This indicates that the higher the value in these two explanatory variables, the higher the level of WTP. In contrast, [PRODLAB] (i.e. the choice of product based on labeling-certification) is found to affect WTP in a negative way (beta $= -0.1$; p-value < 0.05).

Substudy 2 Findings: Bio-nylon Jacket

Most respondents (80%) indicated that they would be willing to pay for a jacket made from bio-nylon textiles (mean WTP: €116.55). Among those, 46% would be willing to buy the garment at a premium price (WTPm) compared to the conventional one (WTPm ranges from €125 to €280, with the mean WTPm being €155.38). Consumers not willing to pay for the bio-based jacket denoted scepticism over the materials-inputs used to produce the textile and the manufacturing methods (32%), uncertainties on the actual environmental benefits such product may have (22%) but, primarily, on the quality and durability of the bio-nylon garment. Regression results indicate that [ATTITOWBIO] and [PURCHINT] affect in a positive way the consumers' WTP for a bio-nylon jacket (beta $= 0.203$ and beta $= 0.190$, respectively). There is also a negative association between [ENVCONC] and WTP at the 5% significance level (beta $= -0.105$; p-value $= 0.01 < 0.05$). Those who answered "Not at all" and "A little" in the [INTINBIO] variable are less likely to exhibit a higher WTP compared to all the other categories at the 1% significance level (beta $= -0.848$; p-value $= 0.001 < 0.01$ and beta $= -0.644$; p-value $= 0.002 < 0.01$, respectively).

Substudy 3 Findings: Bioplastic Bottled Water

The absolute majority of the respondents in our study (95%) expressed their willingness to purchase the PHA-bioplastic bottled water textiles (mean WTP: €1.52). Among those, 72% would be willing to buy the product at a premium price (WTPm) compared

Table 3 Parameter estimates along with significance levels and corresponding confidence intervals for the finally selected covariates in all three models

	Breadsticks						Jacket						Bottled water					
Parameter	*B*	Std. error	*t*	*P*-value	95% confidence interval		*B*	Std. Error	*t*	*P*-value	95% confidence interval		*B*	Std. error	*t*	*P*-value	95% confidence interval	
					Lower bound	Upper bound					Lower bound	Upper bound					Lower bound	Upper bound
Intercept	−0.563	0.474	−1.188	n.s	−1.494	0.368	0.098	0.428	0.229	n.s	−0.742	0.938	−0.415	0.471	−0.880	n.s	−1.341	0.511
INTINBIO (Ref. category = very much)																		
[INTINBIO = Not at all]							−0.848	0.259	−3.275	0.001	−1.357	−0.339						
[INTINBIO = A little]							−0.644	0.204	−3.154	0.002	−1.045	−0.243						
[INTINBIO = Fairly enough]							−0.190	0.158	−1.203	n.s	−0.501	0.120						
[INTINBIO = Pretty much]							−0.088	0.094	−0.933	n.s	−0.273	0.097						
ALTR													−0.102	0.045	−2.280	0.023	−0.190	−0.014
INNOV	0.14	0.042	3.319	0.001	0.057	0.223							0.157	0.042	3.729	<0.001	0.074	0.239
PRODLAB	−0.100	0.044	−2.301	0.022	−0.186	−0.015												
ENVCONC							−0.105	0.041	−2.592	0.010	−0.185	−0.025						
ATTITOWBIO	0.18	0.054	3.297	0.001	0.073	0.287	0.203	0.049	4.128	<0.001	0.106	0.300	0.194	0.054	3.589	<0.001	0.088	0.301
TRUSTSCI																		
PURCHINT							0.190	0.062	3.072	0.002	0.069	0.311	0.172	0.068	2.530	0.012	0.039	0.306

to the conventional one (WTPm ranges from €1.05 to €2.5, with the mean WTPm being €2.04). Those not willing to pay for the specific bio-based product expressed doubts regarding the net benefits to the environment of such a product (67%), the bottle's material and manufacturing processes (63%), and the durability-reliability of the PHA biopolymer. Regression results suggest a positive and statistically significant association between WTP and [INNOV] (beta = 0.157; p-value < 0.01), [ATTITOBIO] (beta = 0.194; p-value < 0.01), and [PURCHINT] (beta = 0.172; p-value < 0.05). A negative association between WTP and [ALTR] is also identified, i.e., the higher the level of altruism describing the consumer, the lower the level of WTP for a bioplastic bottled water (beta = − 0.102; p-value = 0.023 < 0.05)—a finding that merits further investigation in future research.

Concluding Remarks

Research on consumer preferences for bio-based products and underlying determinants that shape purchase intentions for such products should be advanced on its own merit. In this respect, the recent wave of relevant studies [9–11, 18, and 49–51, among others] offer a great deal of fruitful insights of relatively less explored aspects of market demand of end products produced with bio-based processes and/or renewable biomass materials. Studies such as ours encapsulate implications in terms of bio-based products' future communication, advertising, and promotional/marketing strategies toward both the general public and the pertinent key stakeholders (i.e., wholesale distributors and retailers). Such findings can refine market segmentation, inform supply chain management as well as product design, and, ultimately, allow for the industry to realize new business opportunities within the scope of consumers' intentions and motivations to purchase bio-based products.

Despite the fact that the results reported here do not support all the expected associations, we believe that the statistically significant findings make a useful contribution to a better understanding of the extent to which consumer and product-specific characteristics may influence WTP for products of this emerging and growing market. Regarding demographic characteristics, the three substudies' results did not confirm the expected critical effect they may have in shaping WTP for the selected bio-based products. Still, our study points out that there is plenty of room for further investigation into the factors that affect certain purchasing decisions under the scope of bioeconomy-oriented transitions in Greece, which could be particularly helpful in future policy design, consumer education initiatives, and awareness-raising campaigns. While we focused on only three (types of) products and did not combine a spike model analysis, the preliminary data of the Greek context can be a starting point for regional- or prefecture-wide studies or country-level cross-country comparisons with a special focus on national settings of the Balkan and/or Mediterranean peninsula.

Re-examining scales/variables such as altruism, previous experience with bio-products, and how WTP(m) for bio-products is measured may allow us to further delineate causal relationships of such variables (along with psychological factors explaining them). In this sense, we may evaluate more comprehensively aspects describing the essence of consumer reactions toward bio-based products and further motivate business entities in employing targeted, product-specific, advertising campaigns to attract consumers' attention and effectively communicate the multidimensional benefits of bio-based products. Along with innovative techniques and approaches of waste valorization and sustainable separation of

natural products from waste biomass, consumer engagement and the increase of critical stakeholders' (social) awareness of such activities and relevant bio-based products should be a priority [12, 52] if we are to ensure the upscaling and growth patterns of bioeconomy in the post-COVID era [53]. Placing emphasis on how individuals assess the economic relevance of these products' attributes based on their previous (or the lack of) experience with eco-friendly products or services, we will certainly contribute to a better understanding of consumer decisions in the context of this growing market segment.

Author Contribution Antonis Skouloudis and Demetris-Francis Lekkas contributed to the study's conception and design. Data analysis was performed by Antonis Skouloudis and Chrysovalantis Malesios. Material preparation and data collection were performed by Altani Panagiotopoulou. The first draft of the manuscript was written by Antonis Skouloudis, Demetris-Francis Lekkas, and Chrysovalantis Malesios, who developed the original idea of the article and substantially engaged in the write-up of the first version of the manuscript.

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Data Availability The data supporting the results reported in this article are available by the authors upon reasonable request.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Conflict of Interest The authors declare no competing interests.

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