What do trout eat: Acceptance of insects in animal feed*

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Abstract

This paper aims to characterize the determinants of consumers' acceptance of insects as feed, by evaluating the willingness to choose products from animals fed with insects and the impact of an environmental information about over-exploitation of marine resources and use of insects as alternative feed sources. A hypothetical choice experiment was conducted on smoked trout fillets fed with or without insect meal with different prices. 15% of participants consider that it is disgusting to consume trouts fed with insects. The probability to choose trouts fed with insect meal is higher when participants have been informed.

Keywords: Insects, Willingness To Accept, Animal feed.
JEL classification: C99, D11, D12.

1 Introduction

The world population is expected to increase to 9 billion by 2050. This increase in human population will have a major impact on both future demand for commodities, especially sources of protein, and available natural resources with cascading consequences on the ecosystem.

In this context of increasing demand in alternative protein sources, insects represent an untapped source of protein for human food and for animal feed and, in this way, a radical food innovation. Insect rearing could appear as one of the ways to enhance food and feed security (van Huis et al., 2013) and be one of the solutions to nutritional and environmental world problems.

The advantages of this farming are multiple, from various points of view: environmental, nutritional, and economical. In comparison to conventional livestock in general, insects have a higher feed conversion rate, the ability to live in high densities (van Huis, 2010; van Huis et al., 2013), a higher fecundity (Rumpold and Schlüter, 2013). Insects are reported to emit fewer greenhouse gases and less ammonia than most livestock (Oonincx et al., 2010). More, insect rearing requires significantly less land and water than cattle rearing and compared with mammals and birds, insects may also pose less risk of transmitting zoonotic infections to humans, livestock and wildlife (van Huis et al., 2013). Insects contain many nutrients such as essential amino acids and have high fat, protein, vitamin, fibre and mineral content (van Huis et al., 2013; Rumpold and Schlüter, 2013).[1]

However, in western countries, there are regulatory and psychological barriers against the use of insects as food and feed. Some regulatory barriers are coming down, because a European Commission text allowing the use of insects protein for feeding aquaculture animals is expected to be formally adopted during the spring 2017. In this context, the most obvious challenge is the consumer acceptance of edible insects (van Huis et al., 2013; Rumpold and Schlüter, 2013; Verbeke, 2015).

Psychological barriers, such as food neophobia, and socio-cultural barriers, such as food taboo, explain the disgust response or aversion to insects as food. Unlike many animals who instinctively know what to eat, humans are omnivores and must learn what to eat. The advantage of being an omnivore is the flexibility and adaptability this brings, but the disadvantage is an increased risk of consuming toxic ingredients. According to the psychologists Haidt, Rozin, McCauley and Imada (1997) or Pliner and Hobden (1992), this is why people both seek diversified and new foods and apply scrutiny before they taste. The authors thus define a food related emotion called "core disgust". This also explains the food neophobia, that is, the fact to be vigilant about new foods, in particular animal foods (Haidt et al., 1997). Haidt et al. (1997) show how the emotion of disgust has developed from helping humans to know what to eat in the world around them to later what to do in a society with cultural, social and moral norms. Insects are often found in large groups, they are often wiggly and move very quickly. Insects are also more similar looking to bacteria and parasites, which are known to spread filth and disease, some of the "core disgust" triggers. Furthermore many insects live in garbage, such as worms and cockroaches. These reasons, but also education, cultural and social norms, creating "food taboo", explain why many people from western countries find the idea of eating insects disgusting.

The entomologist Matan Shelomi considers that "entomophagy in the West is a failed innovation, with no indication that it will succeed with the current diffusion tactics" (Shelomi, 2015). One of the numerous reasons for failure is the physical appearance of insects, causing aversion

[1] Potential risks associated with the use of insects as food and feed are related to microbial contamination and allergic reactions. Rumpold and Schlüter (2013) note that all health risks can be prevented by the consumption of common edible insect species reared on pollutant-free feed.

and incompatible with the Western view of the food appearance and acceptation (Shelomi, 2015). Many different studies confirm that people are more ready to eat or value more products containing the less visible, more processed insect ingredients (Schösler et al., 2012; Pascucci and de-Magistris 2013; de-Magistris et al., 2015; Tan et al., 2015; Gmuer et al., 2016; Caparros Megido et al., 2016). Therefore, the first step to increase the acceptance of entomophagy may be to develop insects as livestock feed rather than direct human food, by putting emphasis on ecological benefits of this new practice, for instance (Shelomi, 2015).

Fishmeal and fish oil are still considered the most nutritious and digestible ingredients for farmed fish feeds (FAO, 2016). While the available data from FAO are not very precise, it can be estimated that a significant proportion of around 25% of world fisheries production is processed into fishmeal and fish oil.[2] Insects as an alternative to fish meal in feed formulae could help alleviate economic and environmental pressures on marine resources. Of the total number of stocks assessed in 2013, 58.1% of the fish stocks were fully fished (FAO, 2016) and, according to the NGO Greenpeace, 80% of fish stocks are over-exploited or at the limit of over-exploitation. Feed accounts for more than 50% of the production costs in European intensive finfish aquaculture today due to strong dependence to fishmeal and therefore, price changes of feed ingredients have a major impact on economic sustainability (EFARO, 2013). More, insects are components of the natural diet of marine and freshwater fish (van Huis, 2013).

Due to the increasing interest in insects as alternative protein sources, there is an increasing number of studies investigating consumers' perception of insects as food and readiness to eat insect-based products more or less processed. All studies show that people from western countries generally have a rather low willingness to adopt insect into their diet (Vanhonacker et al., 2013; Verbeke, 2015; Schouteten et al., 2016), especially when insects are visible (Schösler et al., 2012; Pascussi and de-Magistris, 2013; de-Magistris et al., 2015; Hartmann et al., 2015; Tan et al., 2015; Caparros Medigo et al., 2016; Gmuer et al., 2016). To our knowledge, only one paper studies the acceptance of insects in animal feed (Verbeke et al., 2015). Verbeke et al. (2015) analyze data collected from some 415 visitors of Agriflanders 2015, including 196 farmers and 137 stakeholders from diverse sectors linked with agriculture. Two thirds of the participants are willing to accept the use of insects in animal feed. Perceived benefits such as lower dependence on protein imports and better use of organic wast outweigh the perceived risks, such as microbiological contamination in the food chain and lower consumer acceptance of animal products. The most favorable beliefs, perceptions and attitudes were recorded among agriculture sector stakeholders. The sample of this study is not representative for the overall study population, since farmers are more critical towards the use of insects in animal feed than agriculture sector stakeholders or citizens and all participants have been recruited in an agricultural show.

The main objective of the present study is to evaluate the determinants of consumers' acceptance of insects as feed. Specific objectives are to (1) assess the willingness to choose products from animals fed with insects, using a common consumer product, namely, smoked trout fillets, (2) characterize the relationship between the insects acceptance as feed and food neophobia, disgust, and other personality traits, (3) evaluate the impact of positive environmental information on the willingness to choose products from animals fed with insects. Consumer purchase decision depends on many different factors, including personal values and opinions, socio-cultural norms, information and knowledge, product characteristics and prices. We assume that consumers

[2]Over the past 30 years fish meal and fish oil production have ranged between 6.2 and 7.4 million tonnes and 1.0 and 1.7 million tonnes respectively and it takes four to five tonnes (depending on the body protein content of the species) of whole fresh fish to produce a tonne of fish meal (Médale and Kaushik, 2009).

perceive smoked trout fillets fed with insect meal very differently and they are also more or less sensitive to an environmental issue, such as over-exploitation of the marine resources. We then develop a model to analyze theoretical consumer preferences for two types of smoked trout fillets, fed with or without insect meal. This allows us to characterize consumer choice as a function of product price difference, insect perception, and self environmental awareness. To draw a parallel with these theoretical predictions, a study was conducted using online questionnaires. The consumption of smoked trouts fed with insect meal having not been authorized by the national food and drug agency (ANSM) for our study, we conducted a hypothetical choice experiment on smoked trout fillets fed with or without insect meal with different prices. Next, we developed a questionnaire to investigate both participants' attitudes towards the consumption of trouts fed with insects and participants' opinions on fish feeding and on the consumption of trouts fed with insect meal. We introduced two different information treatments: a first group of participants has not received any information; a second group of participants has received information about the over-exploitation of marine resources and the use of insects as alternative feed sources. We also expected that food neophobia would be an important predictor for willingness to accept insects as feed. Few questions of the Food Neophobia Scale (FNS) are then introduced, besides questions of the big-five test for personal traits.

The survey was conducted in December 2016 in France with 327 participants. First results show that 60.55% of participants declare to be agree or strongly agree with the fact that it is natural for fish to eat insects. At the other end, 15.29% of them consider that it is disgusting to consume trouts fed with insects. The number of participants choosing trouts fed with insect meal is higher when they have been informed about the negative environmental impact of current feeding methods on marine resources and the possible alternative feeding with insects, whatever the price difference between products. However, price difference is also a key attribute in the choice between both types of products.

The remainder of the paper is structured as follows. In Section 2, a simple theoretical model is developed to analyze the determinants of consumer preferences for two varieties of smoked trout fillets, fed with insect meal or not. Section 3 introduces the choice experiment led to identify the willingness to accept insect meal in animal feed. Sections 4 and 5 present the data, the preliminary results and conclude.

2 Consumer choice for smoked trout fillets

We expect that consumers' behaviors towards trouts fed with insect meal may be very heterogeneous, from disgust, indifference to high interest. Insect and, consequently, trouts fed with insect meal insect, may cause disgust for many different reasons. On the contrary, feed trouts can be viewed as something natural, thus be appreciated.

We describe the consumer market by developing a theoretical framework using differentiation model to highlight the expected determinants of consumer choice for trouts which may be fed with insect meal. We adopt a discrete horizontal differentiation model with three consumer segments. First, we build a basic framework to represent different visions of insects as feed for trouts. After, we integrate a vertical differentiation hypothesis to include the fact that insect meal is a good substitute to fish meal and that, by this way, it represents a good solution for conserving the marine resources. This allows us to characterize the segmentation of the market.

2.1 Basic model

We consider two varieties i of smoked trout fillets: the one produced conventionally, denoted by 1, and the other where trouts were fed with insect meal, denoted by 2. The market is comprised of a unit mass of consumers. Each consumer has a demand of at most one unit of the product and each consumer can only choose between the two varieties of the product. Consumers have a common reservation price v for the product, smoked trout fillets. Consumers have the information about trout feed.

We assume that there are three segments of consumers in their insect perception: disgusted (indexed by D), indifferent (indexed by I), positive (indexed by T for taste). Let α denote the proportion of people disgusted by eating animals fed with insects, β the proportion of people in favor of using insect meal as feed, then $1 - \alpha - \beta$ is equal to the proportion of people indifferent as to whether trouts are fed with insect meal or not.

Without any other information except trout feed, a consumer of type I derives the following (indirect) utility from buying one unit of the product i

$$u^I = \begin{cases} v - p_1 & \text{by buying one unit of product 1} \\ v - p_2 & \text{by buying one unit of product 2} \end{cases}$$

with p_i the price of product i. A consumer of the type D derives the following (indirect) utility

$$u^D = \begin{cases} v - p_1 & \text{by buying one unit of product 1} \\ v - \delta - p_2 & \text{by buying one unit of product 2} \end{cases}$$

with δ the loss of valuation from consumer's perspective due to the fact that trouts of the product 2 are fed with insect meal. A consumer of the type T derives the following (indirect) utility

$$u^T = \begin{cases} v - p_1 & \text{by buying one unit of product 1} \\ v + \tau - p_2 & \text{by buying one unit of product 2} \end{cases}$$

with τ the utility rise due to the fact that trouts of the product 2 are fed with insect meal.

The consumer' choice is then the product 1 if

$$\begin{cases} p_2 - p_1 > -\delta & \text{if her type is } D, \\ p_2 - p_1 > 0 & \text{if her type is } I, \\ p_2 - p_1 > \tau & \text{if her type is } T. \end{cases}$$

This means that the consumer' choice between the two varieties of smoked trout fillets depends on her insect perception and on the price difference between these two varieties. If the price difference in favor of the conventional variety is very high, all consumers choose this variety. As the price difference decreases and becomes in favor of the insect variety, the positive consumers, the indifferent consumers and then the disgusted consumers turn to the insect variety.

2.2 Double differentiation

Smoked trout fillets differ in their environmental quality. Quality q measures the positive external effects of the animal feed with insects in relation to conventional trout feed. This quality can be certified by a label. With information about the trout feed and the environmental quality of insect meal over conventional animal feed, in line with vertical differentiation models à la Mussa-Rosen, we consider that each consumer is characterized by their taste for quality or a marginal willingness to pay for quality, θ, assumed uniformly distributed over $[0, 1]$. We suppose that the market is fully covered (i.e. all consumers buy one of the two varieties).

Consumer willingness to pay for quality q is then defined by θq and measures the gross surplus of consumer θ when choosing the variety having the quality q, that is, the fillets of smoked trout fed with insect meal. The type of the consumers concerning the insect perception and the taste for quality are independent characteristics. Then, all consumers characterized by their taste for quality have the same probability to being disgusted by insects, indifferent to insects, and favorable towards insects, that is, respectively, α, β, and $1 - \alpha - \beta$.

Consumer preferences are therefore represented by following (indirect) utility functions:

$$u^D(\theta) = \begin{cases} v - p_1 & \text{if this consumer of type } D \text{ buys one unit of product 1} \\ v - \delta + \theta q - p_2 & \text{if she buys one unit of product 2} \end{cases}$$

$$u^I(\theta) = \begin{cases} v - p_1 & \text{if this consumer of type } I \text{ buys one unit of product 1} \\ v + \theta q - p_2 & \text{if she buys one unit of product 2} \end{cases}$$

$$u^T(\theta) = \begin{cases} v - p_1 & \text{if this consumer of type } T \text{ buys one unit of product 1} \\ v + \tau + \theta q - p_2 & \text{if she buys one unit of product 2} \end{cases}$$

The following threshold values allow to characterize consumers' choices:

$$\begin{cases} \overline{\theta}_D & = \frac{p2 - p_1 + \delta}{q}, \\ \overline{\theta}_I & = \frac{p2 - p_1}{q}, \\ \overline{\theta}_T & = \frac{p2 - p_1 - \tau}{q}. \end{cases} \tag{1}$$

Therefore, type D consumers of the variety 1 are characterized by $\theta < \overline{\theta}_D$, type I consumers of the variety 1 are then characterized by $\theta < \overline{\theta}_I$, and type T consumers of the variety 1 are then characterized by $\theta < \overline{\theta}_T$. This allows to obtain the total demand function for each variety $i = 1, 2$: $D_1(p_1, p_2) = \frac{p_2 - p_1}{q} + \frac{\alpha\tau - \beta\delta}{q}$ and $D_2(p_1, p_2) = 1 - \frac{p_2 - p_1}{q} - \frac{\alpha\tau - \beta\delta}{q}$.

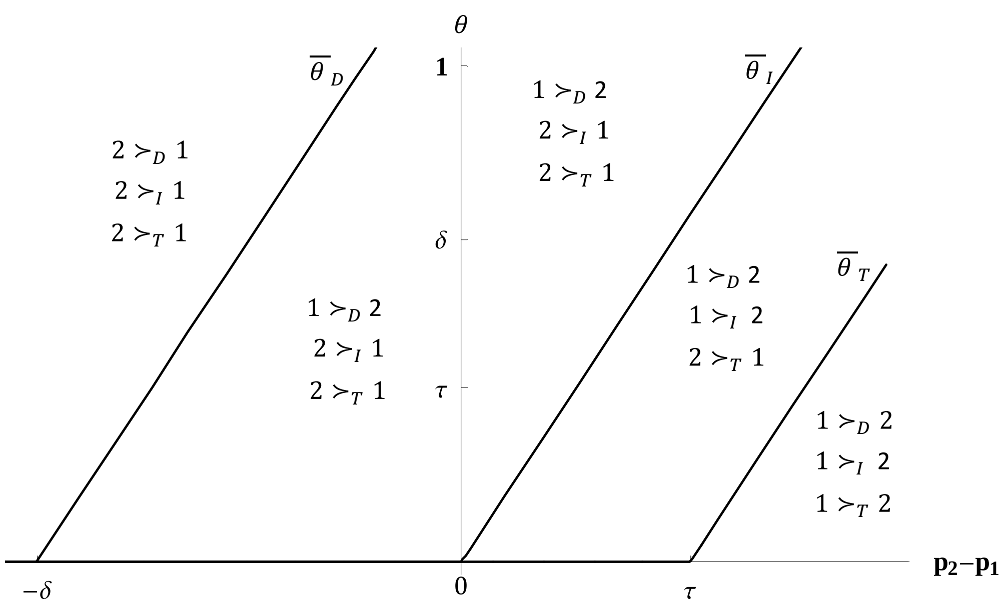

Figure 1: Consumer choice (with $q = 0.5$, $\delta = 0.65$, and $\tau = 0.35$)

In this revised model, the consumer choice between the two varieties of smoked trout fillets depends on her insect perception, on the price difference between these two varieties, and on her taste for environmental quality. Figure 1 represents the consumer choice according to the price difference between the two varieties and to the consumer taste for environmental quality, with fixed values for insect perception parameters. If the price of the fillets of smoked trout fed with insect meal is very low compared to the price of the conventional variety, an individual disgusted by the animal feeding with insect may nonetheless choose the insect variety if she has a sufficiently high valuation for environmental quality. If the prices of the fillets are equal, all indifferent consumers prefer the product fed with insect meal whatever their their taste for environmental quality. This type of consumers may prefer the conventional variety if the price of this variety is relatively low in relation to the price of the product where trouts have been fed with insect meal and their taste for environmental quality is also relatively low. Finally, the positive consumers prefer the product from the insect industry, except when the price of this product is relatively high in relation to the price of the conventional product and for positive consumers with a low valuation of the environmental quality. Therefore, using such a double differentiation framework, we can infer the determinants of the demand for products such as two varieties of smoked trout fillets and characterize the segments of the market in presence of information about the environmental quality of one variety.

3 Material and method

The above analysis highlights the main determinants of consumers' choice in the context of a radical food innovation with environmental benefits. In this section, we describe the protocol of a choice experiment (CE) conducted in France for drawing a parallel with the previous theoretical framework and for addressing the question of insects acceptance in animal feed.

3.1 Choice experiment

In order to elicit preferences for animal feed we led a choice experiment. In choice experiments, respondents are typically presented with a set of experimentally designed choice tasks composed of product alternatives. The required respondents have to state their choice over a set of alternatives. Each alternative is described by several characteristics, known as attributes, and responses are used to infer the value placed on each attribute.

Respondents faced to 16 choice tasks in an online survey. At each choice task, respondents faced to two products and to an opt-out option. The selected products were smoked trout fillets packs containing four slices (120g). The products had been defined according to two attributes : the price and the feed of the trouts. The table 1 presents selected attributes and levels. The levels of prices have been calibrated on the model developed in the previous section. Only two levels describe the trout feeding: inclusion or not of insect meal in the trout feeding. Participants could see the types of smoked trout fillets and their respective prices on the computer screen. The price attribute is announced in the label by the price of the 120g pack and the corresponding price per kilo, and the use of insects in trouts feeding was signaled by a logo.

Participants had to enter their choice between the three alternatives: product 1, product 2 or opt-out option. Efforts were undertaken to make the experiment similar to a real buying situation.

As the hypothetical bias are well known (Cummings and Taylor, 1999), we introduced a cheap talk in order to limit this bias (Carlsson at al.2005). We used a generic, short, and neutral cheap talk script.[3] Cheaptalk effectiveness is widely discuss in the literature and Tonsor and Shupp (2011)

[3]The cheaptalk script is avalaible from authors upon request.

Table 1: Attributes and levels

Insect \ Price (in euros)	2.86	3.32	4.14	4.95
Feed without Insects	P11	P12	P13	P14
Feed with Insects	P21	P22	P23	P24

propose an analysis of this practice in the online survey context. They show that the cheaptalk is particularly important when participants are not familiar with the evaluated attribute. Given that most of consumers is not familiar with the content of feeding for farmed fish, it seems to us adequate to include a cheap talk script. In order to reinforced the effectiveness of the cheap talk we also included an repeated opt-out reminder (Ladenburg and Olsen, 2014).

The impact of animal feeding on environment is not clearly identified by the consumers. FAO report (2016) warns that to continue to grow sustainably, aquaculture needs to become less dependent on wild fish for feeds and introduce greater diversity in farmed culture species and practices. The diversity in practices could include the substitution of fish meal by insect meal in farmed fish feed. In order to test if this argue can convince consumers to pay attention to this attribute, we divided the sample into two groups. The first group is a control group without specific information. The second group, called informed group, received an information before the choice tasks. This information was given as an information campaign presenting the impact of over-fishing for farmed fish and the available substitution solutions such as insect meal and oil.

3.2 Questionnaire and measurement scales

In order to complete the information given by the CE, participants answered to a questionnaire. This questionnaire includes three parts.The first part is interesting on food habits and consumption. Based on the NHANES food questionnaire developed in the US, with respect to appropriate scale, we selected and adapted some questions to our purpose. A second part of the questionnaire was dedicated to the consumers perception of fish feeding. Given that repeated food safety crises and lack of knowledge of consumers about farmed fish, we wanted to know how consumers perceived the use of insects in animal feed (particularly farmed fish). The third part of the questionnaire deals with the food neophobia concept.

Verbeke (2015) studies the readiness of consumers to adopt insects as a substitute for meat. He shows that food neophobia makes the largest contribution to consumers' readiness to adopt insects. To take this effect into account in our study, a psychometric instrument developed by Pliner and Hobden (1992), the Food Neophobia Scale (FNS), is included in the questionnaire. More precisely, six items of the FNS with a five-point Likert response set, ranging from "agree strongly" to "disagree strongly", are selected and translated in French: I am constantly sampling new and different foods; I don't trust new foods; I am afraid to eat things I have never had before; If I don't know what is in a food, I won't try it; I like foods from different countries; I will eat almost anything.

Table 2: Socio-demographics characteristics

Characteristics		Sample (%)		
		Non-informed N=166	Informed N=161	Total N=327
Sex	Male	46.99	52.17	49.54
	Female	53.01	47.83	50.46
Age	less than 25	3.01	6.83	4.89
	[25;35[	27.71	23.60	25.69
	[35;45[	27.71	24.22	25.99
	[45;55[	24.10	21.12	22.63
	[55;65[	16.27	21.12	18.65
	65 and more	1.20	3.11	2.14
Employment	Student	2.42	5.00	3.69
	Unemployment	9.09	4.38	6.77
	Part-time worker	13.33	10.62	12.00
	Full-time worker	67.27	64.38	65.85
	Retired	6.67	12.50	9.54
	No occupation	1.21	3.12	2.15

4 Data and Results

4.1 Data

The survey was conducted in December 2016 in France with 327 participants to the choice experiment (CE). Participants were selected from a consumer panel, managed by the market research company responsible for data collection. Questionnaire administration procedures were done electronically. Our online survey included CE questions and other questions regarding the attitudes towards food habits, fish feeding concerns, food neophobia and the socio-demographic characteristics of the participants.

Table 2 describes socio-demographic characteristics of the participants according the treatment groups. The participants were randomly assigned to treatment groups. Most of the participants are full-time workers, even if most of the characteristics are similar in the two groups, the proportion of retire people is slightly higher in the informed group.

4.2 Statistical analysis

In this subsection, we first describe the sample according to the answers on the questionnaire. In a second time, we present the first analysis of the choice experiment.

Even if 60.55% of participants declared to be agree or strongly agree with the fact that it is natural for fish to eat insects, only 38.23% of them would not be disturbed by having an insect farm close to home. The share of participants who consider that it is disgusting to consume trouts fed with insect based food is 15.29%. This result suggests that there exist a segment of consumers who are clearly not ready to accept the insect meal in animal feeding.

In order to obtain an overview of preferences for trouts fed with insects, we verify the frequency of the non-purchase behavior. It appears that 22.61% of the observed choices consist to not

Table 3: Choice frequency according to group and price differences

Choice	Non-informed	Informed	Total
$p_1 = p_2$			
Conventional trouts	60.60%	45.88%	53.22%
Trouts fed with insects	39.40%	54.11%	46.78%
$p_2 < p_1$			
Conventional trouts	42.72%	27.19%	34.94%
Trouts fed with insects	57.28%	72.81%	65.07%
$p_2 > p_1$			
Conventional trouts	81.13%	76.32%	78.71%
Trouts fed with insects	18.87%	23.68%	21.29%
All price differences			
Conventional trouts	61.59%	50.29%	55.92%
Trouts fed with insects	38.41%	49.71%	44.08%

purchase any of the two proposed products. We also notice that some respondents never choose to buy a product. We decided to focus our analysis on participants who choose at least once to buy a product (answers of 24 participants have been removed of the analysis). In this new context the non-buying option represents 16.48% of the observed choices.

Table 3 shows the frequency of choice according to the attribute "insect" over the groups (informed or not). Results of the Mann Whitney test show a significant difference between the informed and uninformed groups. It seems that the information about the impact on biodiversity of the use of insect in animal feed is important. The probability to choose trouts fed with insect meal is higher when the participants have been informed. This particular point is real when price difference between the insect and non-insect alternatives is null. When the price of the trouts fed with insect meal is higher than the price of the conventional product, the difference between the two treatment group is lower. This result seems to show that the premium for these products is limited, even if the consumers are informed on negative impact of farmed fish feeding. Nevertheless, in the inverse case, when the price of conventional trouts is higher than the price of trouts fed with insect meal, the information seems to clearly improve the share of consumers willing to accept the use of insect meal in animal feeding.

4.3 Econometric Analysis

According to Lancasterian approach, goods are defined as a bundle of characteristics, and consumers' references are stated over characteristics. In our context, products' characteristics are described by attributes in table 1.

Each individual n is faced with j alternatives in each of t time periods or choice situations. He chooses the alternative that maximizes its utility. The utility that individual n obtains from choosing alternative i in choice situation t is : $U_{nit} = V_{nit} + \epsilon_{nit}$.
Where V_{nit} is a function of observable attributes of the alternatives (depending of β_n, a vector of individual specific coefficient, and x_{nit} a vector of observed attributes) and of the decision maker, and ϵ_{nit} is an unobserved random term.

The probability that the participant n choose alternative i in choice situation t is :

$$\begin{aligned} P_{nit} &= Pr(U_{nit} > U_{njt}) \forall j \neq i \\ &= Pr(V_{nit} + \epsilon_{nit} > V_{njt} + \epsilon_{njt}) \forall j \neq i \\ &= Pr(\epsilon_{njt} - \epsilon_{nit} < V_{nit} - V_{njt}) \forall j \neq i \end{aligned}$$

McFadden and Train (2000) show that mixed logit model is an appropriate specification to take into account for heterogeneity in preferences that are not related to observed characteristics. We are interested in analyzing the distributional effects of production conditions. Thus in our specification of the model we included feeding conditions (and label) and price ranges.

The probability P_{nit} that individual n may choose alternative i in the t choice situation is given by :

$$L_{nit}(\beta_n) = \frac{exp(x'_{nit}\beta_n)}{\sum_{j=1}^{J} exp(x'_{njt}\beta_n)} \tag{2}$$

For a given value of β, the conditional logit choice probability is a conditional logit:

$$S_n(\beta,) = \Pi_{t=1}^{T} L_{ni(n,t)t}(\beta_n) \tag{3}$$

Where $i(n, t)$ denotes the alternative chosen on choice occation t. The unconditional choice probability, in the random parameter logit is given by :

$$P_{nit} = \int S_n(\beta_n) f(\beta_n \mid \theta) \mathrm{d}\beta_n \tag{4}$$

where $f(\beta_n \mid \theta)$ is the density function of θ. This specification allows that different participants may have different preferences.

The mixed logit estimation is based on **xx** observations (**xx** participants performing 16 choice tasks with 3 three option for each task).

Two models have been estimated. In the model 1, a basic specification is estimated included the main attributes (price, insect feeding, group). Model 2 proposes to estimate how the price of the alternative choice impacts the preferences. In this aim we included two dummy variables, "Cheaper" is equal to 1 if the product is the cheaper product in the choice set and "Higher" is equal to 1 if the product is the more expensive in the choice set.

The estimation results of the mixed logit are shown in table 4. An alternative specific constant (ASC) associated with opt-out option captures the utility related to the no-buy option. The ACS is highly significant and negative, it means that consumers gained a lower utility from choosing no buy-option than any alternative. In other words, consumers increase their utility when choosing one of the proposed product compared to the no-buy option.

As expected, the price has a significant and negative effect indicating that consumers utility decreases with increasing price. The effect on the price is very slightly impacted by the fact to be informed (parameter is significantly different of zero but close to zero).

Table 4: Estimation Results

	(1) Model 1	(2) Model 2
ASC	-7.028***	-6.333***
	(-39.05)	(-28.14)
Price	-1.575***	-1.333***
	(-34.64)	(-20.79)
Price * Info	-0.0598**	-0.0626***
	(-2.53)	(-2.64)
Insect * Info	1.185***	1.215***
	(3.72)	(3.75)
Insect	-0.645***	-0.665***
	(-2.86)	(-2.89)
Cheaper		0.498***
		(4.59)
Higher		0.0780
		(0.75)
SD		
Insect	2.735***	2.787***
	(17.76)	(17.80)
N	14544	14544

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The estimated coefficient for the attribute "insect" is significant at 1% level and indicates that the utility of consumers decreases when choosing the trouts feed with insects. The standard deviation of this coefficient is highly significant, indicating that this coefficient does indeed vary in the population. The negative effect of the insect attribute is clearly reverse when participants were informed on impact of over-fishing for farmed fish. The information campaign on impact of biodiversity seems to have a strong effect on preferences. The lack of knowledge about fish breeding and feeding could explain the magnitude of this cross-effect. In this case it also means that consumers are not indifferent on these condition fish breeding.

5 Conclusion

This paper presents a formal framework to analyze the willingness to accept of consumers for insect meal in animal feeding. After developing a theoretical framework in order to analyze the existence of demand for products inspiring either disgust or positive taste for the same attribute, we conducted a choice experiment to evaluate which demand segmentation can emerge. First results seem to show that the information about the environmental impact of feeding methods in aquaculture may influence consumers choice. The preference for animal feeding with insect meal could be improve with information campaigns on the negative impact of traditional feeding practices.

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