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Integrating sensory evaluations in incentivized discrete choice experiments to assess consumer demand for cricket flour buns in Kenya

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Abstract

In this study, we present one of the first thorough assessments of potential consumer demand for an insect based food product. We assess the demand in terms of Kenyan consumer preferences and willingness to pay for buns containing varying amounts of cricket flour. The novel feature of the study is that it uses an incentivized discrete choice experiment method integrated with sensory experiments intended to reduce any hypothetical bias and to allow participants to acquire experience in terms of tasting the different buns before they make their choices in the choice tasks. We find significant and positive preferences for the buns which contain cricket flour. Interestingly, the bun products with medium amounts of cricket flour are preferred to no or high amount of cricket flour. Finally, we show in a simulated market that the cricket flour based buns are likely to obtain a greater market shares than that of standard buns today.

Keywords: Cricket Flour, insect, incentivized discrete choice experiment, Taste, Willingness to pay

1. Introduction

With the world population expected to reach 9 billion people by the year 2050 (UN, 2015) the demand for protein, and in particular animal protein, is expected to increase profoundly. Furthermore, despite access to animal protein in many developing countries being somewhat limited due to increasing prices (Ivan and Martin, 2008) and climate change related reduced production of livestock (IPCC, 2007), the continued general rise in income and living standards in many developing countries and emerging economies is expected to lead to particularly dramatic increases in the demand for animal protein (Delgado et al., 1999; FAO, 2006). Faced with the fact that animal protein is not a very sustainable

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source of protein (Steinfeld et al. 2006; FAO, 2009) and that increasingly negative impacts of climate change are making agricultural production more and more difficult in these parts of the world, finding novel and sustainable ways of meeting this increasing demand for protein arguably poses one of the biggest challenges of our time.

In relation to this, edible insects have recently been highlighted as a potentially valuable future source of food (FAO, 2013); specifically in areas where food insecurity and malnutrition represent severe societal problems that will only worsen given the expected future changes. Insects contain nutrients such as protein, minerals and vitamins which are essential for human consumption (DeFoliart, 1989; Bukkens, 1997; Paoletti et al. 2003). Due to their high feed conversion efficiency, rearing of edible insects for human consumption will emit much less greenhouse gases (GHG) than compared to obtaining the equivalent amount of protein from conventional livestock production (Oonincx et al. 2010; and Oonincx and Boer, 2012). Today, livestock production is responsible for about 18% of the total GHG emissions to the environment (Steinfeld et al. 2006), and if the increased demand for animal protein in the future is to be met by increased traditional livestock production, this environmental problem will only increase. Instead, establishing a small- to large-scale edible insect production sector presents an opportunity to cover substantial proportions of the increasing demand for animal protein while at the same time avoiding increasing GHG emissions. Additionally, and of particular importance for the many developing countries where land and water are becoming crucially scarce due to increasing populations and decreasing precipitation, rearing of insects requires less land and less water compared to traditional cattle rearing (FAO, 2013).

Despite being consumed more or less worldwide at some point of time or another, edible insects are today used as food in only a few cultures mainly in developing countries (Ramos-Elorduy, 1997). The insects are typically collected from harvesting in the wild (van Huis, 2013). In western Kenya for instance, locals have traditionally consumed insect species such as lake flies, termites, black ants, and grasshoppers (Christensen et al. 2006; Ayieko et al. 2010, Kinyuru et al. 2012). However, edible insects are not part of the conventional food chain, and if the aim is to develop insect-based food products and introduce them into the everyday diet of a significant proportion of the world's population, there is a need to investigate whether consumers accept them as food or not. For instance, developing a production of edible insects will be pointless if the consumers do not want to eat insects or insect-based products. Therefore, information on the potential demand for edible insects as food is of paramount importance, and may facilitate product development which meets consumers' preferences (Brown and Eisenhardt, 1995; van Kleef et al. 2005). This may further facilitate the assessment of the prospects and the challenges in relation to mass-rearing, quality control and trade, as well as political and economic incentives for the production of edible insects.

While several studies have investigated various aspects of utilizing insects for food (see FAO, 2013), very few studies focusing on the consumer acceptance of insects as food have emerged (Hartmann et al. 2015; Megido et al. 2014; Tan et al. 2015, Verbeke, 2015). However, these studies focused mainly on meal formulations and sensory liking rather than on consumer preferences and Willingness-To-Pay (WTP) for product characteristics. Focusing specifically on these aspects, this paper aims at providing a first insight into the potential demand for edible insects using data from a field experiment in Kenya. Using an incentivized discrete choice experiment (DCE), we assess the demand in terms of consumer preferences and WTP for buns made from cricket flour (CF). As hypothetical experiments are generally found to induce hypothetical bias (de-Magistris and Gracia 2014) which is likely to be caused to a large extent by lack of incentive compatibility (Vossler et al. 2012), several studies have employed nonhypothetical DCEs to assess demand for goods and services (e.g. Lusk and Schroeder 2004; de-Magistris & Gracia, 2014; Gracia et al. 2011; Moser & Raffaelli, 2012; Mørkbak et al. 2014). A novel feature of this study is that the DCE was integrated with a sensory experiment (Peryam and Girardot, 1952) designed to measure taste preferences for the different compositions of buns. We argue that this increases the credibility and validity of our demand estimates because, besides paying for the chosen products, respondents obtained direct experience with the new food products under investigation by actually tasting them before making their purchase decisions in the DCE. Sensory evaluations such as product tasting are important to collect reliable information in consumer studies (McIlveen and Armstrong 1998; Bi et al.2015). However, accounting for taste is usually overlooked in consumer valuation studies (Mueller et al. 2010; Chowdhury et al. 2011) while it is without a doubt one of the most important factors influencing consumers' food choices (Lappalainen, et al. 1998; Arvola et al. 1999).

In the next section we present the theoretical framework and the experimental setup as well as the product development and the field study design. Then we present the results followed by a discussion and conclusion.

2. Methodology

2.1 Theoretical framework and econometric specification

The DCE method was originally developed by Louviere and Hensher, (1983) and Louviere and Woodworth, (1983) to forecast consumer demand in marketing research. Since then it has been increasingly used in consumer food preference and marketing research (e.g. Ewing and Sarigöllü, 2000; Jaeger and Rose, 2008; Drescher et al. 2014). An advantage of the DCE method is that it uses multi-attribute expression of utilities (Lancaster 1996). In addition, the presentation of choice scenarios that resemble consumers' actual market-based decisions makes the DCE method popular among researchers (Adamowicz et al. 1998). More importantly, the DCE method utilizes the random utility theory (RUT) (McFadden, 1986) which provides a theoretical framework to deal with unobserved choice behavior when modeling choice responses. Since there are utility elements the researcher does not observe, the utility expression consists of an observable as well as an unobservable component. The former is defined based on the data available, i.e. the observed choices, and the latter is specified by assuming an error term capturing the remaining unobservable parts. The identification of the econometric model is then guided by the assumptions placed on the error term and the preference heterogeneity.

The model applied in this study is a mixed logit (ML) type of model, which can be derived in a number of different ways (Train, 2009). Following the RUT, the utility *U* of individual *n* choosing alternative *k* among *J* given alternatives in choice situation *t* can generally be expressed as:

$$U_{ntk} = \begin{cases} V(X_{ntk}\beta, \varphi) + \varepsilon_{ntk}, k = 1,2; \\ V(ASC, X_{ntk}, \beta) + \varepsilon_{ntk|}, k = 3(optout) \end{cases} \qquad (1)$$

where the indirect utility function, V, is a function of the attributes of the alternatives (X_{nk}) and the respective parameters (β') , i.e. $V = \beta' X_{nk}$, and φ is an error component. Assuming that the error term ε_{nk} is Gumbel-distributed, the probability that individual *n* chooses alternative *k* among *J* given alternatives in choice situation *t* is given by:

$$P_{ntk} = \frac{e^{\mu \beta'_n X_{nkt}}}{\sum_j^J e^{\mu \beta' x_{ntj}}} \qquad (2)$$

where β' is the vector of all betas estimated for the attributes, μ is the scale parameter which is commonly normalized to unity. Equation (2) is the most commonly used multinomial logit (MNL) model which assumes that the ε_{nk}'s are identically and independently (i.i.d.) distributed across alternatives, which means that there is no variation in preferences. This is the major drawback of the MNL models as, in practice; preferences are likely to vary within the sample population, which is usually referred to as *preference heterogeneity*. Moreover, there can be correlation across utilities, which is not captured by the Gumbel-distributed error term, and this compels a specification of an additional error component (EC) (Scarpa et al. 2005, 2007, 2008). The role of the EC is to capture any additional variance associated with the cognitive effort of evaluating experimentally designed alternatives compared to the status quo (Herriges and Phaneuf 2002, Ferrini and Scarpa, 2007). Capturing preference heterogeneity and unobserved variance is an important part of data analyses because failure to do so may lead to unreliable estimates which might have great repercussions on the conclusions obtained and the ultimate policy advice (Greene, 2008).

Therefore, in this paper, we extend the MNL model by applying a model formulation which incorporates a random parameter error component logit (RPECL) model, which allows relaxing the assumption of the *i.i.d.* error terms. Specifically, the RPECL[1] model allows for heterogeneity in preferences across individuals and correlation across utilities. Following Train (2009), the estimated parameters, β', vary over individuals with density $f(\beta)$, which can be explained by the mean, b, and standard deviation, γ. Since the analyst cannot fully observe the utility of the decision maker, conditioning the probability on β as in equation (2) is not possible. Therefore, the unconditional probability, which can be derived by taking the integral of equation (2) over all values of β_n will suffice. Let θ represents all the random parameters including the error component, and the probability becomes:

[1] Estimating equation (3) requires an assumption of the distribution for the random parameters and any appropriate distribution can be adopted (Hensher and Greene, 2003). In this paper, a normal distribution, which is the most commonly used distribution (Train, 2009), is assumed for all quality attribute parameters. For simplicity, the price parameter is incorporated as a fixed parameter, thus avoiding the problems associated with specifying a random price parameter (Train and Sonnier, 2005; Meijer and Rouwendal, 2006; Olsen, 2009). We tried estimating our models with a lognormal distribution of the price parameter. However, with this specification the model failed to identify, most likely due to the well-known fat tail issues associated with this distribution. A normal distribution specification was not considered due to its implication of a probability of having positive utility associated with giving up money which is not consistent with economic theory.

$$P_{nk} = \int \left(\frac{e^{\mu\beta' x_{ntk}}}{\sum_j^J e^{\mu\beta' x_{ntj}}} \right) f(\theta) d\theta \qquad (3)$$

The error component (φ) is implemented as a zero-mean normally distributed random parameter ($\varphi|0, \delta^2$). The expressions in equations (3) enable us to account for the panel effect (Train, 2009) as each participant processed a sequence of 12 different choice tasks. Once coefficients are obtained from estimating equation 3, the WTP estimates can be calculated as:

$$WTP = \frac{-(\beta(non\ price\ attribute))}{\beta(price\ attribute)} \qquad (4)$$

The standard errors of the WTP are estimated using the delta method. We use the software BIOGEME version 2.2 (Bierlaire, 2003) to estimate all the models using 1000 Halton draws which was found to be a suitable amount of draws for results to stabilize.

2.2 *Field study design*

The experiments were conducted in three counties[2], namely Siaya, Nandi and Nairobi counties in Kenya. These counties were selected to mirror some of the distribution of the Kenyan population in terms of ethnicity, region (rural or urban) as well as the tradition of eating edible insects. Nairobi is selected since it is the capital and the biggest city in Kenya accommodating more than 3 million people with diverse ethnic, socioeconomic status and culture. Nandi county was chosen since it is located in Rift Valley province which hosts the largest population (more than 10 million) in Kenya according to the 2009 population and housing census (KNBS, 2009). Siaya county with a population of more than 800,000 was selected to represent areas where the insect eating tradition is still present. Both Nairobi and Nandi counties represent regions where insect eating is uncommon. A total of 116 participants were chosen based on a random sampling procedure. They are either head of households or spouses (see table 1). In Siaya and Nandi counties, which represent the rural segment of the sample, five locations were randomly chosen.

[2] A county is a geographical unit which has its own political administration under the 2010 Kenyan constitution.

Table 1: Sample distribution

County	Region	Ethnicity	Insect eating tradition	No. of respondents
Siaya	Rural	Luo	Yes	40
Nandi	Rural	Kalenjin and Nandi	No	34
Nairobi	Urban	Mixed	No	42
Total				116

Then two villages were chosen in each location. In Nairobi, the urban sample, three locations were randomly selected. Since a complete list of households is not available in the study areas, the recruitment of subjects was carried out in cooperation with the chiefs and the sub-chiefs of the respective administrative locations. Table 2 summarizes the characteristics of the subjects across counties.

Table 2: Subjects' characteristics

	Counties					
Variable	Siaya (rural)		Nandi (rural)		Nairobi (urban)	
	Mean	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Age	37.0	11.7	42.9	9.9	36.8	10.9
Household size	5.1	2.1	4.5	1.5	3.7	2.2
Number of children (<18 years)	2.6	1.9	1.9	1.2	1.5	1.6
Land owned in acres	1.9	1.4	2.7	3.8	2.3	2.8
Monthly income in KShs	8331.2	7091.7	14602.9	14686.5	23250	18196.8
			Percent			
Gender (female)	62.5		35.3		52.4	
Education						
Primary education	42.5		29.4		11.9	
Secondary education	22.5		26.5		35.7	
Tertiary education and above	10		17.7		30.9	
Other education[a]	25		26.5		21.4	
Employment						
Formally employed[b]	20		8.8		16.7	
Self-employed	35		35.3		50	
Farming and fishing	35		41.2		2.4	
Other[c]	10		14.7		30.9	

[a] no education, and drop outs from primary and secondary schools
[b] government and private sector employment
[c] student, housewife, retired, unemployed and casual workers

2.3 Product development

The product context is bread, more specifically baked buns that are typically based on wheat flour. The decision to use this product in the experiment was guided by the following three reasons. First, many consumers can afford to buy buns in Kenya as they are commonly available in small kiosks and big supermarkets across the country. Second, focus groups and key informant discussions indicated that bread in general and buns in particular are part of the well accepted and staple food items in Kenya. Third, as the size of buns is smaller relative to other types of bread products, the logistic burden in terms of product transportation as well as cost, time and labor constraints were practically manageable.

Cricket flour was selected because crickets can be mass-reared and there is an increasing interest in establishing such a cricket production in Kenya. Three different bags of buns containing 0g (*Control*), 6.25g (*Medium CF*), and 12.5g (*High CF*), respectively, were baked by professionally trained technical assistants at the Food Processing Workshop Unit at the Jomo Kenyatta University of Agriculture and Technology in Kenya. Before the initiation of the main baking activities, trial buns were produced to validate the recipe specification which was initially based on Kinyuru et al. (2009). In addition, the trial buns were made to verify whether the recipe specification could form the desired buns which would resemble the buns already available in the real market. Next, a focus group discussion was conducted where participants were asked to taste and subsequently evaluate the taste, texture, color and smell. Based on these sensory evaluations, the final recipe specifications as shown in table 3 were developed. Table 4 shows the characteristics of the final bags of buns used in the DCE. The higher the amount of the CF, the heavier, the softer, and the more brown the buns are. In particular, the weight of the buns increases when the amount of the CF increases because CF contains more fat than wheat flour which can also lead to less water transpiration during the baking process.

Table 3: Ingredient composition of the buns

Buns	Amount of wheat flour (g)	Amount of cricket flour (g)	Amount of fortified wheat flour (g)	Baking fat (g)	Salt (g)	Sugar (g)	Yeast (g)	Acetic acid (ml)
Control bun	125	0	0	7.5	1.25	5	2.5	0.125
Fortified control bun	75	0	50	7.5	1.25	5	2.5	0.125
Medium CF bun	118.75	6.25	0	7.5	1.25	5	2.5	0.125
Fortified Medium CF bun	68.75	6.25	50	7.5	1.25	5	2.5	0.125
High CF bun	112.5	12.5	0	7.5	1.25	5	2.5	0.125
Fortified High CF bun	62.5	12.5	50	7.5	1.25	5	2.5	0.125

Note: 'g' refers to grams, and 'ml' refers to milliliters.

Table 4: Texture and visual appearance of the buns

Scones	Final weight (g)	Texture	Appearance
Control bun	158	Firm	White
Fortified control bun	158	Firm	White
Medium CF bun	159	Medium firm	Medium brown
Fortified Medium CF bun	159	Medium firm	Medium brown
High CF bun	160	Soft	Brown
Fortified High CF bun	160	Soft	Brown

The active shelf life of the bun products was seven days. On day 1, the buns were baked, packed and labeled. Since it was not practically possible to ensure that all participants received packages of buns with identical remaining shelf life, participants were told the remaining shelf life when participating in the experiment. Thus, from day 2 to day 5 (see figure 1) the buns were used in the field experiment based on the assumption that there would not be any significant changes in the properties of the buns between these days. Our experience in the field was that there were no noticeable changes in the product characteristics such as texture, appearance and taste from day 2 to 5. Although the buns were still suitable for consumption on the 6th and 7th days, they were not used in the experiment on these days to avoid the effects of potential variation in the properties of the products on peoples' preferences. In addition, the provision of the actual products to the participants was randomized according to their shelf life to further avoid any impact of this variation.

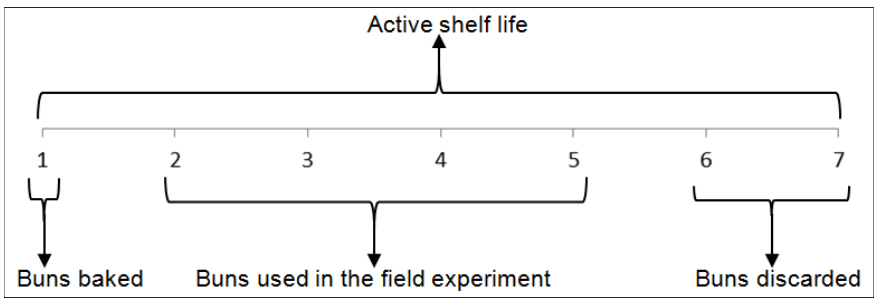

Figure 1: Shelf life of the bun products

2.4 Experimental design and the questionnaire

Conducting nonhypothetical DCEs based on a new product is difficult because it requires the availability of the product itself and all of its profiles. In this study, we deal with this issue by keeping the design size at a practically manageable size in terms of being able to bake and handle the many different types of buns. In the initial phase of the design process, three relevant attributes were identified which were used to produce a design that was practically manageable. These are the amount of CF, whether some portion of the wheat flour is fortified or not *(Fortified),* and price *(Price).* The amount of CF is included to directly test consumers' preferences towards edible insects. Crickets can be consumed either as whole crickets or in a grinded form, i.e. flour. The flour form was used in this study because it can easily be mixed into other staple foods which would likely increase consumer acceptance (Ayieko et al. 2010; FAO, 2013). For instance, in eastern and southern African context, many households depend mainly on cereals that are low in protein (Stevens and Winter-Nelson, 2008). These cereals can fairly easily be enriched with CF. Furthermore, CF is already being produced in other parts of the world such as in Thailand. Hence, introducing the same product in Kenya[3] may succeed in the future as the knowledge and production technologies are already available.

The Kenya National Food Fortification Alliance (KNFFA) has been promoting industrial fortification of major staples and oils with micronutrients since 2011 to reduce the burden of micronutrient deficiency. As a result, food fortification is known to many consumers as most industrialized products such as maize, wheat, salt and major cooking oils are fortified in Kenya (KNFFA, 2011). Therefore, an attribute representing whether some portion of the wheat flour is fortified or not was included to enable assessing the acceptance of the ongoing mass staples fortification programs in addition to providing reasonable quality attributes that enabled participants to make a more realistic purchase decision.

As shown in table 3, the levels for the amount of CF are 0g (*Control with no CF*), 6.25g (*Medium CF*), and 12.5g (*High CF*), which amounts to 0%, 5% and 10%, respectively, of the total wheat flour used per bags of buns. The attribute related to fortification has two levels: 0g and 50g (see table 3). When CF and/or fortified wheat flour is added, the amount of the regular wheat flour is adjusted so that the total amount of flour does not exceed 125g in any of the bags of buns. The price levels were identified following a focus group discussion and a pre-survey assessment of the price of buns in kiosks and supermarkets. The market price of one bun ranged from 5 to 10 Kenyan Shillings (KShs) at the time of the experiment, which means that three pieces of regular buns could cost from KShs 15 to 30. The focus group discussion also indicated that the acceptable price range was between KShs 5 and 10 for one bun. Therefore, setting the minimum price for one piece of bun adjacent to KShs 6 or 7 was found to be appropriate, thus, the price of three pieces of buns contained in one bag was set at KShs 20. The final price levels used in the DCE was KShs[4] 20, 25, 30, 40, 60, and 90.

[3] This study is part of the GREEiNSECT project which aims, among other things, to provide knowledge and technological solutions to establish small- to large-scale insect production sectors in Kenya through collaborative research between public and private institutions. Researchers in the project are testing specific technological aspects of management systems for domesticated cricket production in Kenya.

[4] 1 US Dollar was around 90.50 KShs at the time of the data collection.

The next step was to produce the DCE design. The design process passed through several rounds of testing and design procedures based on experimental design theory following e.g. Louviere et al., (2000). We used the Ngene software (ChoiceMetrics, 2012) to generate the DCE experimental design. Using priors informed by two rounds of pilot studies[5], a D-efficient fractional factorial design was used to generate the 12 choice sets that participants were subjected to. Following this, a full questionnaire was developed. The scenario description explained the attributes used in the experiment and provided some relevant background information on edible insects in general and crickets in particular. In line with Carlsson and Martinsson (2001) and Carlsson et al. (2007a, b), a forced CE was implemented as it was found appropriate for the present context. As discussed in Harrison, (2006) and Carlsson et al. (2007a, b), including an opt-out alternative, e.g. a 'none of these', 'business as usual' or 'status-quo' option that avoids forcing respondents to choose something they would not choose in real life is more important for studies aimed at valuing public goods than marketing studies. As the aim of this paper is to investigate preferences and WTP for buns with and without CF, which is more in line with a marketing study, the opt-out alternative is defined as a standard alternative that is constant across all choice tasks (see figure 2). The final design of the DCE and the questionnaire was tested and validated using a pilot test sample of 42 respondents.

	Bag 1	Bag 2	Bag 3
Amount of cricket flour	12.5g	6.25g	I would purchase the standard buns at a price of 20 KShs
Amount of fortified wheat flour	50g	0g	
Price	30 KShs	25 KShs	
I would choose (check √ one)	◯	◯	◯

Figure 2: An example of the choice sets

2.5 Incentivized discrete choice experiment

The incentivized DCE followed five steps. First, upon arrival to the experimental site, participants were seated and each of them was assigned one enumerator to conduct personal interviews. Second, they received an amount of KShs 30 as a show-up fee and an additional KShs 90 which they could later spend fully or partly on paying for one of the bun products according to their choices in the DCE.

[5] A fairly large effort was put into obtaining as efficient a design as possible since it was known a priori that a relatively limited number of participants would be possible given the time and budget constraints in the project.

Third, participants were asked to view and taste the three samples of the buns, and subsequently fill in a 9-point hedonic scale (Peryam and Girardot, 1952). Fourth, the DCE process was then conducted. In this case, they were given explanation regarding background information about crickets' nutritional importance and the overall DCE scenario. And then the following subject instruction, similar to the incentivization scheme used in Chang et al. (2009) and Mørkbak et al. (2014), was explained to each participant:

"You will be provided with twelve different choice scenarios within which three bags (Bag 1, Bag 2, and Bag 3) of buns are included. Bag 1 and Bag 2 may contain buns made from wheat flour mixed with cricket flour. Some portion of the wheat flour can be fortified. Bag 3 contains only buns made from the wheat flour which was not fortified. In each scenario, you should choose ONE of the bags you would like to purchase (Bag 1 or Bag 2) or you can choose Bag 3 if you would not like to purchase Bag1 or Bag2. After you complete all 12 shopping scenarios, we will ask you to draw a number (1 to 12) from an envelope to determine which shopping scenario will be binding. In the envelope are numbers 1 through 12. If the number 1 is drawn then the first shopping scenario will be binding, and so on. For the binding scenario, we will look at the product you have chosen, give you your chosen product, and you will pay the listed price in that scenario. You should use the 90 KShs for the purchase. The most expensive alternatives cost 90 KShs. If you have chosen a cheaper alternative, you will be given the remaining money. Although only one of the 12 shopping scenarios will be binding there is an equal chance of any shopping scenario being selected as binding, so think about each answer carefully."

While Lusk and Schroeder (2004) and Mørkbak et al. (2014) used a procedure of drawing a number to determine the binding choice set common for a whole group of participants, we followed the procedure used in Alfnes et al. (2006) and Gracia et al. (2011). At the end of the experiment, each individual participant was asked to draw a numbered ball from 1 to 12 (the total number of choice sets) from a hat to determine which choice set would be realized, and participants then had to pay the listed price to receive the product they had chosen in this specific choice set.

3. Results

3.1 The sensory experiment

Results obtained from the 9-point hedonic scale are presented in table 5. *Medium CF* buns are liked the most for their taste and overall liking. The mean taste score of the *Control* buns is 6.32 whereas it is 6.33 for the *High* CF buns. Following Thunström and Nordström (2015), we test for differences in mean scores using Wilcoxon signed-rank test. While the null hypothesis regarding no difference between the mean taste scores of the *Control* and *Medium* CF buns is rejected (*p-value 0.0303),* it cannot be rejected for the *Control* versus *High* CF buns, and *Medium* CF versus *High* CF buns. The same is true for mean scores of the overall liking for the different bags of buns. In other words, the sensory part of the experiment suggests that participants prefer the buns with a medium amount of CF. This is expected to translate into positive preferences for the *Medium* CF attribute in the following analysis of the DCE part of the experiment.

Table 5: Mean taste and overall liking scores for the three buns

	Mean[a]	Std.dev.	Min	Max	Observations	Wilcoxon signed-rank test (p-value)
Taste						
Control buns	6.32	2.07	1	9	116	Medium vs. High (0.2540)
Medium CF buns	6.80	2.13	1	9	116	Control vs. Medium (0.0303)
High CF buns	6.33	2.88	1	9	116	Control vs. High (0.8047)
Overall liking						
Control buns	6.65	1.89	1	9	116	Medium vs. High (0.2577)
Medium CF buns	6.89	1.97	1	9	116	Control vs. Medium (0.0931)
High CF buns	6.31	2.85	1	9	116	Control vs. High (0.7589)

[a] 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neutral, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely

3.2 The incentivized DCE

Results from the RPECL[6] model are presented in table 6. The estimated standard deviations of random parameters are all significant indicating that there is heterogeneity in preferences across individuals. In addition, in agreement with Scarpa et al. (2008), the error components are highly significant, indicating that there is correlation across the two designed alternatives relative to the Control buns. Overall, these results seem to justify the application of the RPECL model. Furthermore, the estimated price parameters are negatively significant which is consistent with economic theory. In addition, the sign of the coefficients of the ASCs are significantly negative indicating that participants generally dislike the Control buns regardless of the attribute levels of the two alternatives.

Further inspection of the results shows that participants have the strongest preferences for the *Medium* CF buns, which is consistent with the results from the sensory experiment. Another notable result is that consumers from Nandi county, where the tradition of insect consumption is not present,

[6] To conserve space, results from the MNL model are not presented here. The results are available from the authors upon request.

appear to have somewhat stronger preferences for both *Medium* CF and *High* CF than consumers from Siaya and Nairobi counties. Moreover, results show that participants have positive preferences for buns with fortified wheat flour, and in relation to this, urban participants exhibit stronger preferences for these products than rural participants.

Table 6: RPECL model results (standard errors)

Parameters	(Siaya – Rural)	(Nandi – Rural)	(Nairobi - Urban)
Random parameters			
Medium CF	2.03(0.391)***	2.38(0.554)***	1.27(0.620)***
High CF	0.622(0.327)*	1.23(0.535)***	0.842(0.665)
Fortified	0.830(0.253)***	0.915(0.251)***	1.23(0.323)***
Nonrandom parameters			
Price	-0.075(0.008)***	-0.059(0.008)***	-0.057(0.008)***
ASC (Control buns)	-1.46(0.355)***	-1.18(0.321)***	-0.819(0.345)***
Standard deviations of random parameters			
Medium CF	0.772(0.323)***	2.33(0.480)***	4.89(0.899)***
High CF	1.79(0.351)***	2.75(0.490)***	5.50(0.889)***
Fortified	0.848(0.281)***	0.490(0.370)	1.33(0.313)***
Error component			
φ	1.75(0.357)***	0.867(0.338)***	1.52(0.401)***
Number of observations	480	408	504
Log-likelihood	-377.3	-324.6	-348.2
Adjusted pseudo R^2	0.268	0.256	0.355

Note: '*', '**', and '***' denote 10%, 5% and 1% significance levels, respectively.

While the results show that the buns with CF are preferred to the buns without CF, consumers' preferences are heterogeneous as indicated by the significant standard deviation estimates. In this regard, while almost none of the consumers in Siaya have negative preferences[7] for the *Medium* CF buns, 15% and 40% of the consumers in Nandi and Nairobi, respectively, reacted negatively to this product. Considering the *High* CF buns, 36% of the consumers exhibit negative preferences in Siaya whereas 33% and 44% of the consumers in Nandi and Nairobi, respectively, have negative preferences for the same product. In general, the results seem to indicate that the proportion of consumers with negative preferences for *High* CF buns is higher than for *Medium* CF buns. In addition, the proportion of urban consumers who exhibit negative preferences for buns with CF is higher than among rural consumers.

3.3 Willingness to pay and market share predictions

[7]The percentage proportion of consumers with negative preferences is calculated by taking the probability that the mean is less than zero of a normal distribution.

The mean marginal WTP estimates are presented in table 7. Participants from Siaya county have an additional WTP of KShs 27 for *Medium* CF buns compared to buns without CF whereas participants from Nandi and Nairobi counties have a WTP of KShs 40 and 22, respectively. Interestingly, participants in Siaya have a somewhat lower additional WTP of KShs 8 for *High* CF buns compared to buns without CF whereas participants in Nandi and Nairobi are willing to reduce their pocket by KShs 21 and 15, respectively, for the *High* CF buns. Consumers in general are willing to pay amounts that range from KShs 11 to 22 for buns with fortified wheat flour relative to buns that have not been fortified, with the highest WTP among consumers in Nairobi. Looking at the confidence intervals of the WTP values show that there seems to be no significant differences between the WTP values for the *High* CF buns across counties.

Table 7: Willingness to pay estimates in KShs (95% confidence intervals in parenthesis)

	(Siaya – Rural)	(Nandi – Rural)	(Nairobi - Urban)
Medium CF	26.9*** (19.2 – 34.6)	40.0*** (20.5 – 59.5)	22.4* (-2.8 – 47.7)
High CF	8.2* (-1.1 – 17.6)	20.7* (-0.9 – 42.2)	14.9 (-13.9 – 43.7)
Fortified	11.0*** (5.1 – 16.9)	15.4*** (8.1 – 22.7)	21.7 ***(10.1 – 33.3)

Note: '*', '**', and '***' denote 10%, 5% and 1% significance levels, respectively.

The potential demand for buns with CF may also be illustrated by predicting the market share in a presumed market scenario (Lee et al. 2011). Using a logistic choice probability formulation (see equation 2), the probabilities of choosing the different alternative bags of buns can be derived by substituting the estimated preference parameters of the full sample, based on which market share can be calculated. Despite the log-likelihood ratio test (which equals 41.8 with critical value of 16.92 at 5% and 9 degrees of freedom) rejected preference equality across the three split samples, consumers overall have the same inclination towards the different CF buns across splits. Thus, market share predictions based on the pooled data will provide useful insights into the average market potential of CF buns. Prediction of market shares requires assumptions concerning which products are available in the market and at what prices they are sold (Gracia, 2014).

Table 8: Relative market scenarios

Scenario I	Two products: the *Control* bun sold at 20 KShs and the *Medium* CF bun sold at prices of 20 – 160 KShs.
Scenario II	Two products: the *Control* bun sold at 20 KShs and the *High* CF bun sold at prices of 20 – 160 KShs.
Scenario III	Three products: the *Control* bun sold at 20 KShs, and the *Medium* CF and *High* CF buns sold at prices of 20 - 160 KShs.

As we are dealing with only buns and as no bread products with CF are currently available in the market, assuming market scenarios where the *Control* buns and additional buns with CF are available would mimic future market trends. In addition, we use the real prices of the *Control* buns as a lower bound to make the analysis more realistic. Furthermore, a fairly wide range of prices is used for the different products in order to reflect a potential price fluctuation of the products in the market scenarios as shown in table 8.

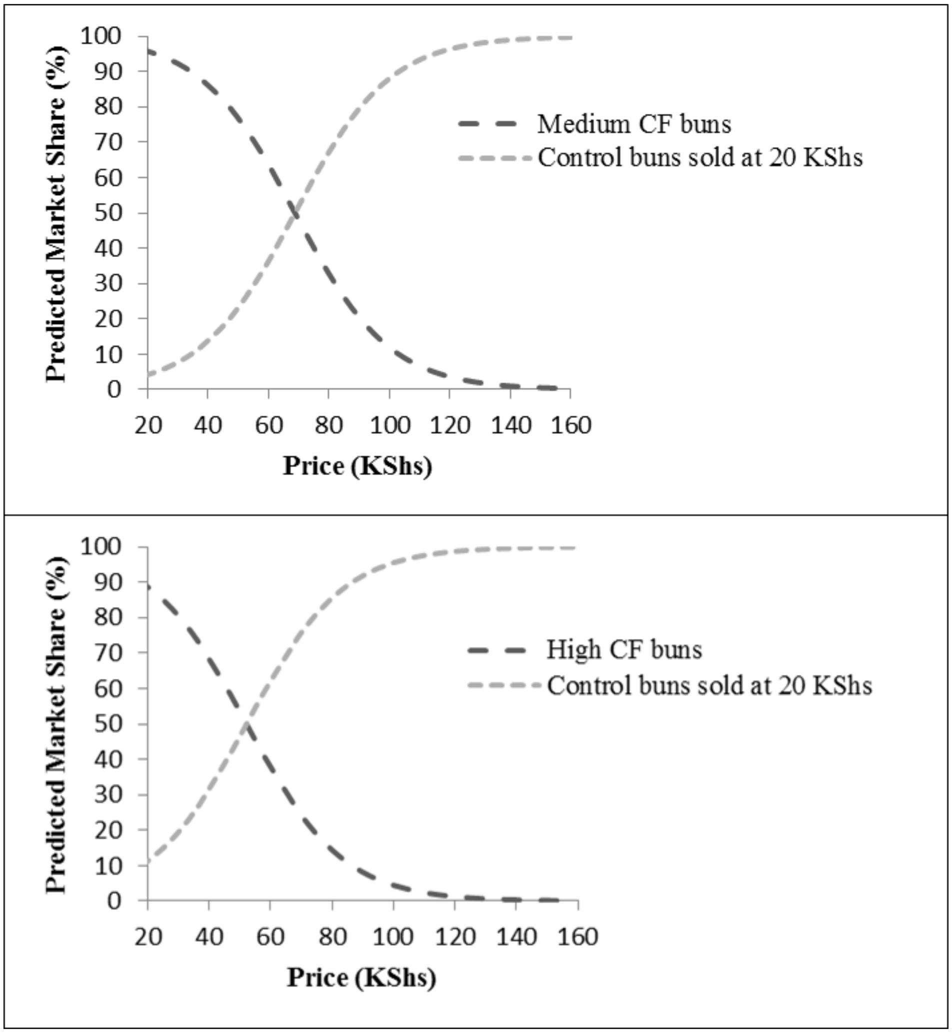

Figure 3: Predicted market shares of alternative market scenarios for two bun products

Figure 3 presents the results of two products scenarios. The results show that the *Medium* CF buns would have a better market share than *High* CF buns at any price level and in all market scenarios relative to the *Control* buns. In accordance with the previous results, we note that the *Medium* CF buns obtain a higher market share than the *High* CF buns at the same price. Figure 4 shows the market share prediction when three products, i.e. the C*ontrol* bun, *Medium* CF and *High* CF *buns* are available in the market. The most interesting result is that when all these products are assumed to be available in the market, their market share decreases markedly as compared to results shown in figure 3.This can be explained by the fact that when the number of products increases, market competition may arise thereby leading to a significant decrease in the market share as price increases. The case of the *High* CF buns is particularly overwhelming in the sense they would only capture around 25% of the market share at a price of 20 KShs.

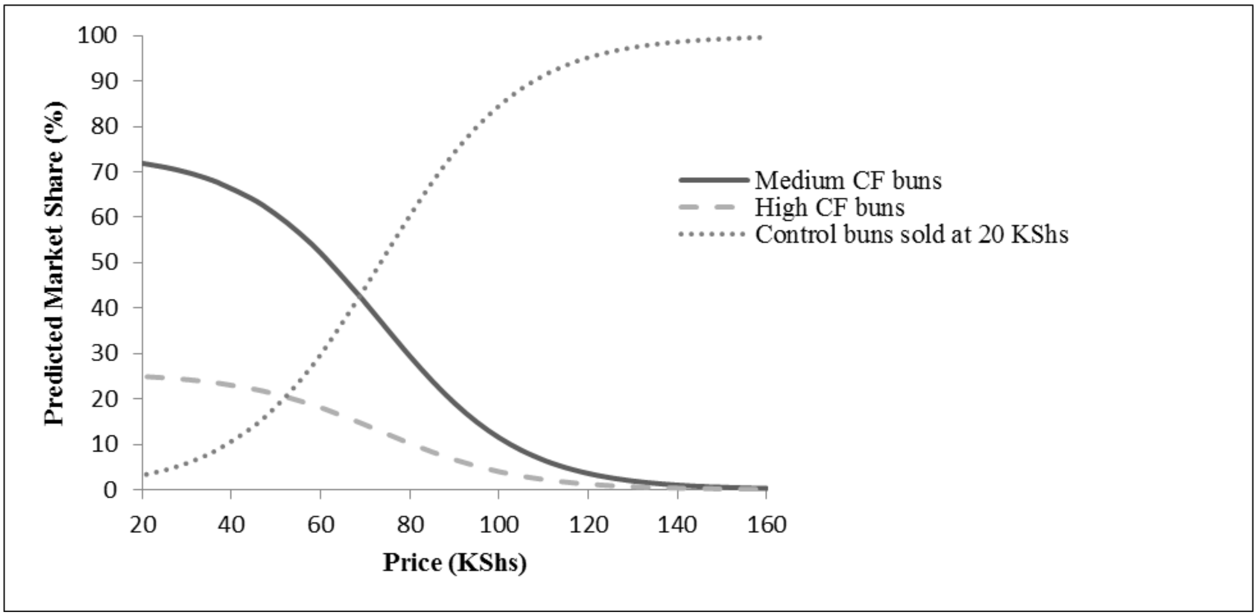

Figure 4: Predicted market share of alternative market scenarios for three bun products

4. Discussion and conclusion

In this paper, we present results from a DCE study concerning the potential demand in Kenya for buns baked using CF as an ingredient. In the conducted study participants are allowed to make sensory evaluations based on tasting the bun products before being subjected to an incentivized DCE. This arguably increases the realism of the choice decisions and thus the validity of the results.

The results reveal the presence of heterogeneity in preferences for the CF buns across participants. The majority of consumers have positive preferences for the CF buns while a smaller proportion exhibit negative preferences for the products. In this respect, increasing the amount of CF in the buns from 5% to 10% and moving from rural to urban areas, the proportion of consumers with negative preferences increases. Overall, the empirical results suggest that most consumers would prefer bun products containing CF to the traditional buns available in Kenya today, and they would actually pay more for buns with CF. However, it seems that it is not simply a question of adding as much CF as possible as the buns with high amounts of CF, despite being preferred over regular buns, are less preferred than buns with lower amounts of CF. This is in line with the results from the sensory evaluation as *Medium* CF buns are preferred over the *High* CF buns for their taste and overall liking.

Since food fortification is known to many consumers as most industrialized products such as wheat and salt are fortified in Kenya (KNFFA, 2011) we expected positive and significant preferences for fortified buns. In line with this, consumers exhibit positive preferences for fortified wheat flour as the estimated coefficients are significantly positive. Specifically, urban consumers value the fortified portion of the wheat flour more than rural consumers in the sample. This is expected since consumers from Nairobi have better access to industrially fortified foods and have more knowledge and awareness about the importance of such foods than rural consumers. These results are somewhat in agreement with De Groote & Kimenju, (2008), and De Groote, Kimenju, & Morawetz, (2011).

The WTP results indicate that consumers from Nandi county would be willing to pay more for bags of buns with CF than consumers from Siaya and Nairobi counties. Although one would expect lower WTP for consumers in Nandi and Nairobi, where traditional insect consumption is not present, than for consumers in Siaya, where insects are traditionally consumed, our results reveal the opposite. Consumers from Nandi and Nairobi counties would pay more for fortified and *High* CF buns than consumers in Siaya with the exception of the WTP for *Medium* CF buns, which is higher in Siaya than in Nairobi. These results imply that it is most likely that there will be a market for edible insects, specifically CF, as food since the demand is present even in areas where insect consumption is not practiced today.

The market share prediction results provide results which are consistent with the WTP results. According to the results, given a certain price level *Medium* CF buns would capture higher market share than the other products. In connection with this, based on figure 3, if one aims at setting the price of the new *Medium* CF buns such that they would get a 50% market share, then the price should be around 70 KShs whereas if the aim is to introduce *High* CF buns, the price would have to be set around 50 KShs if they are to capture 50% of the market. On the other hand, when three products are assumed to be available in the market (figure 4), the price of *Medium* CF buns should be set around 60 KShs in order to achieve a 50% market share. However, *High* CF buns would only capture a market share of up to 25% at a price of 20 KShs, which means that increasing the price beyond this level would reduce the market share of these products. For instance, if the price is set at 40 KShs, the market share would fall to 20% from 25%.

The results of this study in general suggest that when consumers are provided with options of buying buns with none, medium and high CF, they strongly seek the bags of buns with the medium content of CF. This brings to mind that any future commercialization of food products from CF should carefully consider the optimal level of the amount of CF used in preparing the desired food since it greatly affects taste and overall liking (i.e. see sensory results in table 5). Another implication of the results is that food fortification could contribute to reduce the burden of micronutrient deficiency in Kenya as consumers in our sample show demand for fortified buns.

While this study provides firsthand information regarding potential consumer demand for edible insects as food, it is not without limitations. First, the characteristics of the participants in terms of gender and income are not identical across counties, which may affect direct comparison of results across counties. Thus, the results of a likelihood ratio test which indicated differences in preference structure across counties should be viewed with caution. Furthermore, while using the pooled data from the full sample for market share predictions may not be strictly appropriate considering the indications of preference differences across counties, it does essentially average out these potential differences and thus rely less on them. Obviously, more empirical testing and study replications are needed before firm and general conclusions can be made about the potential demand for insect-based food products. In this regard, our study could be extended to a number of future research areas. One area of further research could be considering other food products than buns and potentially with other types of insects. In addition, further research on the acceptance of whole crickets versus cricket flour would be interesting. Finally, while this study is conducted in a developing country where insects have an obvious role as a potentially important new food source, insects may also have a role as a source of food in developed countries. Similar studies in contexts of developed countries would thus be warranted to assess the potential for introducing insects as a food source in these very different settings.

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References

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998). Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. *American Journal of Agricultural Economics*, **80,** 64-75.

Alfnes, F., Guttormsen, A. G., Steine, G., & Kolstad, K. (2006). Consumers' Willingness to Pay for the Color of Salmon: A Choice Experiment with Real Economic Incentives. *American Journal of Agricultural Economics*, **88,** 1050-1061.

Arvola, A., LÄHteenmÄKi, L., Tuorila, H. (1999). Predicting the Intent to Purchase Unfamiliar and Familiar Cheeses: The Effects of Attitudes, Expected Liking and Food Neophobia. *Appetite*, **32,** 113-126.

Ayieko, M.A., Ndong'a, M.F.O., Tamale, A. (2010). Climate change and the abundance of edible insects in the Lake Victoria region. *Journal of Cell and Animal Biology*, **4,** 112-118.

Bi, X., Gao, Z., House, L. A. & Hausmann, D. S. (2015). Tradeoffs between sensory attributes and organic labels: the case of orange juice. *International Journal of Consumer Studies,* **39,** 162-171.

Bierlaire, M. (2003). BIOGEME: a free package for the estimation of discrete choice models. *In: Proceedings of the 3rd Swiss transportation research conference,* Ascona, Switzerland.

Brown, S. L., Eisenhardt, K.M. (1995). Product development: past research, present findings, and future directions. *Academy of Management Review,* **20,** 343-378.

Bukkens, S.G. F. (1997). The nutritional value of edible insects. *Ecology of Food and Nutrition,* **36,** 287-319.

Carlsson, F. & Martinsson, P. (2001). Do Hypothetical and Actual Marginal Willingness to Pay Differ in Choice Experiments?: Application to the Valuation of the Environment. *Journal of Environmental Economics and Management,* **41,** 179-192.

Carlsson, F., Frykblom, P. & Lagerkvist, C. J. (2007a). Consumer Benefits of Labels and Bans on GM Foods—Choice Experiments with Swedish Consumers. *American Journal of Agricultural Economics,* **89,** 152-161.

Carlsson, F., Frykblom, P. & Lagerkvist, C. J. (2007b). Consumer willingness to pay for farm animal welfare: mobile abattoirs versus transportation to slaughter. *European Review of Agricultural Economics,* **34,** 321-344.

Chang, J. B., Lusk, J. L. & Norwood, F. B. (2009). How Closely Do Hypothetical Surveys and Laboratory Experiments Predict Field Behavior? *American Journal of Agricultural Economics*, **91,** 518-534.

Christensen, D.L., et al. (2006). Entomophagy among the Luo of Kenya: a potential mineral source? *International Journal of Food Sciences and Nutrition,* **57,** 198-203.

ChoiceMetrics (2012). Ngene 1.1.1 User Manual & Reference Guide, Australia.

Chowdhury, S., Meenakshi, J. V., Tomlins, K. I., Owori, C. (2011). Are Consumers in Developing Countries Willing to Pay More for Micronutrient-Dense Biofortified Foods? Evidence from a Field Experiment in Uganda. *American Journal of Agricultural Economics,* **93,** 83-97.

DeFoliart, G.R. (1989). The Human Use of Insects as Food and as Animal Feed. Bull. *Entomologial Society of Ametica*, **35,** 22-36.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S., Courbois, C. (1999). Livestock to 2020: the next food revolution. [WWW document].
URL http://ilri.org/InfoServ/Webpub/fulldocs/Lvst2020/LvSt2020.pdf
(Accessed on 18 September 2015).

de Boer, J., Hoogland, C.T., Boersema, J.J. (2007). Towards more sustainable food choices: Value priorities and motivational orientations. *Food Quality and Preference*, **18,** 985-996.

De Groote, H., & Kimenju, S. C. (2008). Comparing consumer preferences for color and nutritional quality in maize: Application of a semi-double-bound logistic model on urban consumers in Kenya. *Food Policy,* **33,** 362-370.

De Groote, H., Kimenju, S. C., & Morawetz, U. B. (2011). Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya. *Agricultural Economics,* **42,** 1-16.

de-Magistris, T., & Gracia, A. (2014). Do consumers care about organic and distance labels? An empirical analysis in Spain. *International Journal of Consumer Studies,* **38,** 660-669.

Drescher, L. S., Roosen, J. & Marette, S. (2014). The effects of traffic light labels and involvement on consumer choices for food and financial products. *International Journal of Consumer Studies,* **38,** 217-227.

Ewing, G., Sarigöllü. E. (2000). Assessing Consumer Preferences for Clean-Fuel Vehicles: A Discrete Choice Experiment. *Journal of Public Policy and Marketing,* **19,** 106-118.

FAO (2006). World agricutlture: towards 2030/2050 - Interim report. [WWW document]. URL http://www.fao.org/fileadmin/user_upload/esag/docs/Interim_report_AT2050web.pdf (Accessed on September 18 2015).

FAO (2009). The state of food and agriculture: Livestock in the balance. [WWW document]. URL at http://www.fao.org/docrep/012/i0680e/i0680e.pdf (Accessed on January 1st 2015)

FAO (2013). Edible Insects: future prospects for food and feed security. [WWW document]. URL http://www.fao.org/docrep/018/i3253e/i3253e.pdf (Accessed on March 09 2014).

Ferrini, S., Scarpa, R. (2007). Designs with a priori information for nonmarket valuation with choice experiments: A Monte Carlo study. *Journal of Environmental Economics and Management,* **53,** 342-363.

Gracia, A., Loureiro, M. L., & Nayga, R. M. (2011). Are Valuations from Nonhypothetical Choice Experiments Different from Those of Experimental Auctions? *American Journal of Agricultural Economics,* **93,** 1358-1373.

Gracia, A. (2014). Consumers’ preferences for a local food product: a real choice experiment. *Empirical Economics,* **47,** 111-128.

Greene, W.H. (2008). *Econometric Analysis*, 6th edition. Prentice Hall, New York.

Harrison, G. (2006). Experimental Evidence on Alternative Environmental Valuation Methods. *Environmental and Resource Economics*, **34,** 125-162.

Hartmann, C., Shi, J., Giusto, A., Siegrist, M. (2015). The psychology of eating insects: A cross-cultural comparison between Germany and China. *Food Quality and Preference*, **44,** 148-156.

Hensher, D., & Greene, W. (2003). The Mixed Logit model: The state of practice. *Transportation*, **30,** 133-176.

Herriges, J. A., & Phaneuf, D. J. (2002). Inducing Patterns of Correlation and Substitution in Repeated Logit Models of Recreation Demand. *American journal of Agricutlrual Economics*, **84,** 1076-1090.

IPCC (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Summary for policy makers. [WWW document]. URL https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf (Accessed on September 25 2015).

Ivanic, M., Martin, W. (2008). Implications of higher global food prices for poverty in low-income countries. *Agricututal Economics*, **39,** 405-416.

Jaeger, S.R., Rose, M.J. (2008). Stated choice experimentation, contextual influences and food choice: A case study. *Food Quality and Preference*, **19,** 539-564.

KNBS (2009). The 2009 Kenyan Population and Housing Census. [WWW document] URL http://www.knbs.or.ke/ (Accessed on February 2nd 2015).

KNFFA (2011). The PSI/Kenya's Food Fortification Social Marketing and Communication Project 2011-2014. [WWW document]. URL www.gainhealth.org/programs (Accessed on January 19, 2014).

Kinyuru, J., N., Kenji, G., M., Njoroge, M., S. (2009). Process development, nutrition and sensory qualities of wheat buns enriched with edible termites **(***Macrotermes subhylanus)* from Lake Victoria region, Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, **9,** 1739-1750.

Kinyuru, J.N., Konyole, S.O., Kenji, G.M., Onyango, C.A., Owino, V.O., Owuor, B.O., Estambale, B.B., Friis, H., Roos, N. (2012). Identification of Traditional Foods with Public Health Potential for Complementary Feeding in Western Kenya. *Journal of Food Research*, **1,** 148-158.

Lancaster, K.J. (1966). A new approach to consumer theory. *Journal of Political Economy*, **74,** 132-157.

Lappalainen, R., Kearney, J., & Gibney, M. (1998). A pan EU survey of consumer attitudes to food, nutrition and health: an overview. *Food Quality and Preference*, **9,** 467-478.

Lee, J., Choi, J. Y. & Cho, Y. (2011). A forecast simulation analysis of the next-generation DVD market based on consumer preference data. *International Journal of Consumer Studies,* **35,** 448-457.

Louviere, J.J., Hensher, D.A., Swait, J.D. (2000). *Stated choice methods: Analysis and applications*. Cambridge University Press, Cambridge.

Louviere, J.J., Hensher, D.A. (1983). Using discrete choice models with experimental design data to forecast consumer demand for a unique cultural event. *Journal of Consumer Research*, **10,** 348-361.

Louviere, J.J., Woodworth, G. (1983). Design and analysis of simulated consumer choice or allocation experiments: an approach based on aggregate data. *Journal of Marketing Research*, **20,** 350-367.

Lusk, J. L., & Schroeder, T. C. (2004). Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks. *Americal Journal of Agricutlrual Economics,* **86,** 467-482.

McFadden, D. (1986). The Choice Theory Approach to Market Research. *Marketing Science*, **5,** 275-297.

McIlveen, H. & Armstrong, G. (1998). Opportunities for integrating sensory evaluation into consumer studies. *Journal of Consumer Studies & Home Economics,* **22,** 241-247.

Megido, R. C., Sablon, L., Geuens, M., Brostaux, Y., Alabi, T., Blecker, C., Drugmand, D., Haubruge, E., Francis, F. (2014). Edible Insects Acceptance by Belgian Consumers: Promising Attitude for Entomophagy Development. *Jounal of Sensory Studies,* **291,** 14-20.

Meijer, E. & Rouwendal, J. (2006). Measuring welfare effects in models with random coefficients. *Journal of Applied Econometrics,* **21,** 227-244.

Moser, R., & Raffaelli, R. (2012). Consumer preferences for sustainable production methods in apple purchasing behaviour: a non-hypothetical choice experiment. *International Journal of Consumer Studies,* **36,** 141-148.

Mørkbak, M. R., Olsen, S. B., & Campbell, D. (2014). Behavioral implications of providing real incentives in stated choice experiments. *Journal of Economic Psychology,* **45,** 102-116.

Mueller, S., Osidacz, P., Francis, I. L., Lockshin., L. (2010). Combining discrete choice and informed sensory testing in a two-stage process: Can it predict wine market share? *Food Quality and Preference*, **21,** 741-754.

Olsen, S. (2009). Choosing Between Internet and Mail Survey Modes for Choice Experiment Surveys Considering Non-Market Goods. *Environmental and Resource Economics*, **44,** 591-610.

Oonincx, D.G.A.B., et al. (2010). An Exploration on Greenhouse Gas and Ammonia Production by Insect Species Suitable for Animal or Human Consumption. *PLOS ONE*, **5,** 1-7.

Oonincx, D.G.A.B., de Boer, I.J.M. (2012). Environmental Impact of the Production of Mealworms as a Protein Source for Humans – A Life Cycle Assessment. *PLOS ONE*, **7,** e51145.

Paoletti, M.G., et al. (2003). Nutrient content of termites(syntermes soldiers) consumed bymakiritare amerindians of the altoorinoco of Venezuela. *Ecology of Food and Nutrition*, **42,** 177-191.

Peryam, D., Girardot, N. (1952). Advanced Taste-Test Method. *Food Enginnering*, **24,** (58-61).

Ramos-Elorduy, J. (1997). Insects: A sustainable source of food? *Ecology of Food and Nutrition*, **36,** 247-276.

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

Scarpa, R., Ferrini, S., Willis, K. (2005). Performance of Error Component Models for Status-Quo Effects in Choice Experiments. *In:* Scarpa, R. & Alberini, A. (eds.) *Applications of Simulation Methods in Environmental and Resource Economics*, pp 247-273. Springer Netherlands.

Scarpa, R., Willis, K. G., Acutt, M. (2007). Valuing externalities from water supply: Status quo, choice complexity and individual random effects in panel kernel logit analysis of choice experiments. *Journal of Environmental Planning and Management*, **50,** 449-466.

Scarpa, R., Thiene, M., Marangon, F. (2008). Using Flexible Taste Distributions to Value Collective Reputation for Environmentally Friendly Production Methods. *Canadian Journal of Agricultural Economics*, **56,** 145-162.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & de Haan, C. (2006). *Livestock's long shadow*, FAO Rome.

Stevens, R. & Winter-Nelson, A. (2008). Consumer acceptance of provitamin A-biofortified maize in Maputo, Mozambique. *Food Policy*, **33,** 341-351.

Tan, H. S. G., Fischer, A. R. H., Tinchan, P., Stieger, M., Steenbekkers, L. P. A. & van Trijp, H. C. M. (2015). Insects as food: Exploring cultural exposure and individual experience as determinants of acceptance. *Food Quality and Preference,* **42,** 78-89.

Thunström, L., Nordström, J. (2015). Determinants of food demand and the experienced taste effect of healthy labels – An experiment on potato chips and bread. *Journal of Socio-Economics,* **56,** 13-20.

Train, K. & Sonnier, G. (2005). Mixed Logit with Bounded Distributions of Correlated Partworths. *In:* Scarpa, R. & Alberini, A. (eds.) *Applications of Simulation Methods in Environmental and Resource Economics,* pp 117-134. Dordrecht: Springer Netherlands.

Train, K. (2009). *Discrete choice methods with simulation*, 2nd edn. Cambridge: Cambridge University Press.

UN (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. [WWW document] URL http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf. (Accessed on September 18 2015).

van Kleef, E., van Trijp, H.C.M., Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference,* **16,** 181-201.

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., Doyon, M., & Rondeau, D. (2012). Truth in Consequentiality: Theory and Field Evidence on Discrete Choice Experiments. *American Economic Journal: Microeconomics,* **4,** 145-171.