

# *Do consumers value food products containing upcycled ingredients? The effect of nutritional and environmental information*

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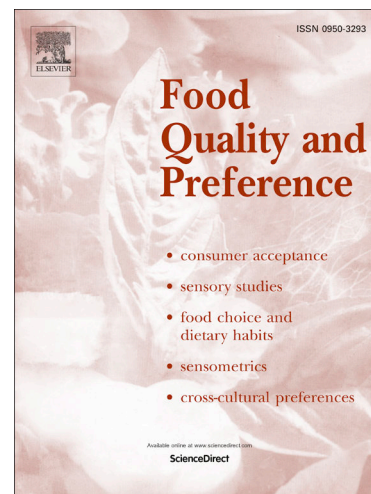
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# Do Consumers Value Food Products Containing Upcycled Ingredients? The Effect of Nutritional and Environmental Information

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## ABSTRACT

This study was the first to use a ranking experiment to estimate the effect of nutritional and environmental information on UK consumers' willingness to pay (WTP) for biscuits containing an upcycled ingredient, namely, defatted sunflower cake flour. Informing consumers about the nutritional and/or environmental benefits of the upcycled ingredient resulted in a significant increase in their WTP for this new food. Moreover, we found that nutritional and/or environmental information similarly affected individual WTP distributions for the upcycled ingredient towards more positive values. Our findings have important implications for product development and marketing strategies of upcycled food businesses.

**Keywords:** Biscuits; Environmental information; Nutritional information; United Kingdom; Upcycled ingredients; Willingness to pay.

## 1. INTRODUCTION

About one-third, or 1.3 billion tons, of the total food produced for human consumption is lost or wasted globally every year (FAO, 2015). Food loss, that is, loss of food at the production, post-harvest, and processing stages, can be reduced in various ways. One way is to upcycle food by-products into valuable ingredients that can be used in the development of novel foods (i.e., upcycled foods) rather than used as feed or sources of energy (Spratt et al., 2020). Upcycled foods can provide several environmental (Augustin et al., 2020) and nutritional benefits, as food industry by-products are rich in valuable compounds, such as proteins, fibres, etc. (Trigo et al., 2020). An example is sunflower seed oilcake, a by-product of sunflower oil production, which contains high levels of proteins, fibres, vitamins, and minerals. It can be treated to become a food-grade high-protein flour that can be used in bakery and meat products in which it has already been tested successfully (Grasso et al., 2020).

However, several financial, policy, and communication issues must be resolved if upcycled foods are to become mainstream products. First, for financial reasons, the food industry is reluctant to invest in circular initiatives, as wasting by-products is in many cases economically more advantageous than saving them (May & Guenther, 2020). Second, a common definition of upcycled foods was until very recently lacking, which created uncertainty (Spratt et al., 2020). Third, there is a lack of market data, consumer studies, and specific labelling regulations regarding upcycled foods. Indeed, very few studies have investigated consumers' preferences for upcycled foods (see Grasso & Asioli, 2020 for a short review). Little research has been conducted to better understand how to position upcycled foods in the market and how to communicate their benefits to consumers (McCarthy et al., 2020). Recently, Zhang et al. (2020) found that consumers have high intentions to purchase upcycled foods and that as the perceived quality of these foods decrease also consumers' intention to purchase also decrease. They also found that Gen X shows lower intentions to purchase upcycled foods compared to Gen Z, Gen Y, and Baby Boomers because of the perceived lower quality. Zhang et al. (2020) also suggest that to increase consumers' willingness to buy for upcycled

50 foods it is necessary to assure consumers about the quality and benefits of such foods. A positive  
 51 quality perception can be created by providing messages that highlight the quality of upcycled foods  
 52 (Zhang et al. 2020) by using intrinsic and extrinsic cues around these new products that drive  
 53 consumers' acceptance and that can be leveraged by marketers. Indeed, recent research demonstrates  
 54 that consumers' acceptance of upcycled foods can be shaped by appropriately communicating the  
 55 value of consuming these new foods (Bhatt et al., 2020). Furthermore, consumers' willingness to pay  
 56 (WTP) studies for upcycled foods show important results. Grasso and Asioli (2020) showed that  
 57 without providing information on benefits consumers reject upcycled biscuits. Köpcke (2020) found  
 58 that by informing consumers that upcycled foods can reduce food loss they are willing to pay the  
 59 same or a premium price compared to conventional foods while Bhatt et al. (2020) found that rational  
 60 messaging is more effective than emotional messaging in increasing consumers' WTP for upcycled  
 61 foods. However, it remains unknown whether other rational messages around nutritional or other  
 62 environmental benefits might be more persuasive and could be successfully communicated to  
 63 consumers.

64  
 65 This study aimed to fill this by conducting a hypothetical ranking experiment (RE) to estimate the  
 66 effect of nutritional and/or environmental information on UK consumers' WTP for biscuits  
 67 containing upcycled defatted sunflower oilcake flour (hereafter "upcycled biscuits"). Nutritional  
 68 (higher protein content) and environmental (lower carbon footprint) messages were chosen as  
 69 intrinsic and extrinsic cues, respectively, as they were considered the most likely to raise consumers'  
 70 WTP. An increased emphasis on nutrition and environmental information has been shown to drive  
 71 consumers' food purchases as Banovic et al. (2018) for nutritional information related to protein  
 72 content in foods and Asioli et al. (2020) for environmental information related to food production  
 73 demonstrate. Furthermore, nutritional, and environmental information are two different types of  
 74 rational messages that can have different effects on consumers' acceptance of new foods. For  
 75 example, Annett et al. (2008) found that health information had an impact on consumers' preferences  
 76 for organic bread, whereas environmental information about organic production did not.

## 77 78 **2. MATERIALS AND METHODS**

### 79 **2.1 Experimental design**

80 To test our research hypotheses, we implemented a between-subjects design based on four RE  
 81 treatments. The four treatments differed only in the kind of information provided prior to starting the  
 82 series of choice tasks. Each participant was randomly assigned to only one of the RE treatments. In  
 83 treatment 1, called "no information (NOINFO)", 106 participants were not provided with information  
 84 on upcycled biscuits' benefits. In treatment 2, called "nutritional information (NUTINFO)", 108  
 85 respondents were provided with nutritional information stating that the upcycled ingredient increased  
 86 the biscuits' protein content. In treatment 3, called "environmental information (ENVINFO)", 108  
 87 respondents were provided with environmental information stating that the upcycled ingredient  
 88 reduced the biscuits' carbon footprint. Finally, in treatment 4, called "nutritional and environmental  
 89 information (NUENINFO)", 108 participants were provided with both nutritional and environmental  
 90 information.

91 With these RE treatments, we constructed a series of hypotheses to examine whether the  
 92 information about the benefits of the upcycled ingredient would affect respondents' WTP for the  
 93 biscuits. To determine the effect of the different types of information, we compared the estimates  
 94 from the four treatments. Specifically, we performed the following six comparisons:

- 95 • Treatment 1 (NOINFO) vs treatment 2 (NUTINFO). The hypotheses to test whether nutritional  
 96 information would affect respondents' WTP were as follows:

$$97 H_{01}: WTP^{NUTINFO} - WTP^{NOINFO} \leq 0$$

$$98 H_{11}: WTP^{NUTINFO} - WTP^{NOINFO} > 0$$

99 A rejection of the null hypothesis ( $H_{01}$ ) would indicate that nutritional information was more  
100 effective than no information.

- 101 • Treatment 1 (NOINFO) vs treatment 3 (ENVINFO). The hypotheses to test whether  
102 environmental information would affect respondents' WTP were as follows:

$$103 H_{02}: WTP^{ENVINFO} - WTP^{NOINFO} \leq 0$$

$$104 H_{12}: WTP^{ENVINFO} - WTP^{NOINFO} > 0$$

105 A rejection of the null hypothesis ( $H_{02}$ ) would indicate that environmental information was more  
106 effective than no information.

- 107 • Treatment 1 (NOINFO) vs treatment 4 (NUENINFO). The hypotheses to test whether both  
108 nutritional and environmental information would affect respondents' WTP were as follows:

$$109 H_{03}: WTP^{NUENINFO} - WTP^{NOINFO} \leq 0$$

$$110 H_{13}: WTP^{NUENINFO} - WTP^{NOINFO} > 0$$

111 A rejection of the null hypothesis ( $H_{03}$ ) would indicate that both nutritional and environmental  
112 information was more effective than no information.

- 113 • Treatment 2 (NUTINFO) vs treatment 3 (ENVINFO). The hypotheses to test whether  
114 environmental information would be more effective than nutritional information was as follows:

$$115 H_{04}: WTP^{ENVINFO} - WTP^{NUTINFO} \leq 0$$

$$116 H_{14}: WTP^{ENVINFO} - WTP^{NUTINFO} > 0$$

117 A rejection of the null hypothesis ( $H_{04}$ ) would indicate that environmental information was more  
118 effective than nutritional information.

- 119 • Treatment 2 (NUTINFO) vs treatment 4 (NUENINFO). The hypotheses to test whether a  
120 combination of nutritional and environmental information would be more effective than  
121 nutritional information only was as follows:

$$122 H_{05}: WTP^{NUENINFO} - WTP^{NUTINFO} \leq 0$$

$$123 H_{15}: WTP^{NUENINFO} - WTP^{NUTINFO} > 0$$

124 A rejection of the null hypothesis ( $H_{05}$ ) would indicate that a combination of nutritional and  
125 environmental information was more effective than nutritional information only.

- 126 • Treatment 3 (ENVINFO) vs treatment 4 (NUENINFO). The hypotheses to test whether a  
127 combination of nutritional and environmental information would be more effective than  
128 environmental information only was as follows:

$$129 H_{06}: WTP^{NUENINFO} - WTP^{ENVINFO} \leq 0$$

$$130 H_{16}: WTP^{NUENINFO} - WTP^{ENVINFO} > 0$$

131 A rejection of the null hypothesis ( $H_{06}$ ) would indicate that a combination of nutritional and  
132 environmental information was more effective than environmental information only.

133  
134 In the RE, we included four attributes with two levels each to describe the different types of  
135 biscuits: "flour", "protein", "carbon", and "price" (for more details, see Grasso & Asioli, 2020). Two  
136 price levels were specified to approximately reflect the lower and upper market prices (£0.40/300 g  
137 and £1.50/300 g, respectively) of a typical 300-g pack of biscuits sold in UK stores.

138  
139 To ease the participants' cognitive burden, the ranking was conducted as a series of choices over  
140 seven screens (for more details, see Grasso & Asioli, 2020). A pre-test involving fifty participants  
141 was performed to calibrate the minimum time needed by them to complete the questionnaire and to  
142 test whether the survey flow (i.e., skip logic) and questions were appropriate to ensure good data  
143 quality.

144  
145 A description of the entire experiment, including information on participant recruitment,  
146 experimental design, and attributes and levels, is provided in Grasso and Asioli (2020).

147

148 **2.2 Data**

149 The randomization of consumers to the four treatments aimed to achieve a balance of observable  
 150 characteristics across the treatments. Indeed, the results showed that the hypothesis of equality of  
 151 means of sociodemographic characteristics across treatments was not rejected at a 5% significance  
 152 level (results not shown). Hence, the random assignment of respondents to the treatments provided  
 153 a balanced sample in terms of sociodemographic characteristics across the four treatments.

154

155

156 **3. ECONOMETRIC ANALYSIS**

157 To test our hypotheses, we used discrete choice models (DCMs) typically applied to analyse  
 158 ranking and choice data (Hensher et al., 2015). We followed the approach used by Øvrum et al.  
 159 (2012) which assumes that ranking options are formally equivalent to being able to choose the most  
 160 preferred option from a set of options, then the second-best, third best and so on, until the least  
 161 preferred option is identified. Thus, for each consumer the ranking data of eight biscuits is converted  
 162 into a series of seven choice sets of reduced size of options (biscuits) such as eight, seven, six, five,  
 163 four, three, and two biscuits, respectively in each choice set. The first-choice set includes all eight  
 164 biscuits, and the participant chooses the biscuit that he or she ranked highest in the experiment. The  
 165 second-choice set includes all eight biscuits minus his or her highest ranked biscuit, and so on until  
 166 the seven-choice sets. Data can be analysed using the rank-ordered mixed logit (ROML) or the  
 167 standard mixed logit (ML) models and we obtained similar results. To test the differences in WTP  
 168 between the four treatments involved in our hypotheses using the estimated coefficients, we  
 169 calculated the marginal WTP (mWTP) in preference space using mixed logit (ML) models (for more  
 170 details, see Grasso & Asioli, 2020) across the four treatments as a ratio of the partial derivative of  
 171 the utility function with respect to the design attribute of interest and then divided it by the partial  
 172 derivative of the utility function with respect to the price variable. The WTP of each attribute level  
 173 was obtained using Krinsky and Robb's (1986) bootstrapping method, resulting in a distribution of  
 174 1,000 WTP values for each attribute. These WTP estimates were then used to test our hypotheses  
 175 using the computational method proposed by Poe et al. (2005). The Poe et al.'s test was performed  
 176 using the STATA 16.0 module *poetest* to obtain the significance levels.

177 Next, we investigated consumers' heterogeneity by calculating the distribution of the individual-  
 178 level coefficients (i.e. mWTP) for flour, protein, and carbon using the kernel density estimation  
 179 across individuals with the *kdensity* command in STATA 16.0.

180

181 **4. RESULTS**182 **3.1. WTP estimates: Effect of nutritional and environmental information**

183 The WTP preference space estimation results for the four treatments obtained by the ML models  
 184 are shown in Table 1. Specifically, the estimated WTP for flour, protein, and carbon and the  
 185 corresponding confidence intervals (95% confidence intervals) are reported. On average, respondents  
 186 were willing to pay higher prices for biscuits that were branded as a "source of protein" and labelled  
 187 with the "Carbon Trust label". Upcycled sunflower flour was preferred over conventional wheat flour  
 188 only if information on the nutritional and/or environmental benefits of upcycled biscuits had been  
 189 provided.

190

191 **Table 1 - WTP in preference space for the four treatments estimated using the mixed logit**  
 192 **models.**

Attribute	NOINFO (N = 106)		NUTINFO (N = 108)		ENVINFO (N = 108)		NUENVINFO (N = 108)	
	WTP	95% CI	WTP	95% CI	WTP	95% CI	WTP	95% CI

	(£/300 g)	(£/300 g)	(£/300 g)	(£/300 g)	(£/300 g)	(£/300 g)	(£/300 g)	(£/300 g)
Flour	-0.28	-0.44, -0.11	0.16	0.02, 0.29	0.09	-0.16, 0.33	0.25	0.12, 0.39
Protein	0.34	0.20, 0.48	0.29	0.19, 0.39	0.27	0.13, 0.41	0.28	0.19, 0.37
Carbon	0.60	0.44, 0.77	0.38	0.25, 0.51	0.47	0.31, 0.63	0.44	0.34, 0.53

Note. WTP: willingness to pay.

Note. CI: confidence interval.

Note. The dataset used for the calculation of the WTPs in the NOINFO treatment is the same used in Grasso & Asioli (2020).

Table 2 reports the participants' WTP for each treatment for flour, protein, and carbon and the corresponding significance levels ( $p$ -values) calculated by the Poe test. Since the main aim of this research was to test the effect of information on consumers' WTP for flour, only the results related to flour are described here. The first null hypothesis ( $H_{01}$ :  $WTP^{NUTINFO} - WTP^{NOINFO} \leq 0$ ) was rejected; thus, the alternative hypothesis was accepted: the WTP will be higher when consumers are provided with information about nutritional benefits compared to when such information is not provided. The second null hypothesis ( $H_{02}$ :  $WTP^{ENVINFO} - WTP^{NOINFO} \leq 0$ ) was also rejected, and the alternative hypothesis was accepted: the WTP will be higher when consumers are provided with information about environmental benefits compared to when such information is not provided. The third null hypothesis ( $H_{03}$ :  $WTP^{NUENINFO} - WTP^{NOINFO} \leq 0$ ) was also rejected, and therefore the alternative hypothesis was accepted: the WTP will be higher when consumers are provided with information about both nutritional and environmental benefits compared to when such information is not provided. The fourth null hypothesis ( $H_{04}$ :  $WTP^{ENVINFO} - WTP^{NUTINFO} \leq 0$ ) was accepted, and thus the alternative hypothesis was rejected: WTP will not be higher when consumers are provided with information about environmental benefits compared to when they were provided with nutritional information. The fifth null hypothesis ( $H_{05}$ :  $WTP^{NUENINFO} - WTP^{NUTINFO} \leq 0$ ) was also accepted, and the alternative hypothesis was rejected: WTP will not be higher when consumers are provided with information about both nutritional and environmental benefits compared to when they were provided with nutritional information only. Finally, the sixth null hypothesis ( $H_{06}$ :  $WTP^{NUENINFO} - WTP^{ENVINFO} \leq 0$ ) was also accepted, and therefore the alternative hypothesis was rejected: the WTP will not be higher when consumers are provided with information about both nutritional and environmental benefits compared to when they were provided with environmental information only.

**Table 2 - Marginal WTP (£/300 g) across four treatments and hypothesis tests.**

Hypothesis test (Poe test)	FLOUR		PROTEIN		CARBON	
	WTP: £/300 g	$p$ -value	WTP: £/300 g	$p$ -value	WTP: £/300 g	$p$ -value
$H_{01}$ : $WTP^{NUTINFO} - WTP^{NOINFO} \leq 0$						
$WTP^{NUTINFO}$	0.16		0.29		0.38	
$WTP^{NOINFO}$	-0.28	0.00	0.34	0.71	0.60	0.99
$H_{02}$ : $WTP^{ENVINFO} - WTP^{NOINFO} \leq 0$						
$WTP^{ENVINFO}$	0.09	0.01	0.27		0.47	
$WTP^{NOINFO}$	-0.28		0.34	0.74	0.60	0.88
$H_{03}$ : $WTP^{NUENINFO} - WTP^{NOINFO} \leq 0$						
$WTP^{NUENINFO}$	0.25	0.00	0.28		0.44	
$WTP^{NOINFO}$	-0.28		0.34	0.75	0.60	0.97
$H_{04}$ : $WTP^{ENVINFO} - WTP^{NUTINFO} \leq 0$						
$WTP^{ENVINFO}$	0.09	0.68	0.27		0.47	
$WTP^{NUTINFO}$	0.16		0.29	0.56	0.38	0.19
$H_{05}$ : $WTP^{NUENINFO} - WTP^{NUTINFO} \leq 0$						
$WTP^{NUENINFO}$	0.25	0.18	0.28		0.44	
$WTP^{NUTINFO}$	0.16		0.29	0.54	0.38	0.25
$H_{06}$ : $WTP^{NUENINFO} - WTP^{ENVINFO} \leq 0$						
$WTP^{NUENINFO}$	0.25	0.15	0.28		0.44	
$WTP^{ENVINFO}$	0.09		0.27	0.45	0.47	0.65



223 *Note.* WTP: willingness to pay.

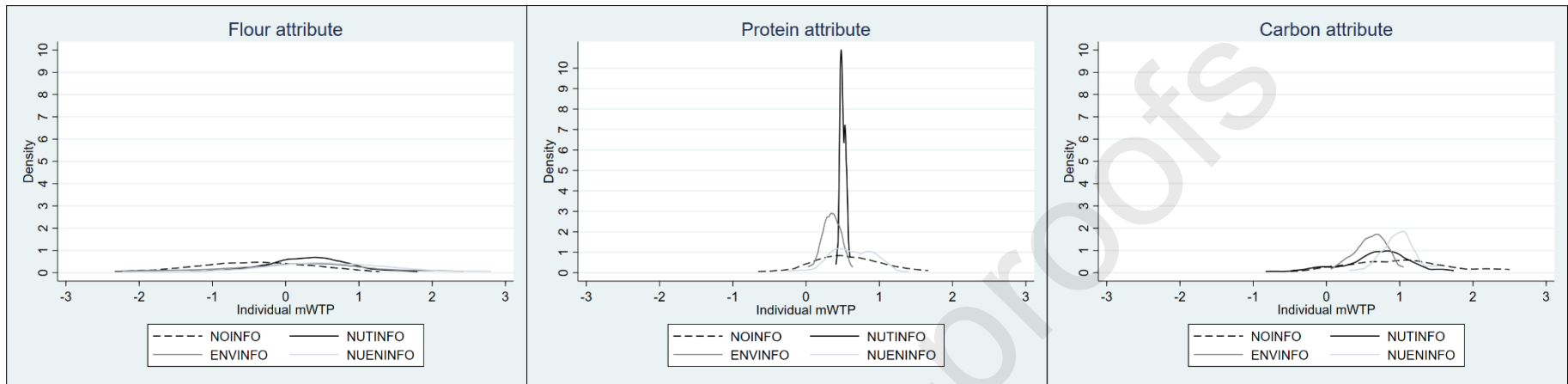
224 *Note.* The dataset used for the calculation of the  $WTP^{NOINFO}$  is the same used in Grasso & Asioli (2020).

225

226

### 227 **3.2. WTP estimates: Distribution of individual mWTP values**

228 Fig. 1 presents the distributions of mWTP values across individuals (kernel density estimates) for  
229 the attributes flour, protein, and carbon across the different information treatments. Not only did the  
230 mean values for each mWTP differ, but some mWTP distributions were considerably more diffuse  
231 (i.e., heterogeneous) than others. Specifically, the probability density functions for flour were  
232 similarly and heterogeneously distributed across the treatments, but the mWTP tended to move  
233 towards more positive values when nutritional and/or environmental information was provided.  
234 Furthermore, there were important differences in the distributions of the mWTP for the attributes  
235 protein and carbon when comparing NUTINFO, ENVINFO and NUENINFO with NOINFO. Indeed,  
236 for the protein attribute when nutritional or environmental information was provided separately  
237 consumers valued more similarly (i.e., homogeneously) this information (similar mWTP) thus one  
238 homogenous consumer segment could be identified. Differently, for protein when both nutritional  
239 and environmental information was provided together consumers valued this information more  
240 dissimilarly (i.e., heterogeneously) thus two or more consumer segments could be identified.  
241 Furthermore, for the carbon attribute when both nutritional and environmental information or  
242 environmental information only was provided consumers valued more similarly this information,  
243 thus one homogenous consumer segment could be identified while when nutritional information only  
244 was provided consumers valued this information more dissimilarly (i.e., heterogeneously), thus two  
245 or more consumer segments could be identified.



246  
247  
248

**Fig. 1 - Comparison of the distributions of individual mWTP for the attributes: flour, protein, and carbon across the NOINFO treatment and each information treatment (NUTINFO, ENVINFO, and NUENINFO).**

## 249 5. DISCUSSION AND CONCLUSIONS

250 This study investigated UK consumers' WTP for hypothetical upcycled biscuits by exploring the  
251 effect of nutritional and/or environmental information about the benefits of upcycled ingredients.  
252 Three main results were obtained. First, when nutritional and/or environmental information about  
253 the benefits of the upcycled biscuits was provided, participants' were willing to pay a premium price  
254 compared to when such information was not provided. This finding is consistent with those of Bhatt  
255 et al. (2020), and Cattaneo et al. (2019). Similarly to our environmental treatment, our results are  
256 corroborated by Köpcke (2020) who found that consumers are willing to pay the same or a premium  
257 price if they are informed that upcycled foods can reduce food loss. Moreover, as suggested by Zhang  
258 et al. (2020), we found that by informing consumers about the benefits (i.e. nutritional and  
259 environmental) of upcycled foods increases consumers' WTP for these foods. Second, the effect of  
260 providing environmental information was comparable to that of providing nutritional or both  
261 nutritional and environmental information. We speculate that although nutrition is more important  
262 than environmental concerns in driving food choices (Lusk & Briggeman, 2009), consumers may  
263 associate upcycled foods more with the environmental benefits of reducing food loss and waste than  
264 with nutritional benefits. This may have counterbalanced the hypothetical stronger effect of  
265 nutritional information on respondents' WTP. Third, we found that for flour the nutritional and/or  
266 environmental information similarly affected individual mWTP distribution across the treatments  
267 towards more positive WTP values, while for protein and carbon, the mWTP distributions differ  
268 depending on the type of information provided. This might eventually suggest that mWTP formation  
269 for flour, protein and carbon were differently affected by the kind of information provided indicating  
270 the existence of different consumers' segments that can be leveraged by different marketing  
271 strategies.

272  
273 These findings have important implications for upcycled food businesses. Marketing campaigns  
274 that emphasize the nutritional and/or environmental benefits of these new foods can increase  
275 consumers' acceptance. Moreover, upcycled food businesses could use our findings regarding the  
276 mWTP to compare it with the production cost and suggest optimal prices of sales of upcycled foods  
277 to their clients (i.e. supermarkets). For policy makers, it seems important to work towards providing  
278 more information to broaden and deepen consumers' understanding of upcycled foods and increase  
279 their familiarity with them. Educating consumers might increase the demand for upcycled foods,  
280 which in turn might make producers more willing to produce such products.

281  
282 Further research is needed to test the robustness of our findings and explore the market potential  
283 of upcycled foods. Similar studies should be conducted in other countries, conduct cross-country  
284 comparisons, and with other upcycled foods. Moreover, future studies could investigate consumers'  
285 WTP by conducting non-hypothetical experiments in real market contexts (e.g., shops) using  
286 auctions combined with sensory evaluations of upcycled foods to obtain more comprehensive and  
287 realistic results.

288  
289 In conclusion, our findings show that consumers' WTP premium prices for upcycled foods  
290 depends on the provided information about the nutritional and/or environmental benefits of these  
291 new foods. Our results provide insights into consumers' acceptance psychology that can be useful  
292 for effectively communicating the benefits of upcycled foods to the public to maximize the chances  
293 of making them commercially viable.

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298

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302

303 **TRANSPARENT REPORTING**

304 Pre-registration of the study is available at <https://aspredicted.org/blind.php?x=z7cy6b>.

305

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### CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

358

359 **Daniele Asioli:** Methodology, Formal analysis, Software, Validation, Writing - original draft,  
360 Writing - review & editing. **Simona Grasso:** Conceptualization, Investigation, Funding acquisition,  
361 Project administration, Writing - original draft, Writing - review & editing.

362

363 **Declaration of interests**

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365

366  The authors declare that they have no known competing financial interests or personal  
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369  The authors declare the following financial interests/personal relationships which may be considered as  
370 potential competing interests:

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377 **HIGHLIGHTS**

378 • 430 UK consumers chose biscuits containing a conventional or an upcycled ingredient.

379 • Nutritional and environmental information of the upcycled ingredient were provided to  
380 consumers.

381 • Nutritional and environmental information similarly increased consumers' WTP.

382 • Implications for upcycled food businesses and policy makers were provided.

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