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Søren B. Olsen
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Department of Food and Resource Economics (IFRO)
University of Copenhagen
Rolighedsvej 25
DK 1958 Frederiksberg DENMARK
www.ifro.ku.dk/english/

Consumer acceptance and willingness to pay for edible insects as food in Kenya: the case of white winged termites

Mohammed H. Alemu[a*], Søren B. Olsen[a], Suzanne E. Vedel[a], Kennedy O. Pambo[b], Victor O. Owino[c]

[a] *Department of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25, 1958, Frederiksberg C Denmark*
[b] *Department of Agricultural and Resource Economics, Jomo Kenyatta University of Agriculture and Technology, P.O.BOX 62000 – 00200, Juja, Kenya*
[c] *International Atomic Energy Agency, P.O.BOX 100, 1400, Vienna, Austria*

Abstract

Edible insects are receiving substantial attention because of their potential as a significant future food source of high nutritional value and with important environmental benefits. As a result, there is a focus on the supply side to establish and optimize the insect production sector and develop the value chain. However, as the ultimate success of a product development depends on consumers' product judgement and acceptance, acquiring information about potential demand is of paramount importance for policy advice. In this paper, we aim to give a first insight into the potential demand for termite-based food products (TBFPs) in Kenya. We assess the demand in terms of consumer preferences and willingness to pay using a stated choice experiment method. A novel feature of this paper is that it focuses on how the termites should be presented and introduced, either as whole or processed, in a typical daily meal in order to increase consumer acceptance. Results from the latent class model reveal that consumers prefer and are willing to pay more for TBFPs with high nutritional value and when they are recommended by officials. In addition, results show that high to a very high food safety control levels of the TBFPs are valued positively by most consumers.

Keywords: Stated Choice Experiment; Edible insects; Latent class model; Termite-based food products; WTP

Introduction

The world, and in particular developing countries and emerging economies, is witnessing a rapidly increasing demand for food, especially in terms of animal protein. With the world

[*] Corresponding author. Tel.: +4535331492. Email address: mha@ifro.ku.dk

population projected to reach 9 billion people by the year 2050 the demand for protein, and in particular animal protein, is expected to increase dramatically. There is no doubt that the world has to provide food for its inhabitants, but how to meet the increasing demand in the future remains an open and critical question. Furthermore, despite access to animal protein in many developing countries being somewhat limited due to increasing prices and climate change related reduced production of livestock, the continued general rise in income and living standards in some developing countries and emerging economies is expected to lead to profound increases in the demand for animal protein. Animal protein is however not a very sustainable source of protein (Steinfeld et al. 2006; FAO, 2009; Aiking, 2011)

Recently, policy makers, scientists and public organizations including the United Nations (UN) have called for diversification of the sources of food in the face of climate change and increasing population. In this regard, edible insects may provide a valuable future source of food (FAO, 2013). Insects contain nutrients such as protein, minerals and vitamins which are essential for human consumption (DeFoliart, 1989; Bukkens, 1997; Ramos-Elorduy, 1997; Paoletti et al. 2003). Furthermore, due to their high food conversion levels, rearing of edible insects for human consumption will emit much less greenhouse gasses (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 protein in the future is to be met by animal protein, this environmental problem will only increase. If instead a small- as well as large-scale edible insect production sector can be established, it might cover the increasing demand for food while at the same time avoiding increasing GHG emissions.

Edible insects are used as food in some cultures mainly in developing countries (Bukkens, 1997; Ramos-Elorduy, 1997); however, they are mainly collected from harvesting in the wild (Ramos-Elorduy, 1997; van Huis, 2013). For instance, in Kenya insect species such as Lake Flies, Agolo termites, Black ants, and Grasshoppers have traditionally been consumed in some local areas (Christensen et al. 2006; Ayieko and Oriaro, 2008; Ayieko et al. 2010, 2012; Kinyuru et al. 2010). However, little is known about the role of insects in a particular economy, especially concerning their contribution to food security (van Huis, 2003). In line with this, the socio-economic aspect of embracing insects as food is a somewhat unexplored area of research. As the ultimate goal of product development depends on consumers' judgment (Brown and Eisenhardt, 1995; van Kleef et al. 2005; van Trijp and Fischer, 2011), information on the potential demand for edible insects as food is of paramount importance because decision making without such information can be sub-optimal. Essentially, developing a production of edible insects will be pointless if the consumers do not want to eat the insects. In this regard, while assessing the potential of edible insects as food and feed, van Huis (2013) and Rumpold and Schlüter (2013) emphasized the necessity of consumer acceptance studies regarding insects as food. 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 (Hartmann et al. 2015; Tan et al. 2015, Verbeke, 2015) focusing on the acceptance of insects as food have emerged. However, these studies focused mainly on willingness to eat as well as product liking rather than on the economic aspects, i.e. consumer preferences and willingness to pay (WTP) for edible insects. Focusing specifically on these aspects, this paper strives to give a first insight into the potential demand for TBFPs using individual level data in Kenya. To investigate how the termites should be presented and introduced in a typical daily meal, two products, i.e. whole and processed termites, are considered in this study. Since real market data for insect-based products are not available, we use a stated choice experiment (SCE) method based on hypothetical markets. The SCE is widely applied in consumer research for assessment of consumer preferences and WTP for food attributes (e.g. Hu et al. 2004; Carlsson et al. 2007; Kikulwe et al. 2011; Ortega et al. 2011).

The remainder of the paper is structured as follows. The next section presents the theoretical framework and econometric specification followed by the section describing the data. The final two sections present the results, and the discussion and conclusion, respectively.

Theoretical framework and econometric specification

The SCE is used to an increasing extent to measure demand for goods and services in various fields including marketing and food preferences (see e.g. Ewing and Sarigöllü, 2000; Jaeger and Rose, 2008; Kikulwe et al. 2011). They are originally developed by Louviere and Hensher (1983) and Louviere and Woodworth (1983) to forecast consumer demand in marketing research. SCE is highly suited to measure and forecast demand for products which are absent in the market. In the SCE setting, goods and services are described in terms of their attribute characteristics (Lancaster 1996). Furthermore, SCE is based on random utility theory (RUM) (McFadden, 1986) which provides a theoretical framework for modelling choices based on observable as well as unobservable utility components. In addition, the RUM postulates that an individual chooses an alternative among a given bundle of alternatives that maximizes her utility. Based on these theoretical frameworks, different models can be formulated to analyze data from SCE.

In this paper, we applied the latent class model (LCM) to model respondents' choices in the choice tasks. This modelling approach is particularly suitable for capturing heterogeneity in preferences across segments. Focus groups had indicated that a great deal of heterogeneity could be expected due to the urban-rural gradient and cultural differences across subsamples. In addition, designing efficient policies usually requires ex-ante information about the target population to address a certain problem (Boxall and Adamowicz, 2002). In this respect, the LCM can provide an important analytical tool to estimate data at segment level in which subjects in the same segment likely share homogenous preferences and subjects across segments likely exhibit heterogeneous preferences. The origin of the LCM traces back to earlier marketing research by Swait, (1994) and there are several studies which have employed these models to identify class-specific segments of a population based on their choice decisions. For instance, Ortega et al. (2011), Bechtold and Abdulai, (2014) and de Jonge and van Trijp (2014) have applied the LCM to study consumer preferences for food safety certification levels, consumer preference for functional dairy products and consumer perception of the animal friendliness of broiler production system, respectively. All of these studies discerned the role of LCM in unraveling policy relevant results based on homogeneous class-specific groups. In a similar vein, Scarpa et al. (2003); Hu et al. (2004); Kikulwe et al. (2011); and Koistinen et al. (2013) analyzed their data based on a LCM to systematical identify class-specific segments.

Similar to other logit models, the LCM rely on random utility theory to analytically deal with decision makers' choice behavior which is usually difficult to fully account for (Boxall and Adamowicz, 2002). That said, assuming that we have *s* sets of classes, we can specify the following general utility expression:

$$U_{ntk} = \begin{cases} V(X_{ntk}, Z_n, \beta_s, \gamma_s, \mu) + \varepsilon_{ntk|s}, k = 1,2; \\ V(ASC_s, X_{ntk}, Z_n, \beta_s, \gamma_s) + \varepsilon_{ntk|s}, k = 3(optout) \end{cases} \quad (1)$$

where the indirect utility function, V, is a function of the observed explanatory variables related to the attributes, X_{ntk}, and consumer characteristics, Z_n, and the associated parameters, β_s and γ_s, respectively. Notice that the utility expression in equation (1) can be decomposed into two parts: one for the choice model and the other for the membership model. Assuming that the error term ε_{nk}

is Gumbel-distributed, the probability that an individual *n* chooses alternative *k* among *R* given alternatives in choice situation *t* in class *s* can be represented as:

$$P_{nt}(k) = \frac{e^{\mu\beta_s' x_{ntk}}}{\sum_j^J e^{\mu\beta_s' x_{ntj}}} \qquad (2)$$

where β' is the vector of all betas estimated for the attributes, μ is the scale parameter which is normalized to unity, and the alternative specific constant (ASC), which is specified following Scarpa et al. (2005), and the error term are left out for ease of simplicity. The latent grouping of subjects into different classes is a function of their characteristics such as socio-economic variables. As a result, the probability that an individual belongs to class *s* can be given by:

$$P_{ns} = \frac{e^{\gamma_s' Z_n}}{\sum_{s=1}^S e^{\gamma_s' Z_n}} \qquad (3)$$

where γ_s' denotes the class-specific vector of estimated parameters, and Z_n represents the individual characteristics. For the sake of model identification, the estimated parameters of the last class *S* are usually normalized to zero and results from the other classes are compared relative to this class (Boxall and Adamowicz, 2002). Combining equations (2) and (3) makes it possible to simultaneously estimate both β_s and γ_s. Following Boxall and Adamowicz, (2002), the probability becomes:

$$P_n(k) = \sum_{s=1}^S \left(\frac{e^{\gamma_s' Z_n}}{\sum_{s=1}^S e^{\gamma_s' Z_n}} \prod_{t=1}^T \frac{e^{\beta_s' x_{ntk}}}{\sum_j^J e^{\beta_s' x_{ntj}}} \right) \qquad (4)$$

Equation (4) can be estimated using the maximum likelihood framework. And once parameters are obtained, class-specific WTP values can be estimated using the equation:

$$WTP = \frac{\beta_s(non\ price\ attribute)}{\beta_s(price\ attribute)} \qquad (5)$$

We refer the reader to Boxall and Adamowicz (2002); and Greene and Hensher (2003) for further details regarding the maximum likelihood expression of the LCM models.

Data

Study Sites and Sampling design

Kenya is host to more than 42 distinct ethnic groups, and an incredibly varied demographical distribution. No ethnic group constitutes a majority, but the five largest – Kikuyu, Luo, Luhya, Kamba and Kalenjin – accounts for 70% of the population (OBG, 2014). To capture this diversity, five counties, Kisumu, Siaya, Kakamega, Machakos and Nairobi were purposively selected for this study. Entomophagy has traditionally been practiced by the communities in the western regions of the country. In our sample, the counties of Kisumu, Siaya and Kakamega, with a total population of 2.5 million people (2009 census) represented this region. The counties of Machakos and Nairobi represent eastern and central regions respectively, where consumption of edible insects is not popular. Given that Nairobi and Kisumu counties host two out of the three cities in Kenya, the choice of these five counties induces variation in the data.

Nairobi being the capital city is the most populated county in Kenya. According to the 2009 national population census (KNBS, 2009), the population of Nairobi County was estimated at 3.1 million people and possibly, has the highest number of consumers in the country. Furthermore, the diversity in terms of ethnicity, demographic, cultural, and socioeconomic characteristics makes Nairobi a representative county, of the whole country.

The target population included households residing in the five counties. Since internet coverage was considered insufficient for an online survey, and a suitable sampling frame for a phone survey was not available, the survey was conducted using face-to-face interviews. This method of data collection was preferred because the respondents' concerns and questions could be addressed at hand by the interviewers and further clarifications given instantly. It also enabled the use of visual aids. Furthermore, this method was also instrumental in ensuring that only members of the household who were responsible for food shopping (responsible for dietary decisions) were asked to answer the questionnaire.

The survey was conducted between December 2014 and January 2015. The sample was drawn using a multistage sampling procedure and stratified into rural and urban consumers, with Nairobi County and parts of Kisumu and Machakos counties representing urban areas and the remainder representing rural areas. A multistage sampling method was considered appropriate for this study because a sampling frame with a complete list of all households in the study areas was not available. The five counties were divided into smaller administrative units called sub-counties (constituencies). To ensure greater sample representation within the selected counties, two sub-counties were considered, except in Nairobi County where five sub-counties were involved. Within each sub-county, a random sample of locations was drawn, from which a number of smaller administrative units (sub-location) were drawn with regard to the distribution of consumers (population) within each sub-county. A total of 28 locations were selected, with Nairobi County, due to its high population and ethnic diversity, taking up larger share of selected locations at 7.

Within the sub-locations, smaller units (Villages in Kakamega, Machakos & Siaya counties and Estates in Nairobi and Kisumu counties) were randomly selected, which formed the primary sampling units. The secondary sampling units were the households, from which respondents were drawn using a systematic random sampling criterion. More importantly, to select the households, a line-sampling method was used; that is, a "line" was drawn on the village map and every 3rd household along the "line" with a random start (either left or right) was interviewed. Where the targeted respondent was unavailable or uninterested in participating, the next randomly selected household on the list was chosen to ensure that the desired sample size was realized. Employing a sampling proportionate to size criterion, a total sample size of 611 consumers was realized (140 in Nairobi County, 134 in Kakamega County, 122 in Kisumu County, 110 in Siaya County and 105 in Machakos County). The overall response rate was high (90%), largely due to the face-to-face nature of the survey instrument. The data collection was conducted by six skilled interviewers who had been specifically trained for this survey.

Survey instruments

Different edible insects are traditionally consumed in the western area and Lake Victoria region of Kenya. These are grasshoppers, termites, black ants, lake flies and crickets (Christensen et al. 2006; Ayieko and Oriaro, 2008; Ayieko et al. 2010; Ayieko et al. 2012; Kinyuru et al. 2012). In this particular study, we chose to focus on termites following a focus group discussion which indicated that termites were relatively popular among participants, even among those not used to eating insects. In addition, termites are part of the traditional diet in western and Lake Victoria region of Kenya (Kinyuru et al. 2013). Moreover, these insects contain protein and other important nutrients that can help reduce nutritional deficiency (Ayieko et al. 2010; Nyukuri et al. 2014). As a result, enriching low protein foods such as maize and sorghum with protein using alternative and acceptable sources can be a crucial step in combating the shortage of protein in the region. This is of particular importance when considering the fact that cereals are the most consumed food items in eastern and southern African countries (Stevens and Winter-Nelson, 2008).

Insects can be eaten in three different forms; as whole insects, in powder or paste form, and as protein extract (FAO, 2013). In order to investigate how the termites should be presented and introduced in a typical daily meal to increase consumer acceptance, we identified two products for our study and used photo representations to display them to respondents. They were: 1) whole termites fried and salted (WTFS) and 2) termite powder (TP). The second product type is not popular as residents in western Kenya (mainly in rural areas) traditionally eat whole termites after boiling or sun-drying or roasting them. We informed respondents that the TP is mixed into Ugali and the WTFS served on the side of it. Ugali (stiff porridge) is the staple daily food in Kenya and is made from either Maize or Sorghum.

Next we identified relevant attributes of these products to be included in the SCE. Attributes were identified following an extensive literature review and focus group and expert discussions. Since the survey targeted consumers in both rural and urban areas of Kenya, effort was exerted to ensure that all the attributes were simple and understandable by all the respondents so that they could make informed choices. Originally, we identified five non-price quality attributes: *nutritional value*, *food safety control*, *shopping location*, *feedstock,* and *recommendation*. However, results from the focus group discussion indicated that the *feedstock* attribute appeared to be irrelevant for this particular SCE study, and it was consequently dropped. Table 1 below summarizes the description of attributes and their respective levels.

The *recommendation* and *shopping location* attributes were included to acknowledge that consumer preference decisions can be affected by contextual factors in addition to product attributes. As mentioned in Grisolia et al. (2012), the *recommendation* attribute is mostly used in theater, cinema and hotel review services. While contextual factors can influence the choice and preference of food items, they have been overlooked in most food preference studies (Stroebele et al. 2004; and Jaeger and Rose, 2008). The attributes *nutritional value*, *food safety control* and *shopping location* have three levels where as the *recommendation* attribute has four levels. To enable calculation of marginal WTP estimates for the quality attributes, we included a *cost* attribute in the choice design, which represents the cost of purchasing 200g of WTFS or 200g of TP. A pilot survey was conducted to validate all the attributes and their levels.

Table 1 Attributes and their levels[1]

Attribute definition	Attribute name	Attribute levels
Nutritional value of the TBFPs may differ depending on the production method (e.g. the feed quality they are fed on); processing methods (e.g. drying, boiling, and frying) and storage methods (e.g. whether stored appropriately in cool and dry conditions).	Nutritional value (NV) (effects coded)	Low (base) Average Very good
Food safety control indicates to what extent the TBFPs are controlled for their safety. *Standard* represents the traditional way of preparing termites for food, i.e. drying, boiling, frying or roasting. *High* represents the termites are fed based on a controlled feed quality and living conditions. Proper processing and handling strategies are applied to prevent hygienic and re-contamination problems during food preparation processes. The products are packed. *Very high* denotes that in addition to high food safety control, the products are inspected for specific food safety issues by the Kenyan bureau of standards to ensure that they are safe.	Food safety control (FSC) (effects coded)	Standard (base) High Very high
Shopping location indicates whether the TBFPs are available in local or street markets, kiosks, and big supermarkets.	Shopping location (SL) (effects coded)	local market (base) Kiosks Supermarkets
Recommendation represents whether people get recommendations from various sources to consume foods from TBFPs.	Recommendation (RC) (effects coded)	None (base) Friends and relatives (peers) Media Official recommendation
Price is the cost of 200g of the TBFPs in Kenyan Shillings (KShs)[2]	Price (PRICE)	50,60,70,85,105,120

Experimental design and the questionnaire

The paper adopts the SCE method to measure the preferences of consumers for TBFPs. We used the Ngene software (ChoiceMetrics, 2012) to produce the experimental design. Using priors from a pilot study, a D-efficient fractional factorial design with 36 choice sets were generated. However, as 36 choice tasks were considered too demanding for a respondent to process, the choices were blocked into three so that each respondent faced 12 choice tasks. Half of the choice tasks concerned WTFS whereas the other half represented TP. We randomized the product order so as to avoid product ordering effects in the SCE. Once the SCE design was produced, a questionnaire was developed including questions on demographic and socio-economic information, familiarity and experience with edible insect eating, attitudinal questions related to using edible insect as food, and food neophobia.

[1] Effects coding has been used in the choice experiment design to avoid the confounding effect between the base level of the different attributes and the 'none of these' option.

[2] 1 US Dollar was around 90.50 KShs by the time of the field survey

Table 2: Example of the choice sets

	Option 1	**Option 2**	
Nutritional value	Low	Average	
Food safety control	High	Standard	
Recommendation	Media	Official recommendation	None of these
Shopping location	Kiosks	Big supermarkets	
Price	70	85	
Which option do you prefer?	○	○	○

The main body of the questionnaire presented the scenario for the SCE, the description of attributes used in the experiment and some background information as to why edible insects can be important for consumption. Then, the sequence of choice sets was presented. The final design of the SCE and the questionnaire was tested and validated using a sample of 43 respondents.

Results

Consumer characteristics

More than 90% of the respondents sampled in the survey are heads or spouses in the household. As can be seen in table 3, the average age of consumers participating in the interview is 40.02 years.

Table 3: Consumer characteristics

Variable	**Category**	**Sample statistics**	
		Mean	**SD**
Age		40.02 years	12.97
Land ownership		2.20 acres	3.18
Number of household members		5.14	2.64
Number of children below 18 years		2.20	1.85
		Percent	
Gender	Female	51	
Relationship to the household	Head or spouse	93	
Highest Education completed	Primary	23	
	Secondary	20	
	Tertiary	22	
	University level	19	
	None and dropouts	16	
Monthly income in KShs	Low (0-15,000)	51	
	Middle (16,000-50,000)	29	
	Upper middle (52,000-100,000)	11	
	High (>100,000)	7	
Employment	Formally employed	29	
	Self employed	27	
	Farming and fishing	21	
	student	3	
	Retired	3	
	Unemployed	4	
	Others	11	
Accommodation	Owned	60	
	Rented	40	
Region of residence	Rural	60	
	Urban	40	

Note: SD = standard deviation

In terms of number of members of the household, the average is 5.14 persons, which is in line with the national average of 5.1 persons. In terms of gender, 51 percent of the respondents in our sample are females whereas the national average is 50.3 percent. The majority of the respondents in our sample are located in rural areas, though a little below the national average of 67% living in rural areas. The highest completed education level of the respondents in the sample is fairly evenly distributed by category. Generally, 65% of the sampled respondents have completed primary, secondary and tertiary education whereas 19% have completed university education. The rest includes those who either do not have any education or who dropped out from primary and secondary education. We classified our sample into four categories using income categories following Kimenju and Groote (2008). Government and private sector employment are collapsed to one variable as *formally employed*.

Latent class model results

The LCM enables incorporating socio-economic variables as well as attitudinal statements in the membership function for specific classes. Table 4 presents the different explanatory variables included in the membership function.

Table 4: Explanatory variables used for model estimation

Variable	**Description**	**Mean**	**SD**	**Min**	**Max**
Age (AGE)	Age of the respondents in years	40	12.97	18	85
Education (EDUCATION)	1 if the respondent has completed tertiary education and above	0.40	0.49	0	1
Gender (Female)	1 if female	0.51	0.50	0	1
Number of household (HH_NUM)	The number of people living in the household	5.14	2.64	1	18
Number of children (CHILD_NUM)	The number of children below 18 years old in the household	2.20	1.85	0	11
Has children (HAS_CHILDREN)	1 if the respondents has one or more children	0.81	0.39	0	1
Formally employed (EMPLOYED)	1 if the respondent is employed in either government or private sector	0.29	0.45	0	1
Farming and fishing (FAR_FISH)	1 if the respondent's main occupation is either farming or fishing	0.22	0.42	0	1
Taste experience (TASTED)	1 if the respondent has tasted edible insects or meals containing edible insects before	0.82	0.37	0	1
Pro-entomophagy attitude (PRO_ENT ATTITUDE)[3]	Scores are calculated for each individual based on the weights obtained from the PCA	-0.0021	1.73	-6	2.4
Environmental and nutritional benefit attitude (ENV_NUT ATTITUDE)	Scores are calculated for each individual based on the weights obtained from the PCA	-0.0023	1.48	-5.9	2.5
Familiarity with edible insects' nutritional importance for humans (FAM_NUT)	1 if the respondent said s/he is familiar with the nutritional importance of edible insects for humans	0.60	0.49	0	1
Insect eating tradition (INSECT_EAT_TRAD)	1 if the respondent lives in areas where edible insects are traditionally	0.59	0.49	0	1

[3] We identified ten attitudinal statements relevant to assess consumers' attitudes toward the use of edible insects as food. As is commonly done in the literature (e.g. Kikulwe et al. 2011; Yoo and Ready, 2014), we analyzed the data using a principal component analysis (PCA) to identify components across attitudinal statements. The PCA results give us two distinct components based on a linear weighted combination of the statements (Cronbach's alpha = 0.8155). The first component is highly related to the statements concerning acceptability, safety and preparedness to eat foods from edible insects, thus, we label this component *'Pro-entomophagy'* attitude. The second component concerns statements regarding environmental and nutritional importance of rearing edible insects. Thus, we label this component 'Nutritional-Environmental benefits' attitude.

	consumed				
Food neophobia Scale (FNS)[4]	Measures the food neophobic trait of individuals	20.78	6.36	6	30

The application of LCM entails the determination of the optimal number of classes. This is commonly done by relying on minimizing information criteria such as the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) (e.g. Andrew and Currim, 2003; Scarpa and Thiene, 2005). However, as suggested by Swait (1994); Scarpa and Thiene (2005, 2011); Ruto et al. (2008); and Glenk et al. (2012), relying solely on these criteria can lead to very high number of classes and possibly misleading preference and welfare estimates. Consequently, the selection of the appropriate number of classes must also take the significance of parameters into account (Scarpa and Thiene, 2005). In addition, model interpretability and the agreement of results with the accepted theoretical foundations should also be considered (Ruto et al. 2008). For these reasons, we present results from a specification of the LCM with four classes even if both the BIC and CAIC reached their minimum when specifying five classes, as shown in table 5. Statistical Innovation's Latent Gold Choice 5.0 (Vermunt and Magidson, 2014) was used to estimate the LCM.

Table 5: Number of classes and goodness-of-fit measures

Number of classes	Number of parameters (npar)	Log-likelihood (LL)	BIC (LL)	AIC (LL)	CAIC (LL)
1	11	-6632.195	13334.497	13286.391	13345.497
2	35	-5547.789	11318.645	11165.579	11353.645
3	59	-5334.458	11044.942	10786.916	10103.942
4	83	-5152.992	10834.969	10471.983	10917.969
5	107	-5000.619	10683.183	10215.238	10790.183
6	131	-4932.887	10771.638	10126.680	10830.585

Number of observations (N) = 7032, $BIC(LL) = -2\ LL + (\log N)\ npar$, $AIC(LL) = -2\ LL + 2\ npar$, $CAIC(LL) = -2\ LL + [(\log N) + 1]\ npar$

We estimated three different models. Model 1 represents the full model wherein data from both products, i.e. WTFS and TP, are pooled and then estimated together. Model 2 uses data from the WTFS whereas model 3 utilizes data from the TP meal. We have tested several models with different combinations of membership variables[5] and the best models with more significant parameters that offer meaningful interpretations are presented.

[4]Respondents were asked to what extent they agree or disagree to six food neophobia statements. The food neophobia scale (FNS), which was originally developed by Pilner and Hobden, (1992), contains 10 items; however, we selected six items following Ritchey et al. (2003) to include only items that were deemed culture suitable for Kenyan people. The FNS score was calculated by summing individual scores for each item. In line with Pilner and Hobden (1992), three positively worded items were reversed so that high scores reflect higher food neophobic behavior.

[5] In line with Kikulwe et al. (2011), we used the variance inflation factor (VIF) to test for possible multicolinearity between variables used in the membership model by regressing each variable on the rest variables, i.e. using each variable as dependent and the rest as independent variables. We found no problem of multicolinearity.

All the LCM results show that the estimated price parameters are significant and negative in all classes, which is in agreement with our expectation. In addition, the ASC parameter, which was specified to represent the 'none of these' option is negatively significant in consistent with our prior anticipation that consumers would favor either option 1 or option 2 over the 'none of these' option. The LCM model enabled us to identify a small group of consumers (4-10% depending on the type of the product) who are not sensitive to all the attributes in the SCE. Therefore, in what follows, we disregard the interpretation of results on these segments of consumers.

The results in table 6 reveal that consumers behave differently when making their decision concerning the choice of TBFPs. This justifies the application of the LC models to trace heterogeneity in preferences.

Table 6: Model 1 - Full model (standard errors in parenthesis)

	Class 1	Class 2	Class 3	Class 4
	Price conscious consumers	Non-insect eating consumers	Pro-nutrition consumers	Random choosers
Choice model				
ASC (no choice)	-5.013 (0.249)***	-0.227 (0.138)*	-4.519 (0.514)***	3.424 (5.982)
NV_High	0.146 (0.031)***	0.341 (0.056)***	1.862 (0.169)***	2.095 (2.180)
NV_Average	0.013 (0.029)	0.113 (0.055)**	0.818 (0.121)***	-1.537 (2.958)
FSC_Very_high	0.176 (0.029)***	-0.128 (0.058)**	0.565 (0.111)***	1.021 (2.479)
FSC_High	-0.006 (0.029)	0.111 (0.056)**	0.276 (0.104)***	0.813 (2.124)
RC_Official	0.179 (0.028)***	0.208 (0.069)***	0.605 (0.178)***	0.264 (2.859)
RC_Media	0.059 (0.036)*	-0.047 (0.073)	-0.068 (0.131)	-0.427 (3.786)
RC_Peers	0.028 (0.037)	0.096 (0.071)	-0.134 (0.099)	0.531 (2.595)
SL_Supermarket	-0.108 (0.029)***	0.109 (0.056)*	0.033 (0.106)	-1.682 (3.140)
SL_Kiosks	0.040 (0.029)	-0.157 (0.058)***	-0.251 (0.110)**	1.055 (1.799)
PRICE	-0.011 (0.001)***	-0.007 (0.002)***	-0.007 (0.002)***	-0.071 (0.095)
Class membership model				
Constant	8.075 (2.139)***	6.983 (2.157)***	6.250 (2.246)***	
AGE	-0.063 (0.023)***	-0.056 (0.024)**	-0.087 (0.025)***	
EDUCATION	-1.273(0.765)*	-0.415 (0.768)	-0.686 (0.804)	
FEMALE	-0.559 (0.574)	-0.552 (0.578)	-1.076 (0.613)*	
HH_NUM	0.108 (0.118)	0.083 (0.123)	0.222 (0.124)*	
EMPLOYED	-0.587 (0.672)	-0.814 (0.667)	-0.601 (0.717)	
TASTED	2.536 (0.745)***	1.489 (0.751)***	3.184 (0.870)***	
FAM_NUT	-0.175 (0.649)	-0.073 (0.659)	-1.008 (0.694)*	
FAR_FISH	-0.905 (0.794)	-1.556 (0.842)*	-0.132 (0.837)	
FNS	-0.109 (0.053)**	-0.075 (0.053)	-0.066 (0.055)	
PRO_ENT ATTITUDE	0.705 (0.197)***	0.646 (0.199)***	0.466 (0.211)**	
ENVNUT ATTITUDE	-0.137 (0.213)	-0.122 (0.218)	0.492 (0.241)**	
INSECT_EAT_TRAD	-0.755 (0.704)	-1.246 (0.712)*	-1.077 (0.743)	
Class probability	0.562	0.205	0.189	0.043
Log-likelihood	-5152.992			
Number of observation	7032			

Note: '*' denotes statistical significance at 10% level, '**' denotes statistical significance at 5% level, and '***' denotes statistical significance at 1% level.

The first class (56%) accommodates consumers who are less educated and less food neophobic. They are labeled as price *conscious consumers* as the absolute value of the estimated price coefficient is relatively higher than the other groups. These consumers strongly prefer TBFPs which are characterized by high nutritional value, recommended by officials and have a very high food safety control level. However, their preference for supermarkets as shopping locations is negative. Consumers in the second class (21%) are likely from areas of no insect consumption tradition. In addition, farming and fishing is less likely to be their main occupation since those who are not associated with entomophagy reside mostly in urban areas. Consistent with this result, the estimated coefficient for the supermarket shopping location is positively significant as these consumers have access to supermarkets particularly in Nairobi and Machakos counties. In terms of their utility for the other attributes, they prefer TBFPs with average to high nutritional value and when recommended by officials. In the third class (19%) consumers are likely to be males and with a relatively high number of household members. They put more weight on the nutritional value attribute levels than any other segments of consumers, and thus, they are labeled as *pro-nutrition consumers*. In line with this, the membership probability model shows that these consumers are strongly associated with pro-entomophagy, and environmental and nutritional benefits attitudes. Moreover, these consumers strongly prefer TBFPs with high to a very high food safety control levels, and when recommended by officials.

Table 7 reports results concerning the preferences for WTFS. The first class (48%) assembles a group of consumers who are likely to have more children. They are less inclined to accept recommendation from their peers but they would accept it from media and officials. We thus refer this class as *distrust peers*. Their preference for the nutritional value of the specific product is positive; however, they appear to favor local markets over the other shopping locations. Looking at the results related to the second class (30%) shows that consumers in this class are likely to originate from areas of insect eating cultures and they have a strong pro-entomophagy attitude. These consumers prefer kiosks over local markets; thus, we label them as *kiosk preferring*. Members in this class prefer TBFPs with moderate nutritional content and high level of food safety control. Moreover, they tend to follow friends' and relatives' recommendation to consume TBFPs. The third class (14%) is likely to contain group of respondents who are *content with nutritional value only*. They show less sensitivity for food safety and shopping location attributes. One thing to notice is that the coefficient of the ASC is close to zero, which might elucidate that these consumers inclined to choose the 'none of these' alternative, which to some extent may explain their insensitivity to the shopping location and food safety control attributes.

Table 7: Model 2 - Whole termite fried and salted (standard errors in parenthesis)

	Class 1	Class 2	Class 3	Class 4
	Distrust peers	Kiosk preferring	Content with nutritional value	Random choosers
Choice model				
ASC (no choice)	-6.503 (2.897)**	-5.460 (0.504)***	-0.705 (0.312)**	3.077 (5.567)
NV_High	0.858 (0.123)***	-0.594 (0.166)***	0.336 (0.160)**	2.006 (2.234)
NV_Average	0.156 (0.067)**	0.259 (0.113)**	0.300 (9.118)**	-0.147 (2.025)
FSC_Very_high	0.339 (0.091)***	-0.228 (0.121)*	-0.161 (0.125)	-0.435 (3.052)
FSC_High	-0.148 (0.092)	0.443 (0.112)***	0.171 (0.131)	0.933 (2.656)
RC_Official	0.259 (0.098)***	0.328 (0.139)**	0.250 (0.162)	0.891 (2.310)
RC_Media	0.187 (0.108)*	-0.332 (0.140)**	-0.362 (0.163)**	0.237 (3.883)
RC_Peers	-0.221 (0.103)**	0.437 (0.144)***	0.110 (0.172)	0.791 (3.285)
SL_Supermarket	-0.125 (0.070)*	0.053 (0.092)	-0.005 (0.117)	-0.799 (3.059)
SL_Kiosks	-0.234 (0.068)***	0.539 (0.136)***	0.103 (0.117)	-0.923 (2.408)
PRICE	-0.006 (0.002)***	-0.022 (0.004)***	-0.007 (0.003)**	-0.06 (0.076)
Class membership model				
Constant	0.886 (0.830)	1.054 (0.809)	1.624 (0.861)*	
Age	-0.048 (0.018)***	-0.041 (0.018)**	-0.053 (0.019)***	
CHILD_NUM	0.209 (0.127)*	0.173 (0.129)	-0.015 (0.149)	
Female	-0.345 (0.419)	-0.347 (0.427)	-0.093 (0.462)	
TASTED	3.968 (0.583)***	2.579 (0.576)***	2.592 (0.611)***	
PRO_ENT attitude	0.137 (0.143)	0.482 (0.151)***	0.293 (0.157)*	
ENVNUT attitude	0.015 (0.159)	-0.314 (0.349)**	-0.100 (0.174)	
INSECT_EAT_TRAD	0.441 (0.411)	0.934 (0.419)**	-0.131 (0.449)	
Class probability	0.478	0.301	0.137	0.085
Log-likelihood	-2481.287			
Number of observation	3528			

Note: '*' denotes statistical significance at 10% level, '**' denotes statistical significance at 5% level, and '***' denotes statistical significance at 1% level.

Results concerning the TP are presented in table 8. Members in the first class (67%) tend to reside in insect eating areas and they practice farming and fishing as their main occupation. The most notable result in this class is that consumers have positive preference for all recommendation attribute levels and as a result we label them as *recommendation follower consumers*. In addition, they attach positive utility for the nutritional value and food safety control attributes of the product, and moreover, they would like to purchase the product in kiosks rather than local markets. Like that of the first class, the second class (13%) is likely to contain consumers who live in insect eating areas. However, they have negative utility for all attribute levels but supermarkets. They particularly associate higher negative preferences for the recommendation attribute levels, thus, we call them *recommendation opponents*. The reluctance of these segments of consumers to react to the TP attributes is in harmony with our expectation as people in insect eating areas are familiar with only whole termites, hence, the powder form can be radically new for some of them. Members in the third class (10%) probably have a negative taste experience as the estimated coefficient for taste experience is significantly negative. This may contribute to their insensitivity to the different attributes of the TP meal.

Table 8: Model 3 - Termite powder (standard errors in parenthesis)

	Class 1	Class 2	Class 3	Class 4
	Recommendation followers	Recommendation opponents	Random choosers	Official recommendation conscious
Choice model				
ASC (no choice)	-4.459 (0.322)***	-9.035 (5.463)*	-1.019 (9.904)	-0.887 (0.359)**
NV_High	0.643 (0.058)***	-0.085 (0.180)	0.050 (2.261)	0.341 (0.169)**
NV_Average	0.242 (0.053)***	-1.657 (0.558)***	0.202 (1.785)	0.294 (0.150)**
FSC_Very_high	0.411 (0.081)***	-0.032 (0.233)	-0.334 (1.485)	-0.516 (0.177)***
FSC_High	0.108 (0.052)**	-1.307 (0.524)**	-1.109 (2.243)	0.397 (0.149)***
RC_Official	0.181 (0.077)**	-0.542 (0.263)**	1.238 (2.539)	0.967 (0.219)***
RC_Media	0.478 (0.105)***	-1.989 (0.881)**	-3.107 (4.686)	-0.699 (0.292)**
RC_Peers	0.141 (0.053)***	-0.796 (0.251)***	2.176 (2.349)	0.327 (0.192)*
SL_Supermarket	-0.074 (0.051)	0.410 (0.164)**	0.416 (2.714)	0.405 (0.159)**
SL_Kiosks	0.174 (0.064)***	-0.424 (0.204)**	-0.502 (2.527)	-0.414 (0.164)**
PRICE	-0.01 (0.001)***	-0.008 (0.004)**	-0.129 (0.166)	-0.012 (0.004)***
Class membership model				
Constant	2.060 (0.943)**	1.448 (1.076)	0.907 (1.085)	
HAS_CHILDREN	-0.421 (0.462)	-0.356 (0.543)	-1.106 (0.514)**	
EMPLOYED	0.376 (0.382)	0.167 (0.473)	0.777 (0.464)*	
FAR_FISH	2.035 (1.048)**	1.086 (1.096)	1.563 (1.119)	
TASTED	0.083 (0.462)	0.248 (0.582)	-1.227 (0.499)**	
FNS	-0.017 (0.029)	-0.073 (0.034)**	0.033 (0.036)	
FAM_NUT	-0.558 (0.400)	-0.685 (0.457)	-0.997 (0.461)**	
INSECT_EAT_TRAD	0.901 (0.366)**	1.212 (0.447)***	0.671 (0.448)	
Class probability	0.668	0.129	0.102	0.101
Log-likelihood	-2432.402			
Number of observation	3546			

Note: '*' denotes statistical significance at 10% level, '**' denotes statistical significance at 5% level, and '***' denotes statistical significance at 1% level.

These respondents are likely to be formally employed and have fewer children. We anticipate that these consumers are probably from urban areas as they are formally employed, which also includes private sector employment, and most people employed in this sector concentrate in Nairobi, which hosts the largest urban population in Kenya and is assumed to be non-insects eating site in our sample. The last class contains group of consumers who are content with official recommendation as the estimated coefficient is the highest when compared to the other groups. Hence, they are referred as *official recommendation conscious*. They attach positive utility on nutritional value, supermarkets, and friends' and relatives' recommendation. One notable thing regarding the results of the TP product is that the taste experience parameter is either insignificant or negatively significant. Given that consumers have not tasted this product before, the role of previous taste experience may have a minimal impact.

Willingness to pay

We now turn our attention to the results regarding the WTP for TBFPs. Beginning from table 9, the WTP estimates in the first class are generally lower than others due to the relatively high price sensitivity in this class.

Table 9: Marginal willingness to pay – Full model (standard errors in parenthesis)

	Class 1	Class 2	Class 3	Class 4	
	Price conscious consumers	Non-insect eating consumers	Pro-nutrition consumers	Random choosers	Class weighted WTP
NV_High	13.9 (2.9)***	46.6 (12.0)***	270.9 (85.0)***	-	68.4
NV_Average	1.2 (2.8)	15.4 (8.0)*	118.9 (40.1)**	-	25.6
FSC_Very_high	16.8 (2.9)***	-17.5 (8.8)**	82.2 (31.6)***	-	21.3
FSC_High	-0.5 (2.7)	15.1 (8.1)*	40.1 (17.6)**	-	10.7
RC_Official	17.0 (3.8)***	28.3 (11.1)***	87.9 (41.6)**	-	32
RC_Media	5.7 (3.5)*	-6.4 (9.9)	-9.9 (19.8)	-	3.2
RC_Peers	2.7 (3.5)	13.0 (10.2)	-19.5 (16.5)	-	-
SL_Supermarket	-10.3 (2.8)***	14.8 (8.4)*	4.8 (16.1)	-	-2.7
SL_Kiosks	3.8 (2.7)	-21.3 (9.3)**	-36.5 (19.9)*	-	-11.3
Class probability	0.562	0.205	0.189	0.043	1

Note: '*' denotes statistical significance at 10% level, '**' denotes statistical significance at 5% level, and '***' denotes statistical significance at 1% level.

However, these consumers are still willing to pay amounts from 6 KShs to 17 KShs for TBFPs, and they are willing to accept to purchase the products in supermarkets. The highest WTP amounts are for high (270 KShs) and average (118 KShs) nutritional value, which belong to the pro-nutrition consumers. Results also show that the WTP for TBFPs recommended by officials ranges from approximately 20 KShs to 90 KShs. Regarding the food safety control attribute, consumers attach a WTP value that ranges from 20 KShs to 85 KShs in approximation. Consumers from non-insects eating tradition are willing to pay up to 45 KShs for TBFPs with high nutritional value (45 KShs) and for TBFPs recommended by officials (30 KShs). They also tend to pay more (15 KShs) for shopping TBFPs in supermarkets. In general, consumers would pay more for high nutritional value and official recommendation as revealed by the class weighted WTP values.

Considering the WTP estimates for WTFS in table 10, the highest WTP (136 KShs) is found in the first class for high nutritional value followed by 55 KShs for a very high food safety control. Consumers in the third class are also willing to incur a cost of 50 KShs to compensate low nutritional value with high nutritional value. The next important result is that official recommendation still plays an important role as it gets a marginal WTP of around 42 KShs. Unlike consumers in the first class who put a negative marginal WTP on kiosks, consumers in the second class are positively willing to pay a marginal price of 25 KShs to buy WTFS in kiosks.

Furthermore, consumers in this class would pay more (20 KShs) for recommendation from their peers.

Table 10: Marginal willingness to pay – Whole termite fried and salted (standard errors in parenthesis)

	Class 1	Class 2	Class 3	Class 4	
	Distrust peers	Kiosk preferring	Content with nutritional value	Random choosers	Class weighted WTP
NV_High	136.4 (37.1)***	-27.7 (6.8)***	50.0 (25.8)**	-	63.8
NV_Average	24.8 (12.2)**	12.1 (4.6)***	44.8 (28.9)	-	15.4
FSC_Very_high	53.8 (21.2)***	-10.6 (5.4)**	-24.0 (22.0)	-	22.6
FSC_High	-23.5 (16.7)	20.7 (5.9)***	25.5 (23.5)	-	6.2
RC_Official	41.2 (19.6)**	15.3 (6.6)**	37.3 (32.8)	-	24.3
RC_Media	29.7 (18.2)	-15.5 (6.3)**	-53.9 (39.8)	-	-4.7
RC_Peers	-35.1 (19.7)*	20.4 (5.9)***	16.5 (26.6)	-	-10.7
SL_Supermarket	-19.8 (12.4)	2.4 (4.2)	0.7 (17.4)	-	-
SL_Kiosks	-37.2 (14.2)***	25.1 (4.7)***	15.4 (19.3)	-	-10.2
Class probability	0.478	0.301	0.137	0.085	

Note: '*' denotes statistical significance at 10% level, '**' denotes statistical significance at 5% level, and '***' denotes statistical significance at 1% level.

The final results regarding WTP concerns TP. As shown in table 11, more than 65% consumers in the first class are willing to pay more for recommendation as opposed to 13% of consumers in the second class, who are found to have decreasing utility for TP. Groups of consumers in the fourth class are willing to sacrifice around 80 KShs and 30 KShs for official, and friends' and relatives' recommendation, respectively. The WTP for the nutritional value goes up to approximately 65 KShs. And consumers would pay up to 40 KShs for a very high food safety control of the TP meal.

Table 11: Marginal willingness to pay – Termite powder (standard errors in parenthesis)

	Class 1	Class 2	Class 3	Class 4	
	Recommendation followers	Recommendation opponents	Random choosers	Official recommendation conscious	Class weighted WTP
NV_High	63.9 (8.1)***	-10.7 (25.6)	-	27.9 (17.9)	42.7
NV_Average	24.1 (5.5)***	-208.2 (93.1)**	-	25.2 (13.2)*	-8.3
FSC_Very_high	40.9 (7.6)***	-4.0 (29.7)	-	-42.3 (19.5)**	23.1
FSC_High	10.8 (5.1)**	-164.2 (76.1)**	-	32.6 (15.1)**	-10.7
RC_Official	18.0 (8.3)**	-68.0 (40.9)*	-	79.3 (28.7)***	11.2
RC_Media	47.6 (9.9)***	-249.8 (126.2)**	-	-57.3 (26.9)**	-6.2
RC_Peers	14.0 (5.3)***	-99.9 (48.3)**	-	28.8 (16.5)*	-0.6
SL_Supermarket	-7.4 (5.1)	51.5 (28.0)*	-	33.2 (17.5)*	10
SL_Kiosks	17.3 (5.9)***	52.3 (40.7)	-	-33.9 (18.1)*	8.2
Class probability	0.668	0.129	0.102	0.101	

Note: '*' denotes statistical significance at 10% level, '**' denotes statistical significance at 5% level, and '***' denotes statistical significance at 1% level.

Discussion and conclusion

The results reveal that most consumers are associated with pro entomophagy attitude and less food neophobic traits which can be of great significance to facilitate the promotion of edible insects as food in Kenya. Consumers in the sample, regardless of the tradition of consuming insects, generally prefer TBFPs with high nutritional value signifying that this attribute is the most important factor for most consumers. In particular, households with higher number of members and children value higher nutritional value the highest, suggesting that these consumers may find edible insects to be a viable source of protein.

Results concerning the two products, i.e. WTFS and TP, do not show stark differences in preferences and WTP. However, most consumers value all recommendation attribute levels when they are asked to make purchase decisions regarding the processed termite product. This implies that when consumers are asked to buy and consume novel products which are processed, they may tend to reduce the risk of new experience by seeking information, for example, through word of mouth, from media or from their respective officials. The impact of recommendation on consumers' decision to purchase products is well covered in the marketing literatures (e.g. Trusov et al. 2009). When consumers face new products they will have to deal with a great deal of uncertainties (Hoefler, 2003) and barriers to buy and consume new food products can be relaxed by acquiring a learned experience from others. Apart from being a new product, consumers may potentially distrust the processed alternative (TP) itself as they do not see what they eat and this may induce additional uncertainty. The distrust can be related to food safety concerns as reported in other studies (e.g. Ortega et al. 2011) and such elements of distrust could be reduced if recommendations from other sources are provided for consumers.

Generally speaking, albeit differences in WTP magnitudes, most consumers have positively reacted to the WTFS and TP, which suggests that consumers could accept and buy TBFPs irrespective of how they are presented. This is likely attributable to the fact that most consumers are familiar with termites being traditionally consumed as food in Kenya. In this respect, more than 80% of the consumers in our sample said that they have eaten termites before, and around 97% of them reported that they have heard edible insects being consumed in Kenya. Such level of familiarity may drive consumers in the sample to react positively to the two products. Moreover, presenting the termite products with familiar and readily accepted foods (in this case Ugali) may have increased the likelihood of acceptance of TBFPs no matter how they are presented. Related results are found in Megido et al. (2014); and Tan et al. (2015).

Although it is difficult to draw a conclusion based solely on results presented here, future commercialization of TBFPs in Kenya may benefit from introducing products which are either presented as whole or as processed formats. However, introducing the processed products may require further intervention from the food and health sectors in terms of some official recommendation and labelling. Moreover, according to the results, most consumers gain positive utility from shopping TP in either kiosks or supermarkets other than in local markets, which suggests that there is demand for the processed termite products if they are brought to the conventional food stores. As opposed to this, only 30% of consumers would like to shop the WTFS in Kiosks, and none of them showed tendency to make supermarkets as their shopping destination for WTFS. This may be tied to the fact that whole and roasted termites are usually sold in western Kenya, and other consumers in other parts of the country are aware of this. As a result, consumers may be reluctant to see WTFS in the conventional food stores, perhaps because they fear price increases or because of less experience with purchasing whole and fresh products from supermarkets. In addition, people usually catch termites during the rainy season and serve them after drying and roasting them. This may also contribute to consumers' disinclination to buy such kind of products in supermarkets.

In sum, most consumers in Kenya prefer and are willing to pay more for TBFPs characterized by high nutritional value, with a high level of food safety control and an official recommendation. This remains true irrespective of the presence of the tradition of consuming edible insects. Based on the results so far, two policy implications can be drawn. First, promoting edible insects as food would be effective in Kenya if officials in the health and food sectors take an active role in engendering edible insects into the food chain. As discussed in FAO (2013), since edible insects do not fall within the conventional food chain, national regulations in terms of, e.g. standardization to control food safety and legalizing are scanty. Nevertheless, if insects are to be used as food, administrative frameworks should come into play (FAO, 2013). This is consistent with our findings' that consumers would trust and accept edible insects for consumption if they get information from their respective officials. Second, the fact that consumers in our sample showed significant demand for TBFPs would seem to be very policy relevant in relation to establishing an edible insects production sector so as to facilitate commercialization in Kenya. In other words, the results presented in this paper serve as initial guidance for policy development aimed at overcoming potential challenges and barriers to start mass-rearing and subsequently promote quality control and marketing for human consumption of insects.

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