Consumer acceptance and willingness-to-pay for insect-based foods: The role of proximity of insects in the food chain

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Consumer acceptance and willingness-to-pay for insect-based foods: The role of proximity of insects in the food chain*

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Abstract: Over the last few years, the interest on alternative protein sources, such as edible insects, has been growing rapidly. However, Western consumers' acceptance of insects as a food source is very low, mainly due to unfamiliarity with insect-based food. We investigate consumers' attitude and behavior and estimate their willingness to pay (WTP) a premium for three products that vary on a between-subjects basis, the proximity of insects in the food chain. The data were collected through an online questionnaire of 451 consumers in Greece and WTP was elicited using the Contingent Valuation (CV) method. Our results show that the majority of Greek consumers are not willing to pay a premium for an insect-based energy bar and cookie; on the contrary, they would require a discount to acquire such products. On the other hand, consumer acceptance is higher for a gilt-head bream that is fed with insect-based feed. Consumers with positive WTP are on average willing to pay a premium of 15.8%, 17% and 31.8% for the energy bar, cookie and gilt-head bream, respectively, while consumers that are not WTP a premium would require discounts of 43.8%, 42.4% and 30.7%, respectively.

Keywords: Consumer acceptance, willingness-to-pay, contingent valuation, cheap talk, insect-based products, insect-based feed

JEL codes: C90, D12, Q13

*Data and codes to replicate the analysis have been deposited at the Open Science Framework: https://osf.io/zd6et/?view_only=468779d181934bbeab5837b57681ab38

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1 Introduction

The global increase in demand for meat, coupled with finite inputs for production, has led to a larger intensification in exploration of alternative protein sources (Van Huis, 2016). Consequently, over the last few years, insect-based food products have drawn a lot of attention in both developed and developing countries (Imathiu, 2020). The use of insects as food is widespread in developing countries and it is generally part of the diet of at least two billion people, mostly located in tropical countries. It is estimated that around 1900 species of edible insects are consumed by humans of more than three thousand ethnic groups (Van Huis, 2013; Van Huis et al., 2013), and these foods are consumed in 130 countries with the African, Asians and American continents being the most entomophagous (Gahukar, 2011; Ramos-Elorduy, 2009; Van Huis et al., 2013). People in many parts of those countries consume whole insects in a perfectly recognizable form, either as snacks or as part of their daily diet (Melgar-Lalanne et al., 2019).

However, in most Western countries, the interest in consumption of food based on edible insects as a substitute of meat, remains very low (Hartmann and Siegrist, 2016; House, 2016). The main reason of the low acceptability is, not surprisingly, the feeling of disgust that insects cause to people that are not familiar to insects as part of the human diet (Rozin and Fallon, 1987). Furthermore, there is lack of information on the safety of these products and lack of a clear legal framework and regulations that would allow insects to be useful as primary food source or as input as feed (Halloran et al., 2014). Consumers are also averted to insects as a food source because of the knowledge of the origin and habits of the insects, as well as of the potential perceived negative effects that might have for their health (Rozin and Fallon, 1980).

Despite their low acceptability, foods based on edible insects are an excellent alternative source of protein for humans. In fact, due to the continuous increase of the world population and their nutritional needs, research for innovative food products that are rich in nutrients is expected to intensify. Consumption of foods based on insects can be particularly beneficial because of the high nutritional value that insect-based food has. More specifically, eating foods based on edible insects can constitute important source of vitamins, minerals and especially proteins, contributing significantly in solving food scarcity problems of developing countries, while also being an important complementary food source in developed countries (Caparros Megido et al., 2014; RamosElorduy, 1997).

The environmental impact that mass breeding of insects has in relation to traditional livestock like pork, cows and chicken (Oonincx et al., 2015), is an additional benefit of food based on insects. Farmed insects require small areas to grow and have low water and feed needs (Rumpold and Schlüter, 2013). Furthermore, an important advantage of insects is that they can also be used as a raw material for feed production for farmed fish. The general increase in the demand for aquaculture products is pushing for the development of insect based proteins that can be used as input in aquaculture (Van Huis et al., 2013). For example, Iaconisi et al. (2017) demonstrate that mealworm larvae meal is a promising alternative that can be used as a protein source for the partial replacement of meals in the diet of the blackspot sea bream. Insects can replace a significant percent of the expensive forms of proteins, which are currently used in feed production and on fish farming (Halloran et al., 2014). It is also worth mentioning that according to Piccolo et al. (2017), mealworm larvae meal can replace fish meal up to 25% of inclusion in the diet for gilthead sea bream without negative effects on weight gain, crude protein and ether extract digestibility. In Uganda, roughly 5% of the farmers use termites for feeding fish and the quantity of produced termites depends largely on the number and size of termite hills on the farm as well as on the termite species (Van Huis et al., 2013). In this way, significant quantities of raw materials which are used in the production of animal feed can be diverted to human consumption. Using insects as a cheap source of protein, can lower production costs of breeders without deteriorating the diet quality of the animals while at the same time an important source of protein is added in the diet of farmed fish (Halloran et al., 2014).

Given the importance of insect-based proteins in foods and feed production, we explore the factors that potentially affect consumer acceptance and willingness to pay (WTP) for farmed insects. Because consumer acceptance for farmed insects might differ with proximity of insects in the food chain, we elicit valuations for different products by randomly assigning respondents to one of two treatments. For roughly half of the respondents, we elicit valuations for insect-based food, that is, food in which insect proteins have been directly integrated in the product. For the other half of the respondents, we elicit valuations for farmed fish that have been fed with insect-based feed. As far as we are aware of, there is a lack of studies that assess differences in valuations for food products related to the proximity of farmed insects in the food chain.

The products we use are an energy bar with insect protein and a biscuit with insect flour for the treatment where the proximity of farmed insects with food is short; and a farmed gilthead (sea) bream that has been fed with insect-based feed for the treatment that the proximity of farmed insects with food is long. In the next section we review the relevant literature in order to set the context of our study. In section 3 we present our data collection and value elicitation methods. We then present our results in Section 4 and conclude with a discussion and implications of our findings in the last section.

2 Literature Review

Despite the growing interest for insect-based food and the gradual popularity that insect-based products are gaining, there are still important challenges that insect-based products need to overcome in order to gain a wider acceptance in Western countries. For EU countries in particular, after the approval by the European Commission of the new Regulation on Novel Food (Regulation (EU) No 2015/2283), insect based products were gradually made available in some countries after January 2018 (e.g. in the Netherlands, Belgium, Germany). However, in many other countries (e.g. in Greece, Cyprus, Hungary,) insect based products are still not available likely due to limited consumer acceptability.

Consumer acceptance is a key factor of wider availability of insect-based products in Western markets. Due to the high interest for such products, the literature on consumer acceptance of insect-based products is expanding. Several studies have evaluated consumer acceptance of insect-based products in different parts of the world.

Lensvelt and Steenbekkers (2014) report that approximately 35% of Dutch and Australians consumers, that took part in their online survey had tasted insect-based products before. Furthermore, in their choice experiment in Australia at the same time period, they report that approximately 34.50% of the participants had tasted insect-based food before. Van Thielen et al. (2018) report a lower rate for Belgian consumers: just 11.20% of Belgian consumers had already tasted foods with processed insects. This is in contrast to Caparros Megido et al. (2016) that report that 33% of Belgium participants had tasted insect-based products before.

A few other studies have explored the factors that may determine acceptance for insect-based products. Curiosity has been shown to be one of the most important reasons for a consumer to try insect-based products (Sogari et al., 2017; Van Thielen et al., 2018). However, trying once a product may not be enough to retain a consumer in the long run, since consumers may not be willing to repeatedly consume insect-based food if it is not regarded to be tasty or appropriate for consumption (Tan et al., 2016). As Rozin and Fallon (1987) point out, disgust plays an important role in food rejection. This result is in line with Sogari et al. (2017), where 25% of their sample in Parma in Italy stated that they would not taste edible insects because they perceive insects as disgusting.

Kornher et al. (2019) suggest that apart from the taste factor, consumers who are concerned about environmental and nutrition issues have more chances of trying foods with processed insects. The importance of environmental and nutrition issues in insect-based food consumption is also supported by other studies (Menozzi et al., 2017; Van Thielen et al., 2018), although skeptics doubt whether environmental and nutrition benefits of consuming insects as a source of food, is likely to make consumers adopt insect-based products in their diet (Laureati et al., 2016; Wilkinson et al., 2018).

In addition, willingness to taste insect-based products and acceptability of these products is affected by appearance and food neophobia (Caparros Megido et al., 2014; Wilkinson et al., 2018). Prior consumption of insect-based food and information have been shown to affect consumer acceptance of food containing processed insects by reducing the feeling of disgust (Barsics et al., 2017) and taste exposure seems to increase the acceptance for these products

(Sogari et al., 2018). In one study, the acceptability ratings of Italian consumers after they had received the information about the benefits of consuming insects, significantly increased (Laureati et al., 2016). Moreover, the level of sensory-liking of a mealworm burger among Dutch consumers increased to a similar level as that of the beef burger after tasting, whereas prior to tasting, the mealworm burger was rated significantly less positively than the beef burger (Tan et al., 2016). Schouteten et al. (2016) compared three burgers (insect-based, plant-based and meat-based) and reported that the overall acceptance for insect based-burger was significantly higher than before and the perceived nutritiousness of the insect-based burger was significantly more highly evaluated than the meat-based burger, during an informed condition for a sample of Belgian young adults. These studies indicate the importance of prior consumption, taste exposure and information provided on consumer acceptance of insect-based products. However, Alemu and Olsen (2020) find that peer effects (i.e., observation of peers reacting negatively in terms of disliking an insect-based product) may counter any positive effects from tasting insect-based food products.

As far as demographics is concerned, several studies find that males are more likely to adopt insects as a novel and more sustainable protein source in Western societies than females (Menozzi et al., 2017; Tan et al., 2016; Verbeke, 2015; Wilkinson et al., 2018). In addition, young consumers appear to be more receptive to the idea of insects as food than older ones (Castro and Chambers, 2019).

3 Data Collection Methods and Experimental Design

To evaluate consumers' attitudes and behavior towards insect-based foods, we designed and distributed a web questionnaire in April 2020. The choice of a web questionnaire vis-à-vis face-to-face interviews was dictated by the coronavirus pandemic.

The questionnaire was first pilot tested in a small convenience sample and adjustments for understanding and better flow were made based on feedback received. The link to the questionnaire was distributed in social media as well as directly emailed to a list of subjects from the general population that had previously participated in laboratory experiments at the Laboratory of Behavioral and Experimental Economics Science (LaBEES-Athens) of the Agricultural University of Athens.

The final sample consisted of 451 consumers (52.11% female) and the only criteria that participants had to meet was being over 18 years old. Subjects were randomly allocated to one of the two versions of the questionnaire. The only difference between the two versions was about the valuation questions. In one version subjects were asked about their WTP for products that were based on insects while in the other version, we elicited WTP for a farmed gilt-head (sea) bream that has been fed with insect-based feed. By eliciting valuations for these different products we vary the proximity of insects to human consumption.

Moreover, before eliciting WTP, subjects' were provided with information about edible insects as well as information about nutritional and environmental benefits that may result from insect-based food consumption. Additional questions tried to assess various factors such as whether subjects are knowledgeable about the existence of insect-based products, the importance consumers attach to the nutritional value and the environment footprint of their food choices, their desire to try innovative food products, the importance of safety certifications and confidence in innovative products etc. Standard demographic characteristics were also elicited.

3.1 Value elicitation

To elicit valuations, we employed the Contingent Valuation Method (CVM). The CVM is the main workhorse when it comes to measuring WTP values for public and private goods, services, or amenities. Most CVM studies are conducted in hypothetical contexts, particularly in environmental valuation studies where a real market with salient payments is difficult to establish (Carson, 2012; Carson and Hanemann, 2005; Haab et al., 2013; Kling et al., 2012).

The favored elicitation format in the CVM literature has been the dichotomous choice (DC) format because of its well known property of incentive compatibility.[1] Although alternative elicitation methods are hypothesized to give rise to strategic and untruthful responses, researchers often use alternative elicitation formats driven by efficiency gains (e.g., lower sample size requirement), reduced complications associated with experimental design (e.g., bid design) and the possibility to increase the power of the experimental design (e.g., by asking about multiple goods in the same survey and/or by eliciting more precise information on preferences) (Johnston et al., 2017; Vossler and Holladay, 2018). Vossler and Holladay (2018) identify assumptions under which open-ended and payment card formats are incentive compatible and find that incentive compatibility may not be an elusive goal when considering alternative elicitation formats or when studies include two or more value elicitation questions.

As mentioned before, subjects were randomly allocated to one of two treatments. In one of the treatments subjects valued food products that directly integrated insect proteins while in the other treatment, subjects valued a farmed fish that had been fed with insect-based feed. The insect-based products were a 60 grams energy bar with chocolate that contained insect protein and a 60 grams biscuit with chocolate that contained flour made from insects. Subjects were asked to indicate the premium (if any) they would be willing to pay over the price of a conventional product priced at €2. In the second treatment, subjects were asked to value a

[1] This is due to the Gibbard-Satterthwaite theorem (Gibbard, 1973; Satterthwaite, 1975) which states that for the case of more than two alternatives (i.e., non-DC formats), no non-dictatorial strategy-proof voting procedure exists. The theorem was formalized by Gibbard (1973) and Satterthwaite (1975) and noted in passing by Dummett and Farquharson (1961). See also Svensson and Reffgen (2014).

gilt-head sea bream that has been fed with insect-based feed. Subjects were asked to indicate the premium (if any) they would be willing to pay over the price of a 500 gr conventional farmed gilt-head bream priced at €4 that had not been fed with insect-based feed.

Because the CVM involves creating a hypothetical valuation scenario in which consumers are asked to state their WTP for the product in question, we tried to mitigate hypothetical bias by preceding the valuation questions with a cheap talk script and a budget constraint reminder. [2] The cheap talk script was compiled from several sources as well as our own previous work (e.g., Bulte et al., 2005; Lusk, 2003) and reads as follows:[3]

> "You will be presented with two hypothetical scenarios about whether you are willing to pay a certain amount of money for two products that contain edible insects in different forms. These two products will be a high insect protein energy bar with chocolate and a cookie with chocolate which is based on insect flour."
>
> "It is important to remember that the questions are hypothetical and you will not be asked to pay anything. But we need from you to answer as if you had to pay the corresponding amount of money that you will state, since what happens often in hypothetical questions is that consumers state they are willing to pay a larger amount of money than what they are actually willing to pay. Your honesty is of great importance for us in order to be able to draw reliable conclusions."

The payment cards for the insect-based products were similar and were constructed with the following amounts: {0, 0.01-0.10, 0.11-0.20, 0.21-0.30, 0.31-0.40, >0.40}. Subjects had to indicate one of these as their preferred option. In the other treatment, where subjects had to indicate their premium for the gilt-head (sea) bream, the list of possible values for the payment card were as follows: {0, 0.01-0.20, 0.21-0.40, 0.41-0.60, 0.61-0.80, 0.81-1.00, 1.01-1.20, >1.20 }. Since we anticipated negative attitudes toward insect based products, we also asked subjects that indicated a zero WTP, to indicate whether they would be willing to purchase such products with a discount. Subjects that stated they were not WTP to pay a premium, were subsequently

[2]The Cheap Talk method has been used to reduce hypothetical bias by reminding participants of the tendency among people to inflate their bids when questions are hypothetical (Kling et al., 2012). However, the evidence of its effectiveness are disputed. For example, Cummings and Taylor (1999) proposed a very lengthy cheap talk script which they found to be effective at reducing hypothetical bias in experiments using public good referenda. List (2001) and Lusk (2003) found that the cheap talk in Cummings and Taylor (1999) lowered bids for inexperienced consumers while Brown et al. (2003) and Murphy et al. (2005) concluded it was indeed successful but only for high payment amounts. Blumenschein et al. (2007) on the other hand, found that cheap talk has no significant impact while the results of Morrison and Brown (2009) suggest that it can over-calibrate responses and underestimate the actual WTP. Cummings et al. (1995) found that short scripts inflated hypothetical bias while Loomis et al. (1996) found no effect at all. Our script resembles the ones employed in Drichoutis et al. (2017) which have been documented to have various levels of success (Aadland and Caplan, 2003; Brummett et al., 2007; Bulte et al., 2005; Champ et al., 2009; Poe et al., 2002).

[3]Appropriate adjustments were made for the scripts between the two treatments to account for the fact that valuations were elicited for different products.

asked if they would be willing to purchase the product for a 20% discount with a Yes/No possible answer. If they further indicated they were not willing to purchase the product for a 20% discount, their purchase intention was further solicited for a 40% discount.[4]

4 Data analysis and results

Before analyzing our data, it is useful to check whether there are any significant differences between the two treatments along demographic characteristics and attitudinal variables. Table 1 shows descriptive statistics of several variables and their normalized differences (Imbens and Rubin, 2016; Imbens and Wooldridge, 2009) in means and in dispersion. Normalized differences in means are given by $|\bar{x_1} - \bar{x_2}|/\sqrt{(s_1^2 + s_2^2)/2}$ where $\bar{x_j}$ and s_j^2 $(j = 1, 2)$ are the group means and variances, respectively. Normalized differences in dispersion are given by $ln(s_1/s_2)$ (Imbens and Rubin, 2016). Cochran and Rubin's (1973) rule of thumb is that the normalized difference in location should be less than 0.25. The dispersion difference measure indicates smaller differences in dispersion when its value is closer to zero.

As shown in Table 1, only a couple of variables exceed the rule of thumb of Cochran and Rubin (1973), with a normalized difference in means greater than 0.25. However, these variables exhibit differences in dispersion that are close to zero, indicating a good balance between treatments in this set of characteristics and attitudinal variables.

We can gain some first insights by comparing stated responses regarding WTP. Figure 1 compares WTP responses for the energy bar and the cookie. As evident, the distribution of responses is roughly similar between the two products. A Pearson's χ^2 test confirms this is the case ($\chi^2 = 5.992$, p-value $= 0.541$). Figure 2 adds payment card responses for the gilt-head bream.[5] It is self-evident that the distribution of responses is shifted more to the right compared to payment card responses for the cookie and the energy bar. A Pearson's χ^2 test confirms that responses are significantly different between the products ($\chi^2 = 181.695$, p-value < 0.001).

[4] Subjects could only observe the offered discounts dynamically i.e., once they answered zero on the WTP premium, then the 20% discount was offered and if they answered 'No' to the 20% discount, then the 40% discount was offered.

[5] We merged responses for adjacent payment card cells because the scales in the two payment cards were different.

Table 1: Descriptive statistics of variables and standardized differences of observable characteristics

Variable name and description	Scale of Measurement	Mean (SD)	Normalized difference… in means	in dispersion
Gender (Male dummy)	(0,1)	0.48 (0.50)	0.120	0.005
Age category	(1,2,3,4,5)	2.60 (1.34)	0.225	0.008
Education level	(1,2,3,4,5)	3.53 (1.11)	0.194	0.030
Occupation	(1,2,3,4,5,6)	2.85 (1.66)	0.190	0.001
Household size	(Continuous)	3.66 (1.30)	0.016	0.029
Household's economic position	(1,2,3,4)	2.48 (0.68)	0.113	0.010
Knows about edible insects	(0,1)	0.31 (0.46)	0.022	0.009
Conventional/Vegeterian	(0,1)	0.04 (0.19)	0.001	0.002
Would taste insect-based food	(1,2,3,4,5)	2.33 (1.12)	0.273	0.017
Environmental sensitivity	(Continuous)	16.76 (3.39)	0.051	0.154
Importance of food's nutritional value	(Continuous)	9.94 (2.08)	0.062	0.008
Nutritional value is more important than effects in environment	(1,2,3,4,5)	3.14 (0.99)	0.144	0.003
Looking for new sources of food is good	(1,2,3,4,5)	3.78 (1.06)	0.145	0.008
Confidence for stated WTP	(1,2,3,4)	2.82 (0.90)	0.378	0.025
Willingness for trying innovative products	(1,2,3,4,5)	3.24 (0.86)	0.218	0.007
Innovative products must be attractive	(1,2,3,4,5)	3.47 (0.95)	0.152	0.029
Importance of certification for innovative products	(Continuous)	7.04 (1.82)	0.010	0.069
Consumer trust for innovative products	(Continuous)	6.34 (1.23)	0.048	0.036

Notes: SD stands for standard deviation. Standard deviations in parentheses.

Figure 1: Distribution of WTP responses (First treatment)

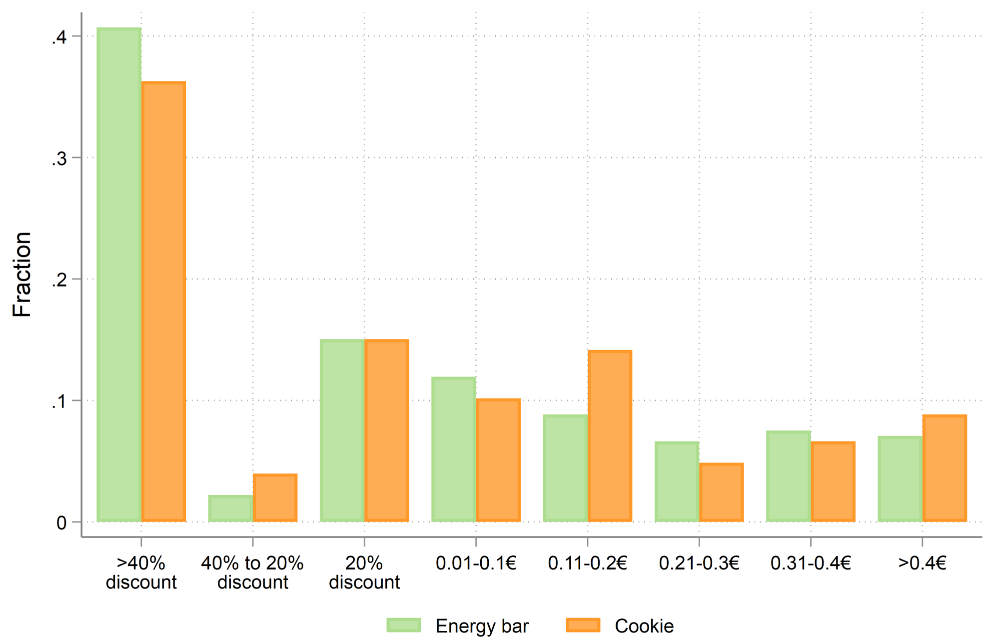
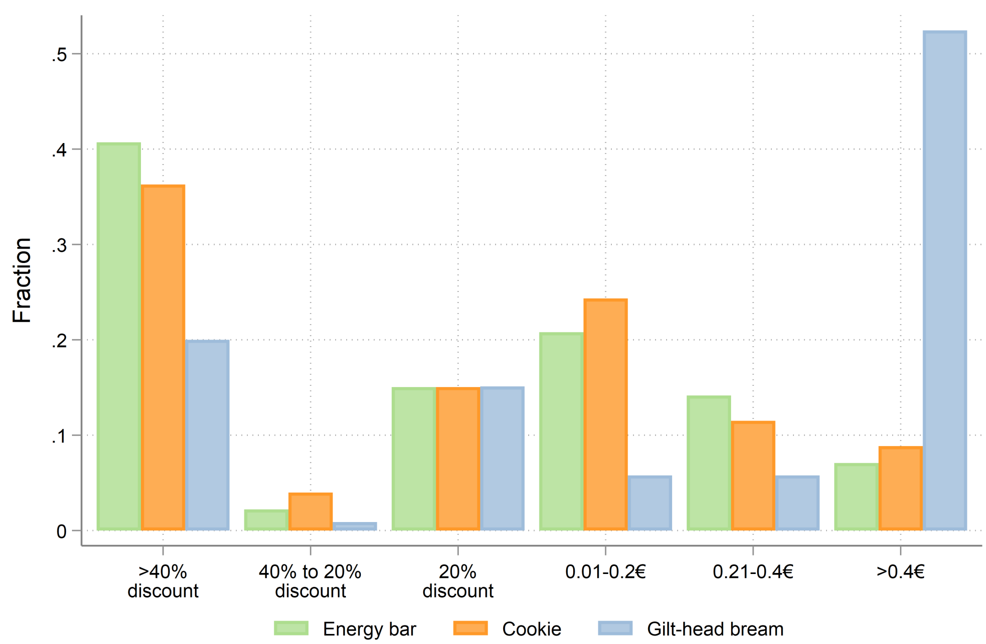


Figure 2: Distribution of WTP responses (Both treatments)



4.1 Econometric analysis

In this section we explore whether insights gained from the unconditional analysis of the previous section hold under conditional analysis. Given the nature of the dependent variable, we estimated interval regression models with clustered standards errors at the individual level where appropriate.[6]

Table 2: Interval regressions estimates without demographics

	WTP for cookie/energy bar (1)		WTP for sea bream (2)		Pooled regression (3)	
Constant	-0.350**	(0.148)	-0.593	(0.504)	-0.576***	(0.184)
Cookie	0.069*	(0.039)	-	-	0.085*	(0.047)
Gilt-head bream	-	-	-	-	0.537***	(0.111)
Somewhat confident	0.142	(0.165)	0.904*	(0.513)	0.343*	(0.194)
Confident	-0.168	(0.177)	0.948*	(0.529)	0.112	(0.203)
Very confident	-0.314*	(0.178)	-0.143	(0.566)	-0.312	(0.211)
σ_u	-0.224***	(0.062)	0.274***	(0.070)	0.052	(0.049)
N	452		225		677	
Log-likelihood	-935.228		-544.393		-1505.827	
AIC	1882.456		1098.786		3025.655	
BIC	1907.138		1115.866		3057.278	

Notes: Standard errors in parentheses. * p<0.1, ** p<0.05 *** p<0.01.

Table 2 shows results using only the product dummies and dummies for the uncertainty scale. Model (1) shows results using the sample for which valuations were elicited for insect based products (energy bar and cookie), model (2) is for the sample of subjects that valuations were elicited for the gilt-head bream and model (3) is a pooled model. Considering both statistical and economical significance, two results come out of Table 2. First, whether the insect based product comes in cookie form or energy bar form, does not have a significant effect on valuations. However, model (3) indicates that consumers are willing to pay a higher premium for a gilt-head bream that is fed with insect-based feed rather than products that contain insects for immediate consumption. Second, the negative constant term of model (1) indicates that, on average, subjects require a discount for the cookie/energy-bar while the coefficient for the constant from model (2) indicates that no significant discount is required for subjects to purchase a gilt-head bream fed with insect-based feed (since we cannot reject the null that the constant is zero). The

[6]In the interval regression model, the upper and lower limits are those specified in the payment card. When consumers indicated they would buy the product for a discount, the intervals were set to the corresponding negative amounts. For example, if a subject indicated she would buy the product for a 20% discount, her interval WTP was set to $\{-20\%p^R, 0\}$ where p^R is the reference price of the conventional product. Similarly, if she accepted a 40% discount her interval WTP was set to $\{-40\%p^R, -20\%p^R\}$ while rejecting both discount offers indicated that her WTP was in the $\{-\infty, 40\%p^R\}$ interval.

uncertainty dummies fail to reject the null of no effect at the 5% level, indicating no significant effect of stated uncertainty over WTP.

Table 3 adds a set of demographic and attitudinal characteristics to the set of variables already used in Table 2. As evident, the effects of the product dummies are robust to the inclusion of the set of demographic and attitudinal characteristics. WTP for cookies and the energy bar do not differ significantly but WTP a premium for the gilt-head bream is significantly higher than the other two products. Moreover, effects from the uncertainty dummies are not significantly different than zero.

Table 3: Interval regressions estimates with demographics

	WTP for cookie/energy bar		WTP for sea bream		Pooled regression	
	(1)		(2)		(3)	
Constant	-2.000***	(0.616)	-0.126	(1.304)	-1.639**	(0.653)
Cookie	0.061	(0.038)	-	-	0.075	(0.046)
Gilt-head bream	-	-	-	-	0.580***	(0.091)
Uncertainty						
Somewhat confident	0.121	(0.202)	0.756*	(0.432)	0.172	(0.212)
Confident	-0.277	(0.208)	0.493	(0.435)	-0.201	(0.216)
Very confident	-0.211	(0.201)	-0.255	(0.454)	-0.355	(0.221)
Demographics						
Gender=Male	0.010	(0.089)	-0.129	(0.161)	-0.012	(0.086)
Age						
26-35 yo	-0.042	(0.139)	-1.011***	(0.240)	-0.290**	(0.136)
36-45 yo	-0.669***	(0.189)	-1.192***	(0.284)	-0.816***	(0.172)
46-55 yo	-0.362**	(0.160)	-1.016***	(0.312)	-0.580***	(0.160)
$\geq$56 yo	-0.250	(0.199)	-0.661	(0.430)	-0.390*	(0.214)
Education						
Up to High school	0.237	(0.274)	-0.283	(0.458)	0.082	(0.274)
Technical School	-0.126	(0.294)	-0.158	(0.481)	-0.060	(0.289)
Undergraduate studies	-0.122	(0.276)	-0.381	(0.442)	-0.182	(0.274)
Postgraduate studies	-0.048	(0.305)	-0.600	(0.467)	-0.191	(0.295)
Occupation						
Private Employee	-0.106	(0.131)	-0.398*	(0.228)	-0.136	(0.131)

Freelancer	0.092	(0.153)	0.163	(0.276)	0.130	(0.153)
Retired	-0.116	(0.247)	-0.935**	(0.376)	-0.319	(0.229)
Student	-0.475***	(0.181)	-1.270***	(0.318)	-0.772***	(0.177)
Unemployed	0.185	(0.163)	-0.128	(0.328)	0.084	(0.181)
Household size	0.011	(0.033)	-0.134**	(0.059)	-0.026	(0.033)
Households economic position						
Moderate	0.182	(0.153)	0.498	(0.414)	0.349**	(0.171)
Good	0.380**	(0.156)	0.380	(0.427)	0.447**	(0.177)
Very good	0.233	(0.354)	0.244	(0.528)	0.310	(0.310)
Other factors						
Knows about edible insects=Yes	0.023	(0.095)	-0.038	(0.164)	-0.005	(0.094)
Diet=Vegetarian	-0.156	(0.232)	-0.816**	(0.402)	-0.343	(0.250)
Would taste insect-based food						
Probably No	0.336**	(0.144)	0.245	(0.236)	0.442***	(0.136)
Maybe Yes, maybe No	0.741***	(0.136)	0.712***	(0.245)	0.845***	(0.137)
Probably Yes	0.771***	(0.146)	0.500	(0.363)	0.921***	(0.159)
Definitely Yes	0.890***	(0.167)	0.682	(0.453)	1.048***	(0.200)
Environmental sensitivity	-0.010	(0.016)	-0.066*	(0.036)	-0.023	(0.016)
Importance of food's nutritional value	-0.027	(0.022)	-0.008	(0.038)	-0.014	(0.023)
Nutritional value is more important than effects in environment						
Disagree	-0.203	(0.173)	-0.215	(0.457)	-0.313	(0.219)
Neither agree nor disagree	-0.271	(0.177)	-0.383	(0.420)	-0.459**	(0.209)
Agree	-0.286	(0.178)	-0.168	(0.429)	-0.311	(0.212)
Strongly agree	-0.126	(0.242)	0.095	(0.471)	-0.180	(0.258)
Looking for new sources of food is good						
Disagree	0.600**	(0.301)	0.209	(0.642)	0.444	(0.345)
Neither agree nor disagree	0.604***	(0.223)	0.807	(0.544)	0.688**	(0.271)
Agree	0.625***	(0.217)	1.458***	(0.544)	0.966***	(0.264)
Strongly agree	0.732***	(0.212)	1.470***	(0.563)	1.059***	(0.269)

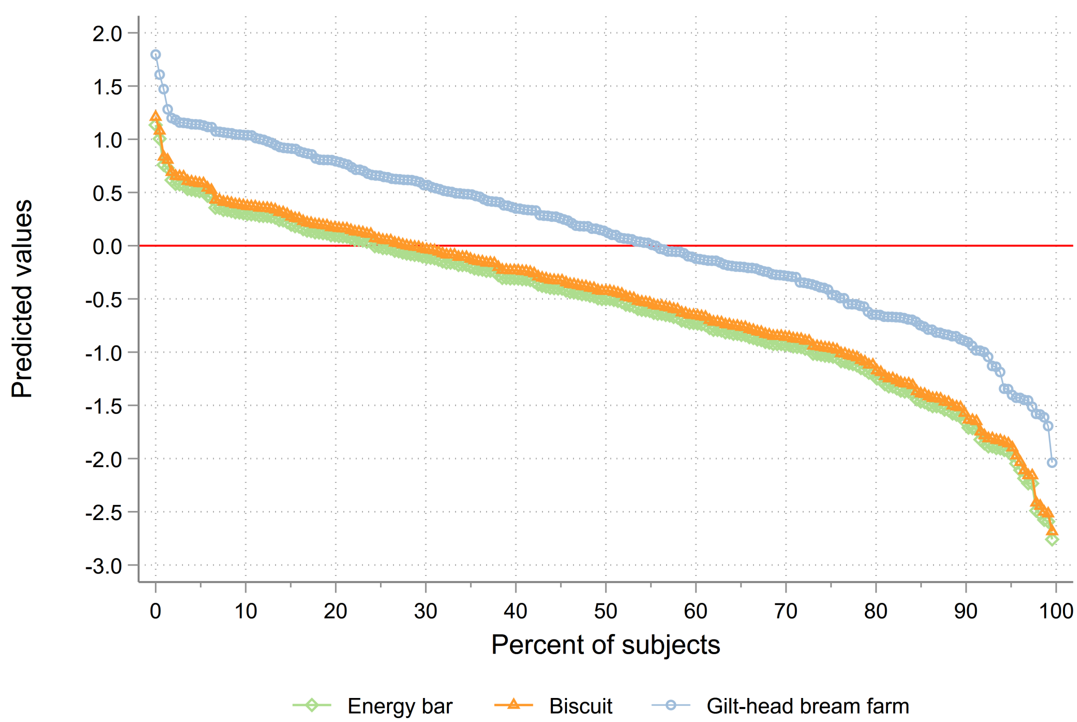
Willingness for trying innovative products						
Disagree	-0.081	(0.287)	0.130	(0.694)	-0.184	(0.348)
Neither agree nor disagree	0.087	(0.289)	0.128	(0.673)	-0.070	(0.340)
Agree	0.055	(0.300)	0.458	(0.675)	0.058	(0.344)
Strongly agree	0.477	(0.345)	1.137	(0.726)	0.554	(0.377)
Innovative products must be attractive						
Disagree	0.287	(0.313)	-0.390	(0.635)	0.128	(0.345)
Neither agree nor disagree	0.238	(0.320)	-0.045	(0.594)	0.255	(0.336)
Agree	0.273	(0.311)	-0.378	(0.593)	0.165	(0.327)
Strongly agree	0.374	(0.333)	0.177	(0.619)	0.390	(0.346)
Importance of certification for innovative products	0.055**	(0.023)	0.126**	(0.054)	0.068***	(0.026)
Consumer trust for innovative products	0.098***	(0.034)	0.054	(0.072)	0.071**	(0.035)
σ_u	-0.600***	(0.067)	-0.026	(0.064)	-0.207***	(0.049)
N	452		225		677	
Log-likelihood	-796.720		-481.996		-1347.348	
AIC	1693.440		1061.991		2796.695	
BIC	1899.124		1229.380		3027.097	

Notes: Standard errors in parentheses. * p<0.1, ** p<0.05 *** p<0.01.

Table 3 may also help to characterize the profile of potential consumers of insect-based products. First, with respect to demographic characteristics, males and females do not differ in their stated WTP while age has a significant effect. In specific, older individuals are less willing to pay a premium across all products. Education and occupation do not produce systematic effects on WTP but income has a positive effect. Among factors other than demographics, those that seem to affect willingness to pay a premium are the stated willingness to taste an insect-based product and agreeing with the statement that looking for new sources of food is good. Moreover, evaluating certification and trust as important for innovative products is associated with a higher WTP a premium.

An additional exercise we can do with our data is to use the predicted values from model (3) of Table 3 to graph the downward slopping curves shown in Figure 3. Each point on the curves indicates the percentage of respondents that would be willing to buy one unit of the energy bar, the biscuit and the gilt-head bream farm products, respectively, at the premium projected on the Y-axis. As evident predicted WTP premiums span both the positive and negative axis. This is because a significant number of respondents stated they would require a discount to purchase the products. The crossover point of the downward slopping curves with the horizontal axis at zero, indicates the percentage of respondents that would be willing to pay a premium and the percentage of respondents that would require a discount. For the energy bar and the cookie, only 24.3% and 28.3% of subjects, respectively, are willing to pay a premium (conversely, 75.7% and 71.7% of respondents would require a discount). The curve for the gilt-head bream is significantly sifted to the right indicating a higher rate of acceptance. About 44.45% of subjects would require a discount to purchase the gilt-head bream fed with insect-based feed, while 55.55% would be willing to pay a premium.

Figure 3: Predicted premiums by product



5 Discussion and conclusions

Given the growing interest for insect based products as an alternative source of protein, acceptability and knowledge of consumer preferences for insect based food can be a critical factor for the agribusinesses sector. Knowledge of consumer preferences would allow to make informed decisions about producing insect-based products, especially for Western countries where entomophagy is mostly non-existent. It would also allow effective targeting of segments of the population that are more likely to accept and purchase insect based products. This paper sought to explore consumer acceptance for insect based products under conditions that vary the proximity of insects in the food chain.

To achieve this goal, we used a survey-based experiment with Greek consumer where we elicited consumer preferences using the Contingent Valuation method. In order to vary proximity of insects in the food chain we selected two kinds of products: a) an energy bar and a cookie, where insect proteins can be directly integrated in the product and b) a gilt-head bream farmed fish where insects are only part of the diet of the fish and are not directly consumed by people. Our results confirm the low acceptance of insect-based foods since most subjects require a discount to purchase such products (we find that 75.7% and 71.7% of respondents would require a discount to consume the energy bar and cookie with insect protein, respectively) while we find a much larger acceptance for a gilt-head bream fish that is fed with insect-based feed (55.55% of subjects would be willing to pay a premium to purchase the gilt-head bream fed with insect-based feed).

Our study can also be used by food companies that are looking to build the profile of consumers that are more likely to buy insect based products: younger consumers, regardless of their gender, occupation or education but of slightly higher income, that already trust innovation in food production, that find food certification important, and are actively looking for new sources of food. Our findings are also interesting for fish farm business that consider partly replacing farmed fish diets with sustainable alternatives (Henry et al., 2015). Our results suggest that fish produced with feeds containing insects may be a larger than a niche market and fish farm business are likely to be able to market their products for a premium.

References

Aadland, D. and A. J. Caplan (2003). Willingness to Pay for Curbside Recycling with Detection and Mitigation of Hypothetical Bias. *American Journal of Agricultural Economics 85*(2), 492–502.

Alemu, M. H. and S. B. Olsen (2020). An analysis of the impacts of tasting experience and peer effects on consumers willingness to pay for novel foods. *Agribusiness 36*(4), 653–674.

Barsics, F., R. Caparros Megido, Y. Brostaux, C. Barsics, C. Blecker, E. Haubruge, and F. Francis (2017). Could new information influence attitudes to foods supplemented with edible insects?. *British Food Journal. 119*(9), 2027–2039.

Blumenschein, K., G. C. Blomquist, M. Johannesson, N. Horn, and P. Freeman (2007). Eliciting willingness to pay without bias: Evidence from a field experiment. *The Economic Journal 118*(525), 114–137.

Brown, T. C., I. Ajzen, and D. Hrubes (2003). Further tests of entreaties to avoid hypothetical bias in referendum contingent valuation. *Journal of Environmental Economics and Management 46*(2), 353–361.

Brummett, R. G., J. Rodolfo M. Nayga, and X. Wu (2007). On the use of cheap talk in new product valuation. *Economics Bulletin 2*(1), 1–9.

Bulte, E., S. Gerking, J. A. List, and A. de Zeeuw (2005). The effect of varying the causes of environmental problems on stated WTP values: Evidence from a field study. *Journal of Environmental Economics and Management 49*(2), 330–342.

Caparros Megido, R., C. Gierts, C. Blecker, Y. Brostaux, ric Haubruge, T. Alabi, and F. Francis (2016). Consumer acceptance of insect-based alternative meat products in western countries. *Food Quality and Preference 52*, 237 – 243.

Caparros Megido, R., L. Sablon, M. Geuens, Y. Brostaux, T. Alabi, C. Blecker, D. Drugmand, r. Haubruge, and F. Francis (2014). Edible insects acceptance by belgian consumers: Promising attitude for entomophagy development. *Journal of Sensory Studies 29*(1), 14–20.

Carson, R. T. (2012). Contingent valuation: A practical alternative when prices aren't available. *Journal of Economic Perspectives 26*(4), 27–42.

Carson, R. T. and W. M. Hanemann (2005). Chapter 17 contingent valuation. In K.-G. Mler and J. R. Vincent (Eds.), *Valuing Environmental Changes*, Volume 2 of *Handbook of Environmental Economics*, pp. 821 – 936. Elsevier.

Castro, M. and E. I. Chambers (2019). Willingness to eat an insect based product and impact on brand equity: A global perspective. *Journal of Sensory Studies 34*(2), e12486.

Champ, P. A., R. Moore, and R. C. Bishop (2009). A comparison of approaches to mitigate hypothetical bias.

Cochran, W. G. and D. B. Rubin (1973). Controlling bias in observational studies: A review. *Sankhyā: The Indian Journal of Statistics, Series A 35*(4), 417–446.

Cummings, R. G., G. W. Harrison, and L. L. Osborne (1995). Can the bias of contingent valuation be reduced? Evidence from the laboratory. *College of Business Administration, University of South Carolina, Economics Working Paper B-95-03 3*.

Cummings, R. G. and L. O. Taylor (1999). Unbiased value estimates for environmental goods: a cheap talk design for the contingent valuation method. *The American Economic Review 89*(3), 649–665.

Drichoutis, A. C., A. Vassilopoulos, J. L. Lusk, and J. R. M. Nayga (2017). Consumer preferences for fair labour certification. *European Review of Agricultural Economics 44*(3), 455–474.

Dummett, M. and R. Farquharson (1961). Stability in voting. *Econometrica 29*(1), 33–43.

Gahukar, R. (2011). Entomophagy and human food security. *International Journal of Tropical Insect Science 31*(3), 129144.

Gibbard, A. (1973). Manipulation of voting schemes: A general result. *Econometrica 41*(4), 587–601.

Haab, T. C., M. G. Interis, D. R. Petrolia, and J. C. Whitehead (2013). From hopeless to curious? thoughts on hausman's "dubious to hopeless" critique of contingent valuation. *Applied Economic Perspectives and Policy 35*(4), 593–612.

Halloran, A., C. Mnke-Svendsen, A. Van Huis, and P. Vantomme (2014). Insects in the human food chain: global status and opportunities. *Food Chain 4*, 103–118.

Hartmann, C. and M. Siegrist (2016). Becoming an insectivore: Results of an experiment. *Food Quality and Preference 51*, 118 – 122.

Henry, M., L. Gasco, G. Piccolo, and E. Fountoulaki (2015). Review on the use of insects in the diet of farmed fish: Past and future. *Animal Feed Science and Technology 203*, 1 – 22.

House, J. (2016). Consumer acceptance of insect-based foods in the netherlands: Academic and commercial implications. *Appetite 107*, 47 – 58.

Iaconisi, V., S. Marono, G. Parisi, L. Gasco, L. Genovese, G. Maricchiolo, F. Bovera, and G. Piccolo (2017). Dietary inclusion of tenebrio molitor larvae meal: Effects on growth performance and final quality treats of blackspot sea bream (pagellus bogaraveo). *Aquaculture 476*, 49 – 58.

Imathiu, S. (2020). Benefits and food safety concerns associated with consumption of edible insects. *NFS Journal 18*, 1 – 11.

Imbens, G. W. and D. B. Rubin (2016). *Causal Inference for Statistics, Social, and Biomedical Sciences, An introduction*. Cambridge and New York: Cambridge University Press.

Imbens, G. W. and J. M. Wooldridge (2009). Recent developments in the econometrics of program evaluation. *Journal of Economic Literature 47*(1), 5–86.

Johnston, R. J., K. J. Boyle, W. Adamowicz, J. Bennett, R. Brouwer, T. A. Cameron, W. M. Hanemann, N. Hanley, M. Ryan, R. Scarpa, R. Tourangeau, and C. A. Vossler (2017). Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists 4*(2), 319–405. (Vic).

Kling, C. L., D. J. Phaneuf, and J. Zhao (2012). From Exxon to BP: Has some number become better than no number? *Journal of Economic Perspectives 26*(4), 3–26.

Kornher, L., M. Schellhorn, and S. Vetter (2019). Disgusting or innovative-consumer willingness to pay for insect based burger patties in germany. *Sustainability 11*(7).

Laureati, M., C. Proserpio, C. Jucker, and S. Savoldelli (2016). New sustainable protein sources: Consumers' willingness to adopt insects as feed and food. *28*, 652–668.

Lensvelt, E. J. S. and L. P. A. Steenbekkers (2014). Exploring consumer acceptance of entomophagy: A survey and experiment in australia and the netherlands. *Ecology of Food and Nutrition 53*(5), 543–561. PMID: 25105864.

List, J. A. (2001). Do explicit warnings eliminate the hypothetical bias in elicitation procedures? Evidence from field auctions for sportscards. *American Economic Review 91*(5), 1498–1507.

Loomis, J., T. Brown, B. Lucero, and G. Peterson (1996). Improving validity experiments of contingent valuation methods: results of efforts to reduce the disparity of hypothetical and actual willingness to pay. *Land Economics*, 450–461.

Lusk, J. L. (2003). Effects of cheap talk on consumer willingness-to-pay for golden rice. *American Journal of Agricultural Economics 85*(4), 840–856.

Melgar-Lalanne, G., A.-J. Hernndez-lvarez, and A. Salinas-Castro (2019). Edible insects processing: Traditional and innovative technologies. *Comprehensive Reviews in Food Science and Food Safety 18*(4), 1166–1191.

Menozzi, D., G. Sogari, M. Veneziani, E. Simoni, and C. Mora (2017). Eating novel foods: An application of the theory of planned behaviour to predict the consumption of an insect-based product. *Food Quality and Preference 59*, 27–34.

Morrison, M. and T. C. Brown (2009). Testing the effectiveness of certainty scales, cheap talk, and dissonance-minimization in reducing hypothetical bias in contingent valuation studies. *Environmental and Resource Economics 44*(3), 307–326.

Murphy, J. J., T. Stevens, and D. Weatherhead (2005). Is cheap talk effective at eliminating hypothetical bias in a provision point mechanism? *Environmental and Resource Economics 30*(3), 327–343.

Oonincx, D., S. Van Broekhoven, A. Van Huis, and J. Van Loon (2015). Feed conversion, survival and development, and composition of four insect species on diets composed of food by-products. *PLoS ONE 10*(12).

Piccolo, G., V. Iaconisi, S. Marono, L. Gasco, R. Loponte, S. Nizza, F. Bovera, and G. Parisi (2017). Effect of tenebrio molitor larvae meal on growth performance, in vivo nutrients digestibility, somatic and marketable indexes of gilthead sea bream (sparus aurata). *Animal Feed Science and Technology 226*, 12 – 20.

Poe, G. L., J. E. Clark, D. Rondeau, and W. D. Schulze (2002). Provision point mechanisms and field validity tests of contingent valuation. *Environmental and Resource Economics 23*(1), 105–131.

Ramos-Elorduy, J. (2009). Anthropo-entomophagy: Cultures, evolution and sustainability. *Entomological Research 39*(5), 271–288.

RamosElorduy, J. (1997). Insects: A sustainable source of food? *Ecology of Food and Nutrition 36*(2-4), 247–276.

Rozin, P. and A. Fallon (1980). The psychological categorization of foods and non-foods: A preliminary taxonomy of food rejections. *Appetite 1*(3), 193 – 201.

Rozin, P. and A. E. Fallon (1987). A perspective on disgust. *Psychological review 94*(1), 2341.

Rumpold, B. A. and O. K. Schlüter (2013). Potential and challenges of insects as an innovative source for food and feed production. *Innovative Food Science & Emerging Technologies 17*, 1–11.

Satterthwaite, M. A. (1975). Strategy-proofness and Arrow's conditions: Existence and correspondence theorems for voting procedures and social welfare functions. *Journal of Economic Theory 10*(2), 187–217.

Schouteten, J. J., H. De Steur, S. De Pelsmaeker, S. Lagast, J. G. Juvinal, I. De Bourdeaudhuij, W. Verbeke, and X. Gellynck (2016). Emotional and sensory profiling of insect-, plant- and meat-based burgers under blind, expected and informed conditions. *Food Quality and Preference 52*, 27 – 31.

Sogari, G., D. Menozzi, and C. Mora (2017). Exploring young foodies knowledge and attitude regarding entomophagy: A qualitative study in italy. *International Journal of Gastronomy and Food Science 7*, 16 – 19.

Sogari, G., D. Menozzi, and C. Mora (2018). Sensory-liking expectations and perceptions of processed and unprocessed insect products. *International Journal on Food System Dynamics 9*(4), 314–320.

Svensson, L.-G. and A. Reffgen (2014). The proof of the gibbardsatterthwaite theorem revisited. *Journal of Mathematical Economics 55*, 11 – 14.

Tan, H. S. G., E. van den Berg, and M. Stieger (2016). The influence of product preparation, familiarity and individual traits on the consumer acceptance of insects as food. *Food Quality and Preference 52*, 222 – 231.

Van Huis, A. (2013). Potential of insects as food and feed in assuring food security. *Annual Review of Entomology 58*(1), 563–583. PMID: 23020616.

Van Huis, A. (2016). Edible insects are the future? *Proceedings of the Nutrition Society 75*(3), 294305.

Van Huis, A., J. Van Itterbeeck, H. Klunder, E. Mertens, A. Halloran, G. Muir, and P. Vantomme (2013). Edible insects: future prospects for food and feed security. (171).

Van Thielen, L., S. Vermuyten, B. Storms, B. Rumpold, and L. Van Campenhout (2018). Consumer acceptance of foods containing edible insects in belgium two years after their introduction to the market. *Journal of Insects as Food and Feed 5*, 1–10.

Verbeke, W. (2015). Profiling consumers who are ready to adopt insects as a meat substitute in a western society. *Food Quality and Preference 39*, 147 – 155.

Vossler, C. A. and J. S. Holladay (2018). Alternative value elicitation formats in contingent valuation: Mechanism design and convergent validity. *Journal of Public Economics 165*, 133–145.

Wilkinson, K., B. Muhlhausler, C. Motley, A. Crump, H. Bray, and R. Ankeny (2018). Australian consumers awareness and acceptance of insects as food. *Insects 9*(2).