Consumer demand for staple food crops biofortified with micronutrients in three Sub-Saharan African countries

by

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DECLARATION OF ORIGINALITY

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Declaration

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……………………………………………………………………………..

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……………………………………………………………………..

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DEDICATION

To The Lord Almighty for His Goodness and Grace

To my late mum Catherine who sat with me in class in the first grade when I did not want to be in school, and my late brother Peter who supported my education to the end

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ABSTRACT

Demand for biofortified food crops in three sub-Saharan African countries

By

Priscilla Hamukwala

Degree:	Doctor of Philosophy (Agricultural Economics)
Department:	Agricultural Economics, Extension and Rural Development
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This study determines consumer demand for staple food crops biofortified with micronutrients in three sub-Saharan African countries. Specifically, the study investigates how the choice of a valuation technique for a nonmarket good or new product, and gender, influence acceptance of biofortified food crops. Biofortification, a new public health intervention for alleviating micronutrient deficiency problems in developing countries, is achieved by enhancing the micronutrient content of staple food crops using conventional plant breeding or biotechnology. The rural poor in developing countries are likely to benefit most from biofortification, for two main reasons. Firstly, their diets are primarily comprised of staple foods that are usually poor sources of micronutrients. Secondly, they have limited access to fortified food products, mineral and vitamin supplements. The novel property of biofortification, however, has been associated with changes in the intrinsic properties of staple food crops that may not be familiar to consumers. Thus, knowing consumers' attitudes and potential reactions to such changes in their staple food crops has been important to researchers and marketers alike. The study employs hedonic evaluations and incentive-compatible economic experimental data from HarvestPlus that aimed at determining consumer acceptance of micronutrient biofortified staple food crops in three sub-Saharan countries, i.e., Nigeria, Rwanda, and Zambia.

The first objective compares the Becker–DeGroot–Marschak (BDM) mechanism to the non-hypothetical choice experiment (nHCE) in revealing the willingness to pay (WTP) for a new maize variety biofortified with vitamin A, under a field setting in Zambia. A mixed logit model was used to determine consumers' WTP for the biofortified orange maize, relative to the two local maize varieties in the nHCE. While a symmetrically censored least square (SCLS) model was used to determine consumers' WTP for the biofortified orange maize in the BDM experiment. The results show that the nHCE yielded significantly higher WTP estimates than that from the BDM mechanism.

The second objective, related to the first, explored potential reasons for the WTP disparity between the BDM and the nHCE. The results indicate that accounting for additional training in the BDM experiment and lexicographic behaviour in the nHCE, together resulted in a decrease by half in the WTP estimates difference between the two methods. This difference, however, remains statistically significant.

The third objective determined whether the gender of the decision-maker is important in determining consumer's attitudes and behaviour towards biofortified food crops. Specifically, the study explores gender differences in hedonic preferences and consumer valuations of food products made from biofortified food crops. Emphasis was placed on the statistical analysis methods that incorporate gender while fully accounting for sources of both the observed and unobserved heterogeneity across gender. Results suggest that the gender of the decision-maker may be an important factor in both hedonic preferences and WTP for biofortified food crops, although the results varied across three countries. In Zambia and Rwanda, gender differences were observed in hedonic preferences for vitamin A-biofortified orange maize and biofortified iron beans respectively, while no evidence of gender differences was observed in hedonic preferences for vitamin A biofortified cassava in Nigeria. On the other hand, gender differences in WTP for biofortified foods were observed across the three countries in the respective biofortified food crops.

While it is not yet clear how the BDM and the nHCE can result in significantly different empirical estimates under similar conditions, these results suggest the solution could lie in controlling for design effects from the two techniques. Similarly, controlling for gender differences not only in the outcome variable but also in its determinants may be necessary to attain valid estimates of consumer acceptance of biofortified foods.

Keywords

Valuation techniques, Becker-DeGroot-Marschak, non-hypothetical choice experiment, Willingness-to-pay, Design factors, gender, preferences

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ACC/SCN	Administrative Committee on Coordination/Sub-committee on Nutrition
BFC	Biofortified food crops
BDM	Becker–DeGroot–Marschak method
DHS	Demographic Health Survey
FAO	Food and Agricultural Organisation
IFAD	International Fund for Agricultural Development
nHCE	Non-hypothetical choice experiment
WFP	World Food Program
WHO	World Health Organisation
WTP	Willingness to pay

CHAPTER 1: INTRODUCTION

1.1 Background

Globally, over two billion people are adversely affected by micronutrient deficiencies, with individuals residing in developing countries suffering the highest level of deficiencies (FAO et al. 2013). Micronutrient deficiencies have been attributed to poor quality diets largely comprised of starchy staple foods, with little consumption of meat and other micronutrient-rich foods. Females of childbearing age, and children under the age of five years are the most adversely affected due to their physiological requirements (ACC/SCN 2000; Nestel et al. 2006). Insufficiency intake of micronutrients that include vitamin A, iron, iodine and zinc are rated among the top 10 causes of death (WHO 2007).

Industrial food fortification, pharmaceutical supplementation, and dietary diversity promotions are the traditional methods used to combat micronutrient deficiency problems in developing countries. However, these methods are being criticised for being costly, and not effectively reaching out to the most vulnerable groups such as the rural poor with limited access to marketed supplies or designated distribution channels (Webb and Thorne-Lyman 2005; Unnevehr et al. 2007). Biofortification, a process of increasing the nutrient content of food crops through conventional plant breeding or biotechnology (Nestel et al. 2006), is a new public health intervention method in combating micronutrient deficiencies. Biofortification is viewed as a more sustainable method in solving the micro-nutrient deficiency problems, and at the same time, a complementary method to the existing methods, especially in developing countries (Bouis 1999).

A number of studies have demonstrated that biofortification is likely to reduce the costs of alleviating micronutrient deficiencies more effectively than the current methods (Dawe et al. 2002; Stein 2006; Qaim et al. 2007). The rural poor are likely to benefit more in that only a single investment will be needed in plant breeding. Additionally, micronutrient-rich germplasm will be available for farmers to grow biofortified crops after initial investment for years with minimal variety purity maintenance costs. This is in contrast to the traditional methods of fortification and supplementation that require larger amounts of investment for sustenance (Dawe et al. 2002). Furthermore, the targeted crops for biofortification are staple food crops that are consumed in developing countries, suggesting that dietary habits will not be altered, thereby increasing the probability of adoption (Nestel et al. 2006). However, the novel property of biofortification has been associated with alterations in some of the intrinsic properties of staple food crops that may pose a threat to consumer acceptance. Some of the changes that have been observed include; colour, taste, dry matter content and end-use characteristics such as flour quality and cooking quality (Banerji et al. 2013; Stevens and Winter-Nelson 2008; De Groote et al. 2014).

With all these expected changes, consumers are also expected to willingly consume biofortified food products regularly for micronutrient deficiency problems to be alleviated (Birol et al. 2015). The willingness to consume these products, however, will depend on how they are perceived by consumers themselves and other actors in the food supply chain. According to Fell (2009), consumers normally consider the traditional foods they have consumed for years as much safer, and would often accept novel foods with circumspection. The case in point is the introduction of genetically modified (GM) foods that has sparked debates regarding GM food safety to consumers, and to the environment (Evans and Cox 2006). Although the staple food crops are targeted for biofortification, it is still unclear how the changes in some of the intrinsic attributes will affect consumer attitudes and behaviour towards biofortified food crops.

Furthermore, in sub-Saharan Africa, the region targeted for biofortified food crops introduction, consumers in the past had rejected yellow kernelled maize varieties donated by the United States as food aid in famine times. This stemmed from the belief that yellow maize was produced exclusively for cattle feeding in the country of origin, and not for human consumption. Since then, yellow maize has been perceived and stigmatised as food for bad times when citizens had to eat cattle food to survive. Additionally, yellow maize was found repugnant by a majority of consumers because of an unpleasant taste and aroma. Currently, yellow maize is still considered inferior to the conventional white maize in the region where people predominantly prefer white maize varieties. Traditionally, white maize garners a better price than yellow maize and consumers customarily only purchase yellow maize if offered at deep discounts.

As earlier stated, the rejection of yellow maize raised concerns among researchers as to how consumers would respond to likely changes in the staple food’s intrinsic attributes from the biofortification process. Thus, the knowledge of consumers' attitudes and food preferences in the early stages of developing biofortified food crops is necessary to provide the needed feedback to guide ongoing product development and inform better marketing strategies (Asp 1999). The main focus of consumer behaviour studies on biofortified food crops has been therefore on understanding consumers' attitudes and valuations of food products made from biofortified food products. Additionally, these studies have also tested demand-creating strategies for biofortified food products. Specifically, sensory evaluations, hedonic tests, and economic experiments (for eliciting consumer's willingness to pay) are the main tools that have been employed to understand consumer acceptance. Behaviour change communication tools for creating demand for biofortified food crops. These included the use of nutrition messages by type, media channels, length, content, branding options and nature of endorsing agents (Birol et al. 2015).

Results of these studies indicate that acceptance is possible in some countries/communities (e.g., vitamin A biofortified orange maize in Zambia) even without nutritional campaigns, while in others, nutritional campaign messages were needed (iron biofortified white beans in Rwanda). Nutrition messages largely attracted premiums over conventional products in most studies, and also changed the lingering negative perceptions of biofortified food crops in others. Additionally, in certain communities, biofortified food crops are rejected despite nutritional campaigns (Birol et al. 2015). All other demand tools besides nutrition campaigns did not matter in all countries (Oparinde et al. 2015; Oparinde et al. 2014; Banerji et al. 2013; Chowdhury et al. 2011; Meenakshi et al. 2012; Stevens and Winter-Nelson 2008).

1.2 Research problems and justifications

Biofortified food crops are underway to be released in the markets of selected sub-Saharan African countries. However, knowledge gaps in consumer acceptance of biofortified food crops still exist which may yield additional important information for ongoing product improvement and promotion. These include; robustness of demand eliciting mechanisms for food preferences in the developing country context; and heterogeneity in demand responses by various consumer groups in target populations, particularly males and females.

Given the lack of market data that would show actual purchases of biofortified products, demand eliciting mechanisms are the only way to get an insight into whether consumers will accept biofortified food crops or not. Hypothetical methods (such as contingent valuations, stated choice experiment) and non-hypothetical methods (e.g., experimental auctions, non-hypothetical choice experiments) are used to value non-market goods or new products. Researchers have often relied on the non-hypothetical valuation techniques for the incentive-compatibility[1] property attributed to these methods but lacking in the hypothetical valuation methods. The non-hypothetical methods though superior to hypothetical methods, however, have also been found to violate some classical economic assumptions. This has been demonstrated in literature by incentive-compatible techniques such as the Becker-DeGroot-Marshack (BDM) and the non-hypothetical choice experiments (nHCE) that have often yielded dissimilar WTP estimates, e.g., Banerji et al. (2013); Gracia et al. (2011) and Lusk and Schroeder (2006). To date, market researchers have not reached a consensus as to which market valuation method gives better estimates. The inconsistent results in valuation techniques suggest that the debate about the correct method to use when eliciting demand for nonmarket goods or new products is still unresolved.

Further, studies conducted in developing countries with different economic conditions and cultural practices have exhibited different behaviours in experiments, with consumer behaviour being influenced by experiment specific design factors and the context of the experiment. Some of the design factors reported include the lexicographic preferences (Banerji et al. 2018), experimenter's effect, endowment effects; ordering effects, and timing effects (Banerji et al. 2018; Morawetz et al. 2011; Rutsaert et al. 2009).

To date, there has been no consensus among market researchers on the best method in revealing true WTP. To contribute to this discussion, WTP estimates elicited from the BDM and nCHE are compared in the valuation of a new maize variety biofortified with vitamin A in Zambia, and the design features that could potentially bias each of the method are accounted for in the analysis. As earlier stated, a valid consumer valuation technique is necessary for successful policy directives when launching a new product.

[1] Provide incentives for consumers to reveal WTP truthfully

Also important in the study of consumer acceptance of biofortified food crops is determining whether there is heterogeneity in the males' and females' preferences for biofortified food crops. This will help researchers, marketers, and policymakers better determine how such differentiation, if any, could affect acceptance and the ultimate adoption of biofortified food crops. Although staple foods are consumed across gender in sub-Saharan Africa, it is not known whether the potential changes of staple foods in their intrinsic attributes may cause males and females respond differently to biofortified food crops, and ultimately pose a challenge to acceptance of biofortified food crops, and in the alleviation of micronutrient deficiencies through biofortification.

The answers to these questions are important to product developers, marketing practitioners, and developmental agencies alike. To the product developers and marketers, knowledge of whether or not there are gender differences in acceptance will provide feedback to the on-going product development and outreach programs. On the other hand, developmental actors are concerned about whether the benefits of nutritional improvements will be distributed equally across gender and /or reach the intended beneficiaries. Thus, accounting for heterogeneity in acceptance among subpopulations may be necessary to ensure nutritional improvements reach the targeted populations. These concerns are justified as research is increasingly demonstrating that developmental initiatives and or program theories may at times operate differently across subgroups within a target population such as males and females, both within and across households (Tannenbaum and Greaves 2016). For example, it has been demonstrated empirically that the theory of a unitary intra-household allocation does not always hold, and this has been proved in both developed and developing countries. This theory assumes that all members in a given household share a single utility function and resources under the household head who maximises it on behalf of every household member. In summary, this theory suggests that regardless of which member of the household is targeted in a developmental intervention or policy, the intended outcomes will all be realised by targeting the household head.

There are quite a number of studies that have shown that such a model has led to unintended outcomes of the policies adopted. Among them include a study by Lundberg et. al. (1997) who determined whether the gender of the recipient of income mattered for consumption decisions in the United Kingdom (UK) involving the child welfare programs. This is a program in which the government provided child benefits to households according to the number of children they had. In the 1970s, there was a policy change in which the decision was made that the cheque or cash transfer should always be given to the child's mother as opposed to the household head who usually would be the father. The authors find that the impact of this program depended on who in the household received the transfer. Specifically, it was found that child welfare improved when the recipient of the child benefit was a mother.

The unitary intra-household allocation model has also often failed to predict household behaviour among some agrarian households in sub-Saharan Africa. A case in point is a study by Udry (1996) who tested whether the gender of the plot owner mattered in crop productivity in Burkina Faso where males and females from the same households had control of separate fields with different cropping activities. Results suggested that the gender of the plot owner was important, with productivity differing in the plots managed by males and females. Specifically, females' yields were about 30 % lower than that of males', with inefficiencies translating to a 6 % loss of total household output. Productivity differences stemmed from lower input intensity on females' plots such as fertiliser, male and child labour. The author further found that efficiency loss could be regained either by allocating all plots to males or reallocating some of the operating inputs to females.

Goldstein and Udry (2008) found similar results in Ghana in a shifting cultivation system where females did not follow some agronomic requirements and had much lower maize and cassava yields than males in the same household. Specifically, females fallowed their land, less frequently than most males would, due to the fear of loss of land from expropriation (i.e., land taken by the authority for public use) during the fallow period. The authors found that fallowing was driven by one's connections to social and political networks which protected one from expropriation, with females less likely to have such connections than males. Aggregate yield losses from this source of inefficient were quite substantial as they were estimated to be slightly under 1% of Ghana's 1997 national GDP. These studies all suggest that a policy impact such as that of public transfer to the household head will often lead to different outcomes depending on which gender is targeted, contrary to the expectations of the unitary model.

Gender is also one of the important factors explaining consumer behaviour in literature and one of the primary means by which the market is segmented for a wide range of products. Differences in purchasing behaviour, for example, have been observed between males and females (Prakash & Flores, 1985) and also in their judgment about products (Meyers-Levy and Mantel 1991). Bakshi (2012) has reported gender differences throughout the consumer's decision-making process, i.e., from need recognition, information search, alternative evaluations, to purchasing behaviour. The author states for example, that males tend to make purchasing decisions based on immediate needs, while females would consider both the short term and long term needs in purchasing the product. Additionally, males and females would normally be looking for different products. Different gender roles have also been observed across products, depending on the decision-making stage, and product type. Bonfield (1978) and Davis and Rigavx (1974) for example, reported that wives take leading roles in products for home furnishing, appliances, and food. Husbands, on the other hand, search for products considered to be in the male domain such as automobiles. Females generally are considered to make purchase decisions on a more emotive level, whereas males go more with the utility aspect of the product (Dittmar et al. 2004).

While the literature has underscored the importance of gender in food consumption behaviour, the focus has mainly been in the developed world. It is unclear the extent to which this can be generalised to the developing countries with different dietary habits that are characterised by staple food consumption across gender. Studies of gender differences in sub-Saharan Africa, on the other hand, have mainly focused productivity differentials by gender, and less on possible gender differences in consumption behaviour. Additionally, most of the previous studies in consumer acceptance of biofortified food crops (BFC), considered only cross effects of gender and crop variety (e.g., in De Groote et al. 2014; De Groote et al; 2018 and Banerji et al. 2018) and also gender differences in the outcome variable without controlling for factors that may vary by gender in the outcome variable. This is less informative about policy and marketing as the source of the gender gap is not explained (see Williams et al, 2009).

This thesis attempts to fill this gap by looking at gender not only as a mediatory variable but will also conduct a subsequent analysis of the possible sources of gender differences in the consumer acceptance of biofortified food crops. Data used to determine consumer acceptance of biofortified food crops covers three sub-Saharan African countries namely, Nigeria, Rwanda, and Zambia, where biofortified food crops are found. This provides an opportunity to test the robustness of the results in three countries and cultures. The thesis will determine whether there are consistent gender gaps in acceptance of biofortified food crops using the hedonic ratings (liking/disliking) and WTP outcomes for biofortified food products. If so, whether the characteristics determining these outcomes matter differently between males and females.

1.3 Research objectives, questions, and hypotheses

The non-hypothetical valuation techniques such as the Becker-DeGroot-Marshack (BDM) mechanism and the non-hypothetical choice experiments (nHCE) are considered in the literature as more reliable in predicting demand for a new product or product with additional attributes than hypothetical methods. In practice, however, these techniques have been shown to still mask several background variables that may influence participants' willingness to pay (Voelckner 2006). Further, there's no consensus among researchers as to which method yields better estimates. With the validity of a valuation technique attained when results are according to what theory would predict or when two valuation techniques yield comparable estimates, this thesis seeks to determine if the BDM and nCHE would yield similar WTP estimates under a field setting in Zambia, and if not, explore possible explanations for such a disparity.

The thesis also explores the existence of systematic gender differences in the preferences and willingness to pay for biofortified food products in the three sub-Saharan African countries namely; Nigeria, Rwanda and Zambia where the biofortified food crops will be first introduced. The datasets were collected in each country using virtually identical survey instruments. This provided a unique opportunity to conduct a cross-country comparative analysis of consumers' attitudes and behaviour towards biofortified staple food crops in sub-Saharan Africa.

1.3.1 Objectives

The main objective is to compare the performance of the two incentive-compatible valuation techniques, i.e., the BDM and the nHCE, using a case of a new maize variety biofortified with vitamin A in Zambia, and explain how consumer demand for biofortified food crops differs by gender in target populations of Nigeria, Rwanda, and Zambia.

Specific Objectives

a) Determine whether the BDM and the choice experiments result in comparable willingness to pay estimates.

b) Determine the effect of experimental features (such as lexicographic behaviour, ordering effects, repeated bidding and experimenter's effects) on consumers' WTP for biofortified maize in Zambia and their effect on the WTP disparities between the BDM and the nHCE.

c) Determine if there are gender differences in the hedonic preferences and WTP for biofortified food crops in Nigeria, Rwanda, and Zambia.

1.3.2 Research questions

To achieve the above objectives, the following fundamental economic questions with regards to consumer acceptance of biofortified foods will be addressed.

- Are there differences in the BDM and choice experiments estimates and if any, which design issues affect the differences?

- Do males and females look for different attributes when evaluating biofortified foods and forming their attitudes and WTP? Can these differences be attributed to their dissimilarities in individual characteristics such as education, prior nutritional knowledge? Or are the differences attributed to preferences for product characteristics?

- If gender differences existed in the preferences for product attributes and WTP for biofortified foods, are they large enough to require different promotional nutritional messages for females and males or suggest changes in product development?

1.3.3 Hypotheses

The following null hypotheses will be tested:

H1: The incentive experimental valuation techniques yield estimates that are equivalent.

This is based on the premise that both valuation techniques were answering the same research question of determining the consumer's WTP for a new maize variety that has been biofortified with vitamin A in similar research contexts and locations. Further, both techniques used real products and real money in the purchasing tasks, suggesting that it was in the best interest of consumers under both experiments to state their true value of the biofortified orange maize. The two techniques, therefore, should yield comparable estimates. Under these assumptions, the null should not be rejected. Conversely, rejecting the null entails WTP estimates from the BDM and nHCE are not equivalent and design features (ordering, repeated bidding, lexicographic behaviour, experimenter's effect) are expected to account for part of the disparities.

H2: There's no gender gap in hedonic preferences and willingness to pay for biofortified foods and if there is any gender gap, it is not explained by differences in explanatory variables.

A gender gap in the attitudes of consumers towards biofortified food crops is not expected since biofortification is targeting food crops that are already consumed across gender in the target populations. Under this assumption, the null hypothesis should not be rejected. On the other hand, the null hypothesis can be rejected based on the likely change in some of the intrinsic and end-use characteristics of biofortified food crops such as, sensory attributes, cooking, and flour quality that may affect males and females differently.

1.4 Research approach and methodology

This part of the thesis deals with the research approach and methodology undertaken in analysing demand for a new food product. First, the conceptual framework is discussed, focusing on factors that influence the demand for a new product. This will be followed by an explanation of the research approach in eliciting demand for a product that is not yet on the market. Specifically, the optimal bidding process in the BDM and the choice process in the nHCE are discussed.

1.4.1 Conceptual framework

Figure 1.1 identifies the main factors reported in the literature as consumer's determinants for food acceptance as expressed by consumer's WTP and food preferences. Following Booth and Shepherd (1988), determinants of food acceptance are grouped into those related to the food itself (product characteristics), the individuals making the decision (personal characteristics), and the environment in which the decision is made (economic, social and cultural context). Recent studies have reported new evidence indicating that the demand eliciting technique used also impacts consumer's acceptance of novel foods. The emphasis in this thesis is placed on the impact of a valuation technique and gender as factors influencing preferences for novel foods even though other factors are considered as well. As Lancaster (1966) pointed out, the consumer's acceptance of a product depends on the product characteristics which in the case of biofortified foods include hedonic attributes , end-use characteristics, perceived health benefits, and price.

The demographic profile of the consumer is another major factor that influences acceptance. Consumer characteristics such as gender, income, age, education, and the environment the individual comes from, are all likely to shape consumer's WTP or acceptance because they affect consumer's attitudes towards nutritious foods. Gender in particular, one of the key variables of interest in this study, affect the acceptance of novel foods in various ways. First gender differences in acceptance may be a result of differences in the composition means of other influential factors (the independent variables) in food acceptance. For example, males may have higher education and more knowledge about novel foods. As a result, males may tend to have more acceptance of biofortified food crops than females even though the effect of having higher education and knowledge may be the same across gender.

On the other hand, the effect of independent variables may also have a different effect on the gender of the decision-maker. For example, gender differences may occur due to different perceptions about the product attributes resulting from social, biological and psychological factors (Nu et al. 1996). Family gender roles related to production and consumption decisions are also likely to affect how males and females behave towards biofortified foods. Additionally, endowments such as education, knowledge, income and/or wealth may also have a different effect on male and female attitudes towards biofortified foods. For example, nutrition knowledge may have a stronger effect on females than it would have on males (Moerbeek and Casimir 2005).

Consumer's product valuation also depends on the demand-elicitation mechanism used. Theoretically, revealed preferences methods are expected to yield similar WTP estimates but empirical literature has shown disparities of WTP results between the BDM and the nHCE. In most cases, the choice experiment has yielded significantly higher WTP estimates than the BDM experiment. A number of reasons have been proposed as causing disparities with emphasis placed on design features of each individual experiment, such as lexicographic preferences (Banerji et al. 2013), experimenter's effect, endowment effects, ordering effects, among others (Banerji et al. 2013; Morawetz et al. 2011). The order effects occur when the order with which the subject received the sample affects consumers' WTP. Lusk et al. (2007) attribute this to inexperience in experiment participation and participation fatigue. Morawetz, DeGroote, and Kimenju (2011) observed this kind of behaviour in the study of WTP for fortified yellow maize in Kenya.

Endowment effects have been reported in cases where many people often do not have enough to eat such as is the case in some areas in sub-Saharan Africa. Rutsaert et al. (2009) studied WTP for quality rice in Senegal and found that WTP declined if the auction experiments were conducted after participants have had their lunch. Experimenters' effects also have shown to affect willingness to pay. Morawetz et al. (2011) noted that both enumerators and experimenters often find it difficult to explain differences in paying a random price than a bid to the BDM auction participants. The authors also note that African participants have more experience with the first-price auction where the winner pays the price equal to their own bid other than the BDM where the winner pays a random-price if their bid is higher than the random price.

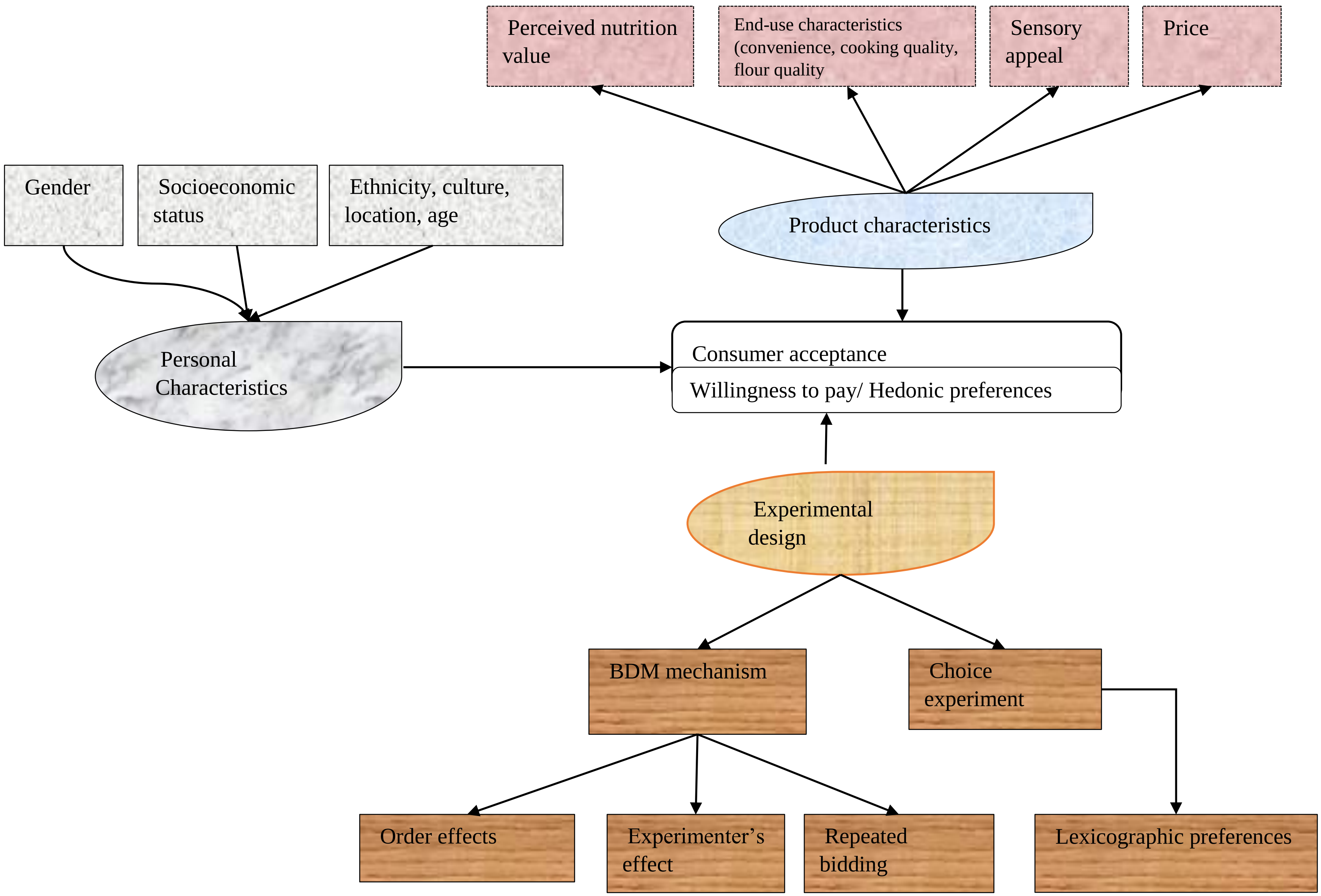


Figure 1.1: Determinants of consumer acceptance of novel food

1.4.2 Bidding behaviour in the BDM

In the BDM mechanism of Becker et al. (1964), bidding starts when the subject is presented with a unit of a product (q) and states the amount (v) they would be WTP for it. The respondent begins with the amount q=0 of the product after which they are asked how much they would be willing to pay to receive q=1 of the product. In making the bid, the subject does not know the selling price and expected to use an expenditure function that is subjected to a budget line for their decision. This expenditure function depends on attributes of the biofortified food crop (e.g., taste, aroma, texture, appearance, perceived nutrition value, etc.,) and individual characteristics. The subject will state their value (v) for the product and the experimenter draws and reviews the random price p. The individual gets the item (q=1) if v is equal or greater than p and pays p for the item. If on the other hand, they bid lower than p, they get nothing and pay nothing.

The price p is random to the subject but then again it can have a known F(.) distribution. Assuming that the individual's income is Y, the individual receives {q=1, Y-p} whenever p is less than v which occurs with a probability of F(v). The individual receives {q=0, Y} whenever p is greater than v, occurring with a probability of 1-F(v). Defining the distribution of q and the realized price (p or 0) as FV, under the expected utility (EU) framework, the individual's utility is as shown in equation (1.1):

$$U(F_v) = u\int_0^V (1, Y-p)\ dF(p) + u(0, Y) \qquad (1.1)$$

The individual reports v to maximize utility and the optimal bid v* is obtained when $u(1, Y-p) = u(0, Y)$. The expression says the utility that the individual gets from bidding their true value is obtained when utility derived from winning the bid is equal to that derived when the bid is lost.

1.4.3 The choice experiment

The choice experiment, on the other hand, is based on Lancaster's (1966) theory of value and the random utility theory (McFadden 1974). According to Lancaster's theory of value, the utility (V_{ij})

that individual i derives from consuming good i is the sum total of utilities obtained from each of the K characteristics of the good. Assuming linearity of parameters in the valuation of attributes, V_{ij} is written as follows:

$$V_{ij} = \beta_1 X_1 + \beta_2 X_2 \dots\dots\dots\dots\dots\dots\dots\dots . \beta_k X_{ki} \qquad (1.2)$$

Where:

V_{ij} is the utility that individual i derives from attribute j

β_{Ki} represents the weight by which attribute k is valued by individual i.

X is a vector of attributes of the good that are of interest to the individual as well as socio-demographics

In random utility theory, it is assumed that individuals make choices according to a deterministic component that comes with some degree of randomness. Allowing U_{ij} to represent the random utility that individual i places on alternative j, V_{ij} now becomes the deterministic component and ε_{ij} is a random component that represents the random component of individual i's choice and can be written as shown in equation (1.3).

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1.3)$$

1.5 Contribution to literature

This study is linked to a large literature in experimental economics and gender. The experimental economics literature has documented a number of variations in valuation techniques. Studies that have investigated the performance of valuation techniques under a field setting in Africa include, Morawetz et al. (2011), Berry et al. (2011) and Banerji et al. (2018).The focus on these studies was mainly on comparing experimental auctions. Most similar to our study was done by Banerji et. al.(2018) who also compared experimental auctions and the BDM experiment to the choice experiment in Ghana. They find that WTP estimates from the choice experiment were significantly higher than those from the BDM experiment. The authors control for censored bids and lexicographic responses in their empirical analyses, however, they do not analyze the impact of specific design features of these valuation techniques in narrowing the WTP gap.

The current study contributes to literature by not only comparing these techniques but also examined experimental design factors such as use of repeated auctions, experimenters' effect and order effects. The thesis shows that the use of repeated bidding in the BDM experiment enhances understanding of the experiment, according to the "preference learning hypothesis" (Plot, 1996) and makes WTP estimates more comparable to that of the choice experiment. Further, the study shows that order effects experienced during sensory tasting can persist even in the purchasing games. However, this can be eliminated by using repeated bidding in the BDM experiment.

Another contribution to literature is in the analysis of gender differences in consumer behaviour towards novel foods under a developing setting where staple food crops are consumed across gender. Research done in this area has concentrated on finding gender differences in the outcome variables, and less on examining the sources of gender differences. Such an undertaking makes an assumption that explanatory variables have the same impact for males and females on the outcome variables. It remains a question whether that would be the case in the presence of multi-dimensional gender inequality prevailing in sub-Saharan Africa that may impact acceptance and access to new crop varieties. Additionally, previous studies on gender have a weak link to theory, even though such an undertaking may be critical to understanding behaviour of consumers. To address this gap in this area, this study has devoted a lot of attention to both empirical and theoretical explanations of gender differences from both the economics and psychological literature. Specifically, gender differences have been analysed in product acceptance, consumer characteristics and promotional tools, and found that males and females may have different attitudes based on their socioeconomic characteristics and also on the promotional tools used.

1.6 Outline of thesis

This thesis consists of four stand-alone papers with their own specific methodologies and questions but applied to the three data sets in Zambia, Rwanda, and Nigeria. Part of the introduction also has some overlap with each of the papers.

Chapter 2 evaluates the equivalence of the willingness to pay (WTP) estimates of the Becker-DeGroot-Marschak (BDM) mechanism and the non-hypothetical choice experiment (nHCE) under similar research conditions. The case of consumer valuations of a new maize variety that has been biofortified with Vitamin A was used to compare WTP estimates elicited from the two valuation techniques when dietary information was not given to the participants. The results suggest that WTP estimates from the two valuation techniques are not statistically equivalent, with the nHCE yielding WTP estimates that are significantly higher than that elicited from the BDM experiment.

Chapter 3 explores the design factors that affect bidding behaviour in the BDM and the choice behaviour in the nHCE and determines their possible effect on the WTP disparities between the BDM and the nHCE. Results suggest that repeated bidding which gives more training to respondents in the BDM experiment significantly affects the BDM bid. Similarly, controlling for lexicographic responses in the nHCE affects choice behaviour. Together, these two design factors provide estimates that are more comparable between the two valuation techniques. Parts of both chapter 2 and chapter 3 are already published in Hamukwala et al. (2019).

Chapter 4 first reviews theories of sources of gender differences in consumption behaviour that would be critical in understanding consumer's attitudes and behaviour towards biofortified food crops. It is followed by the methodology which looks at data sources, conceptual analysis of the conditions under which gender differences can occur. This is followed by research questions, hypothesis, and empirical estimations.

Chapters 5 and 6 focus on answering the question of whether gender differences exist in the preferences and WTP for biofortified food crops in Nigeria, Rwanda, and Zambia. Both hedonic preferences and WTP were used to explore gender differences. Emphasis was placed on the use of econometric models that account for gender heterogeneity in both the choice models and residuals.

Results suggest gender heterogeneity may be a factor to consider in determining consumer acceptance of biofortified food crops, even though this varies by the measure of acceptance and country.

Chapter 7 concludes the thesis by tying together all the findings and highlighting the implications of the research findings for future studies on consumer acceptance of biological product innovations in rural Africa.

CHAPTER 2: COMPARING WILLINGNESS TO PAY ESTIMATES FROM THE BECKER-DEGROOT-MARSCHAK (BDM) MECHANISM AND THE NON-HYPOTHETICAL CHOICE EXPERIMENT: A CASE OF BIOFORTIFIED MAIZE IN ZAMBIA

2.1 Introduction

This chapter answers the question of whether the two incentive valuation techniques i.e., the Becker-DeGroot-Marschak (BDM) mechanism and the non-hypothetical choice experiment (nHCE), are comparable under a field setting in a developing country context. Data used are from a study that looked at how consumers in rural Zambia will value a new maize crop variety that has been enriched with vitamin A through biofortification. By targeting maize, a staple food crop, we expect that dietary habits will not be affected, thereby reducing the chances of non-adoption, and ultimately increasing chances of alleviating the micronutrient deficiency problem. However, the biofortification process may change some crop intrinsic attributes, for example, an increase in vitamin A gives maize the unfamiliar colour orange when the most preferred maize in Zambia is white (Meenakshi et al.2012). With historical evidence of rejection of yellow maize in Zambia and in the region, it leaves a question of whether this problem also applies to biofortified maize which is likely to be orange in colour.

There are two main ways that are commonly used to economically value goods. These include revealed preference and nonmarket valuation methods for the market and nonmarket goods, respectively (see figure 2.1).

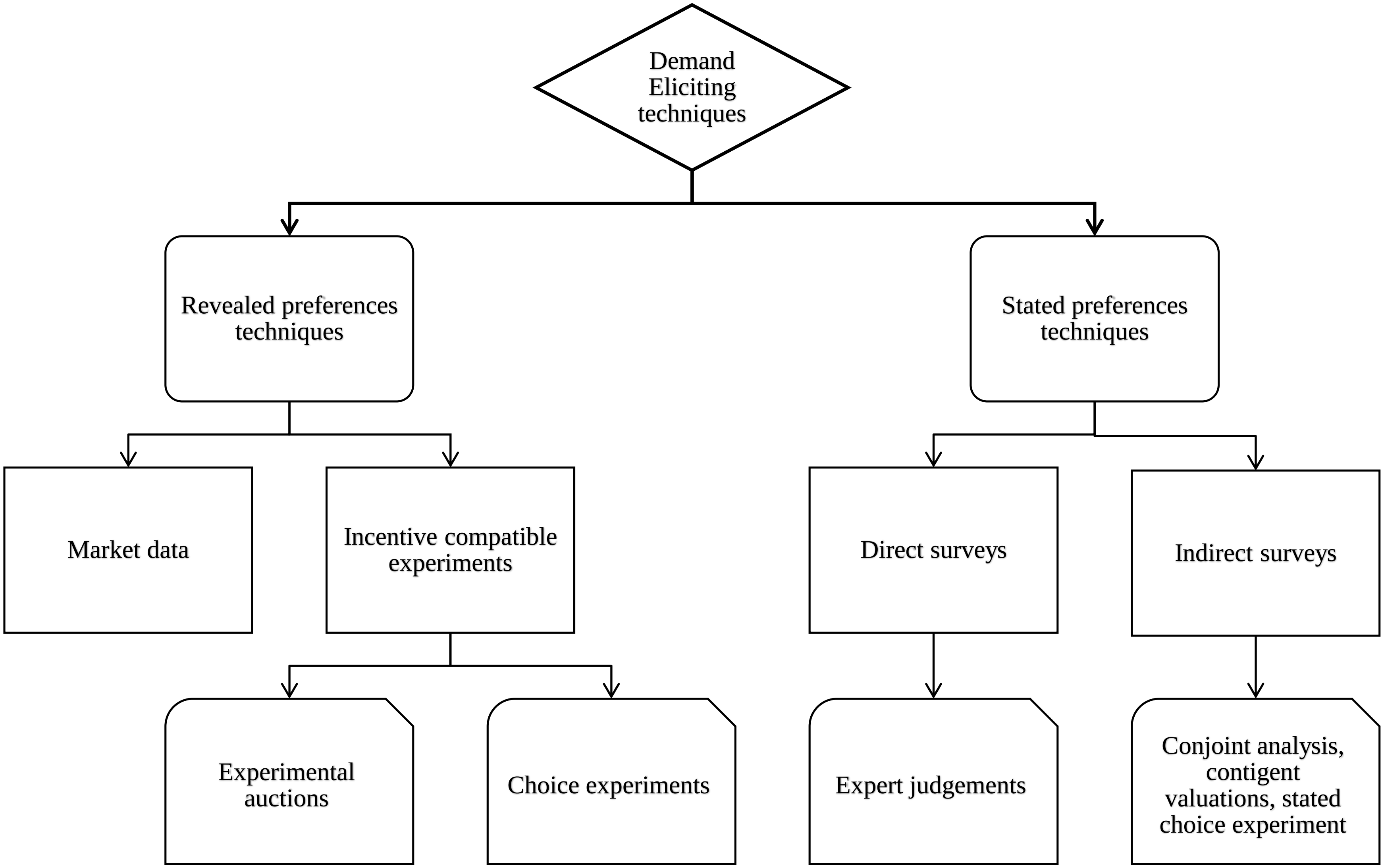


Figure 2.1: Demand eliciting techniques for nonmarket goods

Source: Adapted from Breidert, Hahsler, and Reutterer (2006)

Revealed preference methods use information from actual consumer choices in a real market setting to estimate demand models. They are most preferred when a market and actual consumer behaviour are there for the product under consideration. Nonmarket valuation techniques are an alternative and they include stated preference techniques and incentive-compatible economic experiments. Stated preference techniques use consumers' WTP expressed for a hypothetical good or service. Since neither a market nor actual purchase decisions can be observed, stated preference methods provide no incentives for consumers to reveal their true preferences. As a result, the credibility of WTP estimates elicited from these techniques has been questioned. These tools nevertheless remain useful for estimating the demand for new products or public goods for which revealed preference data do not exist. As such, researchers have come up with various ways to reduce hypothetical bias such as the "use of cheap talk" (Cummings and Taylor 1999) or combining hypothetical with non-hypothetical experiments (Johannesson et al. 1998; Lusk and Shogren 2007; Chowdhury et al. 2011). Examples of stated preference techniques include; conjoint analysis, stated choice experiments and contingent valuation methods.

In the absence of market data to measure demand, valuation techniques used for nonmarket goods are the only way to get an insight into whether consumers will accept a novel product or not, and guide research efforts. An understanding of the robustness of valuation techniques becomes critical in attaining valid estimates for successful policy directives. True preferences are known to be revealed in an actual payment setting, and in the absence of the real market, they could be evoked in incentive-compatible experiments (Zawojska and Czajkowski 2015). Such experiments use non-hypothetical data in which subjects face real budget constraints and products, thereby providing respondents an incentive to reveal their true preferences. Non-hypothetical experiments are therefore considered superior to stated preference techniques (Kaas and Ruprecht 2006) and are also classified as revealed preference methods.

The BDM and the nHCE are examples of such types of methods. Though commonly used in the developed world, the use of the BDM and the nHCE have been on the increase in the past decade in the developing world as well. Some of the studies that have used the BDM to study acceptance of new agricultural technologies in Africa include willingness to pay for fortified yellow maize in Kenya (Morawetz et al. 2011); WTP for pro-vitamin A orange maize in Mozambique (Stevens and

Winter-Nelson 2008); consumer acceptance of pro-vitamin A orange cassava in Nigeria (Oparinde et al. 2014); consumer acceptance of bean varieties biofortified with iron in Rwanda (Oparinde et al. 2015). The non-hypothetical choice experiment studies examples include willingness to pay for orange maize in Zambia (Meenakshi et al. 2012); and willingness to pay for orange-fleshed sweet potatoes in Uganda (Chowdhury et al. 2011).

Although it is now clear that incentive-compatible economic experiments are superior to stated preference methods, they have also shown that in practice they can still mask several background variables that may influence participants' WTP (Voelckner 2006). Experimental literature has attributed this in part to experimental design contexts and various information cues. Berry et al. (2011) noted that if an individual's response to the WTP question was believed to affect the actual price of the product, they would still have an incentive to respond strategically. This was revealed in their study of demand for water filters using the BDM experiment in Ghana, where consumer's WTP estimates were lower if the subjects knew that their bid for the water filter would influence its future pricing.

Further, there are some theoretical debates on whether the BDM, for example, is incentive-compatible or not. On one hand, studies that compared several induced–value experiments (where true values of the product are known) with bidding behaviour in the BDM, yielded similar values. Irwin et al. (1998) and Noussiar et al. (2004) for example compared bids elicited from the BDM mechanisms with actual values obtained from induced value studies and found in their respective studies that bids were equivalent to induced values. On the contrary, others have argued that the BDM is not always incentive compatible outside of the expected utility framework. Karni and Safra (1987) for example demonstrate that the BDM incentives do not fully explain consumer preferences over lotteries (or when unsure of the value of the good) for individuals who are not maximising their expected utility. Horowitz (2006) in more recent literature demonstrates that even when individuals are sure of the good's value, the BDM is still not incentive compatible for non-expected utility maximisers, due to the lottery aspect. Carson and Plott (2014) also indicate that the BDM is not consistent empirically and attribute this to its complexity and possible misconceptions of the incentive structure by subjects.

The non-hypothetical choice experiment, though resembling choices that consumers make in an actual market, hence believed to reveal consumer preferences more accurately (Louviere and Woodworth 1983), has not been without criticisms either. One of the concerns is the possible violations of the independence and transitivity axioms in a series of choice-problems where real incentives involve some random selection of only one of the choice problems to be acted out for real. Holt (1986) for example demonstrated that a choice problem given in a series of other choice problems may not yield the same response as it would if it were the only problem being faced due to the relaxation of the independence axiom and violation of the transitivity axiom. This implies that a decision in one choice problem may be influenced by other choice problems within the experiment which could possibly bias the estimates. There has been also a concern about the repetitive choice questions in the choice experiment which could lead to participant's fatigue or to learning their preferences and subsequently affect the choice behaviour (Bradly and Daly 1994). Another concern is the use of a choice format of more than two options that makes it possible not to select the most preferred option if the respondents consider it unlikely to be implemented, thereby encouraging strategic behaviour (Carson and Groves 2007).

These concerns are further supported by divergent empirical WTP estimates in the studies that have compared these methods in similar research contexts (Lusk and Schroeder 2006; Gracia et al. 2011; Su et al. 2011; Banerji et al. 2013). Theoretically, incentive-compatible methods are expected to yield similar results but the nHCE in these studies exhibited consistently higher WTP estimates over the BDM. Market researchers have not reached a consensus as to which methods give better estimates. Voelckner (2006) noted that there was no simple answer to this question because consumer's true WTP is latent, implying that each valuation technique only represented the attempt to come close to the true WTP. Thus, when observed estimates are similar to what theory would predict or when valuation techniques yield comparable estimates, one can have some assurance that the WTP estimates are valid and would reflect the true market demand once the product is on the market. If on the other hand, the WTP estimates significantly differ by elicitation methods, systematic differences can still be observed and sources of differences can be identified (Banerji et al. 2013).

2.2 Hypotheses

The following hypothesis is tested:

Ho: *WTP estimates elicited from the BDM experiments and the nHCE are equal.*

$$WTP^{BDM} \equiv WTP^{RCE} \tag{2.1}$$

This is based on the premise that both valuation techniques were answering the same research question of consumer's WTP for the new biofortified maize variety in similar research contexts. Further, both experiments were incentive-compatible meaning that it was in the best interest of the consumer to state their true WTP since real products and real money were used in the purchasing tasks. Under these assumptions, the null should not be rejected. Conversely, rejecting the null entails WTP estimates from the BDM and nHCE are not equivalent.

The chapter is organised as follows: In the following section, the methodology is described including the features of the nHCE, the BDM experiment, and the estimation procedure. This is followed by the results and discussion, and lastly the conclusion.

2.3 Methods

2.3.1 Data description

The data from the BDM experiment and the nHCE are part of the larger survey designed to determine consumer's acceptance of vitamin A biofortified-maize in Zambia reported in Meenakshi et al. (2012). Data collection took place in January 2010 in the Southern and Central provinces of Zambia. Multistage stage sampling was conducted. First at the national level, two provinces namely; Southern and Central were purposively picked, on the basis of higher rates of poverty, consumption, and production of the staple maize crop. In each province, one district and one village per district were selected. Participants were invited using the word of mouth by the agricultural extension officers to come to the agricultural training centre for surveys. Members were allocated randomly to treatment groups as they came, which included the choice experiment or the BDM experiment, with or without nutrition information. 145 participants took part in the BDM experiment while 107 took part in the choice experiment without nutrition information.

Before the experiments as shown in fugure 2.2, the participants evaluated the sensory attributes (appearance, aroma, taste, texture and overall liking) of *nsima* made from three maize varieties i.e., biofortified maize, the conventional white maize and yellow maize which is considered inferior in the market. The study used a Likert scale of 1 to 5, with 1=dislike very much and 5= like very much. This was done to familiarise participants with the maize varieties especially the new biofortified maize variety, thereby ensuring that consumer's choices and bids were done while being certain about the products under consideration. In both experiments, there was no nutrition information provided about the biofortified maize variety. The BDM experiment consisted of the biofortified maize grain only, while the nHCE consisted of all the three maize varieties. In the rest of the study, the biofortified maize is referred to as orange maize, conventional white maize as white maize, and the inferior yellow maize as yellow maize.

The choice experiment was labelled with colour (orange, yellow and white) and price as attributes. The colour encompassed all sensory attributes of each of the three maize varieties. The price had 4 levels which depicted 30-50% discounts and premiums of the median price of the conventional white maize varieties that prevailed in the study area. This resulted in $4^{2X3} = 4096$ choice combinations following Louviere et al. (2000) L^AM[2] designs. These were reduced to 16 choice sets by a more applicable fractional factorial design generated using a statistical package for social sciences (SPSS) software, subject to orthogonality and balance level properties. An opt-out option was included in each choice set for subjects to choose from if neither of the three maize-price combination options was liked in any of the choice sets. Subjects were presented with 16-choice scenarios involving the purchase of 2.5kg grain each of the three maize varieties at varying price levels and asked to choose the option they preferred in each scenario (see Table 2.1).

[2] L=levels of Attributes; A=number of attributes; M =number of alternatives per scenario

Table 2.1: Choice sets for the choice experiment

Choice set	White-Maize	Yellow-Maize	Orange-Maize	Opt-out option
1	1200	1200	2000	None of these
2	1200	800	1200	None of these
-	-	-	-	-
-	-	-	-	-
16	1200	1500	1500	None of these

The BDM experiment had two treatment arms in which participants were either subjected to one or ten bidding-rounds prior to the main BDM bid. Participants were then asked to state the maximum amount they would be willing to pay for a 2.5kg orange maize grain in each of the rounds. In each bidding round, the bids were compared to a randomly drawn price from a distribution of 30-50% discounts and premiums of the median price for the conventional white maize that was prevailing in the area. Once the auctions and choices were over, a binding scenario in each experiment was drawn, and subjects were paid off according to the decision each had made on the randomly selected bid or choice, thereby making both experiments incentive compatible.

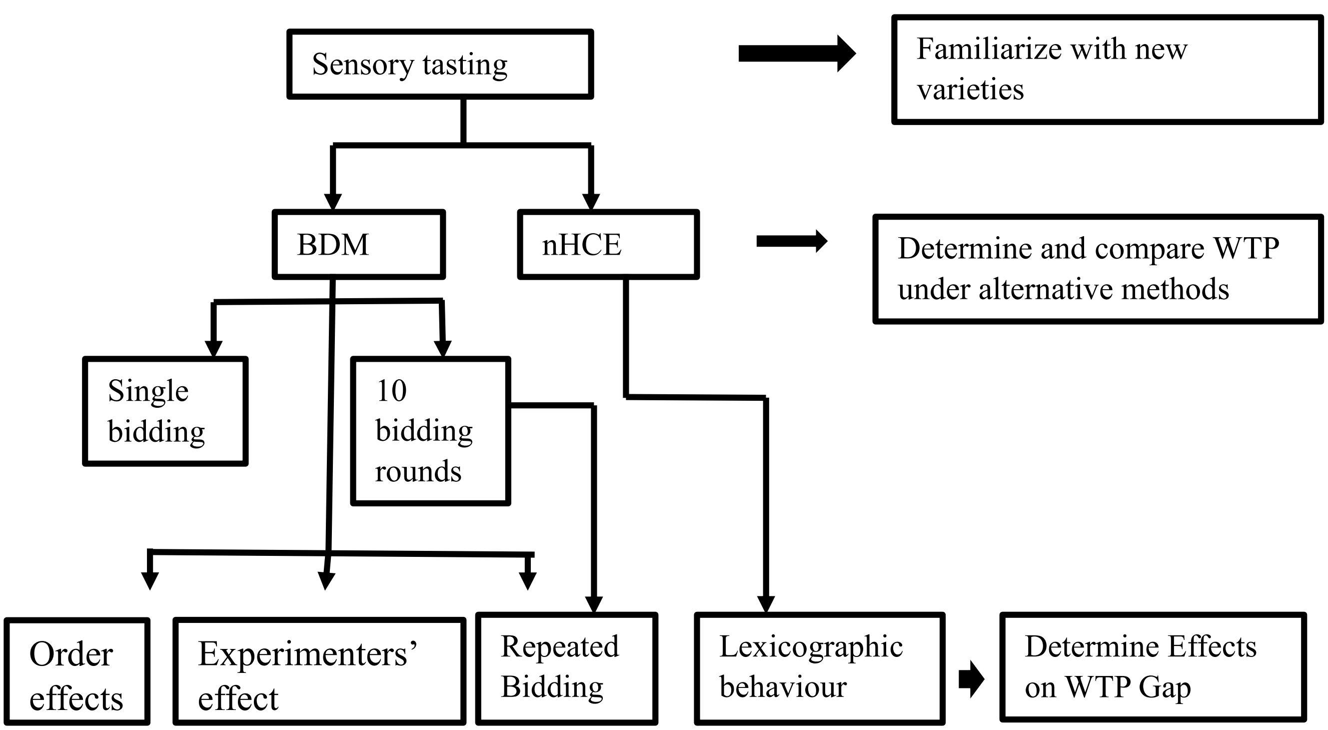


Figure 2.2: Experimental procedure

2.3.2 Model specifications

2.3.2.1 Choice experiment

The basis for modelling the choice experiment is on Lancaster (1966) theory of value which posits that consumers derive utility (U_{ij}) of products from the attributes (V_{ij}) they possess, and from the random utility theory (McFadden 1974) which divides utility into a systematic and a random component as shown in equation (1.3).

Given the latent nature of utility, consumer's decisions are analysed from the probabilistic theory, with the probability that consumer i will choose option j given by;

$$\pi_{ij} = \Pr\{Y_i = j\} = \Pr\{\max(U_{i1,} U_{i2,} \dots, U_{iJ}) = U_{ij}\} \quad (2.3)$$

Assumptions of the error term distribution lead to different models. The conditional logit model is appropriate if the error term is independently and identically distributed (i.i.d) across individuals and alternatives (McFadden 1974). Thus, the probability of individual *i* choosing option j in choice t is:

$$P_{ijt} = \frac{e^{v_{ijt}}}{\sum_{k=1}^{j} e^{v_{ijt}}} = \frac{e^{X_{ijt}\beta}}{\sum_{k=1}^{t} e^{X_{ijt}\beta}} \quad (2.4)$$

Equation (2.4) implies that all individuals have the same preferences (β_i=$\beta_{k,}$ ∀ k). The mixed logit is an alternative model which relaxes this assumption by allowing for random parameters $d\ (\beta)$ with a distribution of $f(\beta)$, implying that parameters are different across individuals (Lusk and Schroeder 2006). Thus, the probability of individual i choosing alternative j in choice t is;

$$P_{ijt} = \int \frac{e^{v_{ijt}}}{\sum_{k=1}^{j} e^{v_{ijt}}} f(\beta) d\ (\beta) \quad (2.5)$$

Empirically, V_{ij} is a function of product attributes and demographics (equation 2.6). The dummies for white maize, yellow maize, and orange maize are used to encompass all of the attributes of each of the maize varieties. While it is well understood that product attributes affect the acceptance of new products, there has been strong evidence of relationships between pricing of new food products and baseline characteristics such as location (Oparinde et al. 2014), wealth rank (De Groote and Kimenju 2008), household composition, education, gender (Stevens and Winter-Nelson 2008), age and ethnicity (Su et al. 2011). These variables were included in the final random utility model. The final variables included in the model, subject to multi-collinearity specification tests, are as shown in equation (2.6).

$$V_{ijt} = \beta_{1jt} + \beta_2 Price_{jt} + \beta_{3j} * Gender_i + \beta_{4j} * Education_i + \beta_5\, Age_i * price_{jt} + \beta_6\, Assets_i * price_{jt} + \beta_{7j} * Age_i + \beta_{8j} * Assets_i \quad (2.6)$$

Where:

V_{ijt} is consumer i's choice of maize variety j in choice set t

β_{1jt}: is the alternative specific constant or dummy variable for a maize variety j (attributes of each maize variety not captured by the model) which is compared to the opt-out option.

$Price_{jt}$: is the price of the maize variety j in choice set t

$Gender_i$: is the gender of the i^{th} consumer choosing variety j

$Education_i$: is the number of years of formal education for the i^{th} consumer choosing variety j

$Assets_i$: is the asset index for the i^{th} consumer choosing a maize variety j

Age_i: is the age of the i^{th} consumer choosing a maize variety j

2.3.2.2 BDM experiment

The BDM (Becker et al. 1964) is a valuation technique in which subjects are asked to indicate the highest price they would be willing to pay for a fixed quantity of a good which is then compared to a randomly drawn selling price. It is not an auction *per se* since an individual makes decisions independent of other participants by bidding against a random price, instead of other individuals as is the case in a typical auction. However, the BDM is theoretically equivalent to a second price auction in which there are at least two bidders, with the highest bidder winning and paying the price of the second highest bidder (Lusk et al. 2007).

To explain respondents' optimal bidding behaviour in the BDM, the analysis derived by Lusk and Shogren (2007), is followed. Let *Vi* represent the value that subject *i* places on a good. An individual purchases the good if the submitted bid is higher than or equal to the randomly drawn price. The utility (U_i) that individual *i* derives from their maximum bid is from the difference between the randomly drawn price (*P*) and the value (*V*) they place on the good (equation 2.7):

$$U_i = (V_i - P) \tag{2.7}$$

If the subject does not win by bidding lower than *p*, they receive and pay nothing, and their monetary value for the good is normalized to zero. Since the bidder does not know the winning price, their expected price can be assumed to be from a random distribution with a cumulative density function G(p), and a probability density function g(p). The dominant strategy for the bidder is to bid one's true value of a good, i.e., submitting a bid that will maximize their expected utility (equation 2.8):

$$E[U_i] = \int_{pi}^{bi} U_i\,(V_i - p)\; d\; G_i\,(p) + \int_{pi}^{bi} U_i\,(0) \; = \int_{pi}^{bi} U_i\,(V_i - p)\; d\; g_i\,(p)dp + \int_{pi}^{bi} U_i\,(0) \tag{2.8}$$

The first integral is taken over all price levels less than the bid (winning range) while the second is taken over levels greater than the bid (losing range). Normalizing U_i (0) = 0, the optimal bid is obtained by taking a derivative with respect to b_i and setting it equal to zero. The optimal bid (b^*_i) is one which is equal to the randomly drawn price (p) as shown below:

$$\frac{\partial E[U_i]}{\partial b_i} = U_i(v_i - p)f(b_i) = 0 \text{ when } b_i = V_i \tag{2.9}$$

The model choice depends on the data distribution. Data used in this thesis show censoring of 21 percent at 2000 ZMK. Incidentally, this is the same amount given as the participation fee (money given for taking part in the experiment which could also be used in their purchasing tasks). It is likely that participants were willing to submit bids higher than 2000 ZMK but had only the participation fee at their disposal, or they saw the 2000 ZMK as the maximum value of orange maize. This requires the use of a right-censored model, suggesting that true WTP for such respondents was at least 2000 ZMK. The parametric Tobit model is used and compared to the censored least absolute deviation (CLAD) and symmetrically censored least squares (SCLS) estimators which are both semi-parametric (Powell 1984; Powell 1986). Each of these models is discussed below:

Tobit

The Tobit model (Tobin, 1958), takes the linear form:

$$Y_i^* = X_i'\beta + \mathcal{E}_i \quad i = 1, \dots, n \qquad \text{where;} \qquad (\mathcal{E} \sim N(0, \sigma^2)) \tag{2.10}$$

Where;

Y_i^* Is the latent dependent variable;

X_i is a vector of independent variables;

$\mathcal{E}_i$ is the error term.

With right censoring, the dependent variable Y_i^* is only observed when it is less than some scalar c_i (2000 in our case) as shown below:

$$Y_i^* = min\{Y_i^*, c_i\} = \min\{X_i'\beta + \mathcal{E}_i, c_i\} = \min\{X_i'\beta + \mathcal{E}_i, 2000\} \tag{2.11}$$

Symmetrically censored least squares (SCLS)

The SCLS estimator (equation 2.12) proposed by Powell (1986) is an alternative to the Tobit as it relaxes the homoscedastic assumption. It is based on the assumption of symmetrically and independently distributed error term with the true dependent variable (y^*) following the same distribution. When the observed part of the dependent variable (Y_i) is asymmetric, it can be restored to symmetry by symmetrically censoring it. Estimation is done using the least-squares of only symmetrically trimmed data. The symmetric assumption is less restrictive than the parametric assumption, thereby providing consistent estimates when parametric assumptions fail to hold. It is, however, stronger than the zero median assumption of the CLAD model.

$$\hat{\beta}_T = \left[\sum_{t=1}^{T} 1\left(X'_t\hat{\beta}_T > 0\right)X_t X'_t\right)\Big]^{-1} \sum_{t=1}^{T} 1\left(X'_t\hat{\beta}_T > 0\right) min\left(Y_t, 2X'_t\hat{\beta}_T\right)X_t \qquad (2.12)$$

Where β is the parameter to be estimated;

X is a vector of independent variables;

T is the sample size;

Y_t is the dependent variable.

Censored Least Absolute Deviation (CLAD) Estimator

The CLAD estimator is another alternative when parametric conditions fail. It uses median regression and since censoring only affects the mean and not the median (if < 50%), it is consistent when distribution assumptions are violated (Powell 1984). The CLAD estimator assumes that$med(\mathcal{E}_i/X_i, \mathrm{c_i}) = 0$. It is estimated as:

$$Y_i^* = med\{Y_i^*, \mathrm{c_i}\} = \mathrm{med}\ \{X_i'\beta\ + \mathcal{E}_i, \mathrm{c_i}\} = \mathrm{med}\ \{X_i'\beta\ + \mathcal{E}_i, 2000\} \qquad (2.13)$$

2.3.3 Comparison of the bids and choice data

The estimates from the nHCE and the BDM experiments are not directly comparable. Subjects' direct bids from the BDM are directly interpreted as their WTP as shown below (Lusk and Shogren 2007).

$$WTP^* = BID_i = \beta X_i + \mathcal{E}_i \qquad (2.14)$$

Where:

WTP^* is an individual*'s* willingness to pay;

BID_i is the individual's bid;

X_i is a vector of explanatory variables;

$\mathcal{E}_i$ is an error term.

In the nHCE, participants did not bid directly on how they valued each maize variety but chose one maize variety at different prices. According to Lusk and Schroeder (2006), regression estimates do not directly reflect consumer's WTP. Instead, WTP with respect to variable *k* is given by dividing the parameter (β) for variable *k* by the negative value of the parameter for the price attribute. Specifically, let *βk* be the coefficient for variable *k*, and *βp* be the price coefficient, WTP for variable *k* will be equal to $-\frac{\beta_k}{\beta_p}$, the total of which gives mean WTP for product *j*. Mean WTP for product *j* can also be obtained by determining the price of maize variety *j* that will equate the systematic component (in equation 2.6) equal to zero while holding individual characteristics at sample averages (Hole and Kolstad, 2012).

The computation of the mean WTP for maize variety j, therefore, is translated to equation (2.15) which is simply the sum of the parameter attributes (i.e., constant, gender, education, age, and assets) evaluated at their sample means divided by the parameters of the negative price attribute (i.e., parameters of the price attribute include the price coefficient β_2; age interacted with price β_5 and assets interacted with assets $\beta_{6)}$. The variables and coefficients are as defined in equation (2.6). Data analyses for both BDM and Choice data were done using Stata 12 software.

$$\overline{WTP_j} = \overline{Price_j} = -\left[\left(\frac{\beta_{1j}+\beta_{3j}*\overline{Gender_i}+\beta_{4j}*\overline{Education_i}+\beta_{7j}*\overline{Age_i}+\beta_{8j}*\overline{Assets_i}}{\beta_2+\beta_5\overline{Age_i}+\beta_6\overline{Assets_i}}\right)\right] \quad (2.15)$$

2.4 Results and discussions

2.4.1 Descriptive statistics

WTP estimates for orange maize obtained from the BDM and the nHCE are compared. The experiments were conducted at a central location where participants were assigned randomly to each experiment. The final sample used in the analysis after data cleaning from the nHCE is 107 respondents, while that for the BDM is 145. Table 2.2 shows summary statistics under both experiments, indicating that individuals were similar in most characteristics except in age and land area cultivated. Participants in the nHCE were about 3 years older, and owned 2 hectares less land than those in the BDM ($p<0.01$). Most participants were married and males in both groups and had on average 8 years of formal education. The average household size was 9 members, while, 8 members shared the same meal. Common household-owned assets include livestock, radio, farm implements, and cell phones. From these assets, an asset index was constructed (a measure of socioeconomic status of a household from which a respondent is a part of) using principal component analysis following Filmer and Prichett (2001).

Table 2.2: Summary statistics of participants in the BDM and nHCE

Variables	RCE (N=107)	BDM (N=145)	Difference	SD	(p-value)
Age (in years)	42.44	38.57	3.87	13.6	0.02
Gender (1=male, zero otherwise)	0.63	0.57	0.05	0.50	0.39
Marital status (1=married, zero otherwise)	0.82	0.87	-0.05	0.36	0.31
Education (in years)	8.37	8.25	0.12	2.74	0.73
Household size	8.59	8.69	-0.10	4.87	0.87
No. of people sharing meals	7.68	8.19	-0.51	3.60	0.27
Land area cultivated (ha)	2.85	4.96	-2.11	5.88	0.01
Income (US$ from 3 major sources)	933.52	1470.57	462.95	509.12	0.28
Asset-index	0.59	0.53	0.06	0.9	0.13

2.4.2 Factors influencing bidding behaviour in the BDM experiment

WTP estimates of the full sample from the Tobit, CLAD and SCLS models are shown in Table 2.3. The response variable in each is the bid submitted to purchase 2.5kg of orange maize grain by each individual. A comparison of results across the models revealed that the parameter estimates were similar in signs except on the household size variable in the CLAD model. The SCLS model produced results similar to the Tobit model in the coefficient signs and significance levels (except gender). Gender is the only variable that consistently gave a positive and significant coefficient across the three specifications. It is therefore clear that males were willing to pay more for orange maize than females.

Table 2.3: Willingness to pay estimates from the pooled bids

Variables: bid	(Tobit)		(CLAD)		(SCLS)	
	Parameters	**Standard errors**	**Parameters**	**Standard errors**	**Parameters**	**Standard errors**
Household size	2.948	(7.415)	-1.956	(13.378)	3.689	(4.374)
Age	10.88	(15.81)	3.933	(20.516)	5.381	(11.72)
Age-square	-0.160	(0.187)	-0.0909	(0.207)	-0.0907	(0.125)
Male	140.1^{*}	(80.39)	145.215^{*}	(122.23)	125.5^{**}	(63.18)
Education	-11.53	(13.61)	-13.899	(18.781)	-10.06	(10.12)
Asset-index	8.752	(16.31)	20.775	(26.017)	4.306	(13.47)
Constant	1581.3^{***}	(320.1)	1821.255^{***}	(486.602)	1609.7^{***}	(251.1)
Sigma constant	390.4^{***}	(28.57)				
Normality test- $X^2(1)$	99.39^{***}					
Homoscedastic test- $X^2(1)$	317.88^{***}					
Root-mean-square-error			254.81		229.03	
Mean-prediction-error			-109.87		$-3.54x10^{-06}$	
N	138		135		138	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Specification Test for the Tobit and Model Selection

Under parametric assumptions, the Tobit model is more consistent and efficient than the semi-parametric estimators (Powell 1986), and these assumptions are tested using the Lagrange multiplier following Cameroon and Trivedi (2010). The results shown in Table 2.3 indicate that both the normality and the homoscedasticity tests are significant at $p<0.01$, thereby making the Tobit model inconsistent. As a result, semi-parametric estimators are considered. From the results of the mean-prediction-errors and root-mean-square errors, both of which require lower values, it is clear that inferences drawn from the SCLS estimator are superior to those of the CLAD estimator. The SCLS is therefore used for the rest of the analyses.

2.4.3 Factors influencing choice behaviour in the choice experiment

Table 2.4 shows the results of the nHCE from both the conditional and mixed logit[3] along with model fit statistics from 107 respondents (see variable definitions in appendix 2.1). Each individual provided 16 completed choice-tasks and each task had 4 possible outcomes resulting in 6848 observations. Both models include alternative specific constants of the three maize varieties and the opt-out option. The dependent variable is the subject's choice of a maize variety at varying price levels. It takes the value of one, on the chosen alternative, zero otherwise. The Akaike information criteria (AIC), Bayes information criteria (BIC) and the log-likelihoods were the statistics used to choose between the two models. A model that minimises the AIC and BIC scores, and has a higher log-likelihood value is most preferred. The results of these indicate that the mixed logit (Table 2.4(2)) outperforms the conditional logit (Table 2.4(1)), hence it is used to interpret results.

As shown in Table 2.4(2), the white-maize constant is significant and positive ($p<0.01$), suggesting that an individual would rather have white maize, than none at all. The orange and yellow maize

[3] The parameters for respondent's age, assets and education were tested for randomness in the mixed logit using the Lagrange multiplier tests according to McFadden and Train (2000). The parameter associated with education was significant and therefore random in the mixed logit model, representing variation in people with the same education over their choice of a given maize variety. Theoretically, individuals with more education are likely to have prior knowledge about the new product and express a stronger preference for a new product or they could be more concerned about the risks associated with the new products and hence place lower values.

constants are not significant, indicating that respondents were indifferent to choosing them. This was expected in a population where white-maize varieties are preferred. The probability of choosing a given maize variety was negatively associated with the price (p<0.01), and older respondents were more likely to be price-sensitive (p<0.1) in the crop-variety choice.

Orange maize choices were positively influenced by age, education, and assets, implying the older, more educated and wealthier respondents were more likely to select it (p<0.01). The choice of white maize was positively influenced by education (p<0.01) suggesting that individuals with more education were more likely to select white maize. Yellow maize choices were influenced by age (p<0.05) and asset-index (p<0.01), where the older, and poorer individuals were more likely to choose it.

Table 2.4: Parameter estimates from the non-hypothetical choice experiment (full sample)

	(1) **Conditional logit coefficients**	***Standard errors***	**(2)** **Mixed logit coefficients**	***Standard errors***
Price^{-02}	-0.2370***	(0.0263)	-0.2840***	(0.0586)
Gender*white	-0.0546	(0.3880)	0.8640	(0.8860)
Gender*yellow	0.3910	(0.3980)	0.9920	(0.9400)
Gender*orange	0.1600	(0.3850)	1.1390	(0.9780)
Education*white	0.0356	(0.0529)	0.4350***	(0.1630)
Education*yellow	0.0199	(0.0539)	0.1610	(0.1650)
Education*orange	-0.0293	(0.0521)	0.391**	(0.1750)
Age*price^{-04}	0.1880***	(0.0578)	-0.2540*	(0.1480)
Asset*price-^{03}	-0.0252	(0.0820)	-0.3010	(0.1850)
Age*white $^{-02}$	0.0762	(1.7500)	-0.1810	(5.6300)
Age*yellow	0.00295	(0.0176)	0.1540**	(0.0601)
Age*orange-^{01}	0.0968	(0.1770)	1.500**	(0.6140)
Asset*white	-0.305	(0.221)	0.4750	(0.4270)
Asset*yellow	-0.314	(0.223)	-1.0700***	(0.4070)
Asset*orange	-0.272	(0.224)	1.8790***	(0.5130)
ASC				
White-maize	4.609***	(0.846)	5.170***	(1.688)
Yellow-maize	3.839***	(0.854)	-0.714	(1.928)
Orange-maize	5.297***	(0.850)	1.279	(2.128)
SD				
Education*white			0.377***	(0.0371)
Education*yellow			0.601***	(0.0549)
Education*orange			0.768***	(0.0709)
N	6848		6848	
Log-likelihood	-1630.61		-981.51	
AIC	3297.2		2005.0	
BIC	3420.2		2148.5	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

2.4.4 Comparison of WTP estimates from the Becker-Degroot-Marshack and the non-hypothetical choice experiments

To make WTP estimates from the nHCE comparable to that of the BDM, the mean WTP from the choice experiment was computed using equation (2.15). Predicted values were used in the BDM since bids are direct WTP estimates, as earlier stated in equation (2.14). The equality of predicted WTP was tested using a two-sample t-test. Table 2.5 shows that WTP estimates from the two valuation techniques are significantly different ($p<0.01$), with WTP average from the BDM experiment lower than that of the nHCE. Therefore, the null hypothesis is rejected with the conclusion that the WTP estimates under the two mechanisms are not equivalent.

Table 2.5: Willingness to pay estimates for orange maize in the BDM and non-hypothetical choice experiment

	Choice (mean)	BDM (mean)	Difference	SD	(p-value)
WTP	2970.24	1691.02	1279.22	589	0.00

2.5 Conclusion

This chapter focused on the first objective and the first research question and therefore compared WTP estimates from the the BDM mechanism, and the nHCE, in the determination for a maize variety that was biofortified with vitamin A in the absence of nutrition information. A non-parametric SCLS was used to determine WTP in the BDM experiment, while a mixed logit model was used in the nHCE and the result that predicted WTP estimates were compared using an independent t-test. Contrary to the economic theory prediction, the results showed that the WTP estimates from the two valuation techniques were not equivalent, with the nHCE yielding estimates that were almost twice as high as that of the BDM. These results are consistent with previous research findings (Banerji, et al., 2013). Possible reasons advanced for such a disparity is that some consumers may not have been so sure about their preferences for the new maize varieties, and thus could have been more influenced by valuation techniques. Literature has identified experimental features that can influence consumer's WTP especially for those who could be unsure of their preferences, and are therefore a subject of the next chapter.

Appendices for Chapter two

Appendix 2.1: Variable definitions for the choice experiment

Variable	Definition
Price	Price of maize in Zambian kwacha
Gender	1=if male, 0 if female
Education	Number of years of formal education
Asset	Asset index (Composite measure of asset levels)
Age	Age in years
White	1=if white maize variety is chosen, 0 otherwise
Yellow	1= if yellow maize variety is chosen, 0 otherwise
Orange	1= if orange maize variety is chosen, 0 otherwise

CHAPTER 3: DESIGN FACTORS POTENTIALLY AFFECTING BIDDING AND CHOICE BEHAVIOUR IN THE WILLINGNESS TO PAY FOR A BIOFORTFIED ORANGE MAIZE VARIETY IN ZAMBIA

3.1 Introduction

While the non-hypothetical choice experiment (nHCE) and the Becker-Degroot-Marshack (BDM) mechanism have long been described as incentive compatible when used in the non-hypothetical context, literature has shown that at times these mechanisms yield preferences that violate the classical economic assumptions of transitivity, rationality, and continuity (Carlsson et al. 2012). This happens when an individual's WTP for a product depends also on design features or experiment context (Karni and Safra 1987; Horowitz 2006). This ultimately leads to yielding WTP estimates that are not consistent with the individual's true value of the product (Payne et al. 1993).

Consistent with previous findings, this thesis showed in the previous chapter that the nHCE yielded estimates that are significantly higher than those from the BDM experiment (Banerji et al.2013; Lusk and Schroeder 2006). The implication of different WTP predictions disparities is that there will be different policies or pricing decisions. In this chapter, potential reasons as to why there is a disparity in the WTP estimates between the BDM mechanism and the nHCE are explored, with emphasis placed on the design features of the experiment. Specifically, the chapter is centred on testing the hypothesis that design factors associated with the BDM mechanism and the nHCE have an impact on the WTP gap associated with the aforementioned valuation techniques. Several empirical studies have identified various design features as possible sources of differences in WTP between the demand-eliciting mechanisms.

This chapter focuses on four of these. First, the chapter looked at whether subjects exhibited lexicographic preferences in the nHCE, which could have affected the choice behaviour. In a nHCE with repeated choices, individuals are expected to consider all the attributes and make trade-offs at each changing attribute level. However, some individuals may exhibit lexicographic behaviour (or be insensitive to all but one attribute) by consistently choosing the same option across choice sets, thereby biasing WTP estimates. This is a non-compensatory behaviour which violates the continuity axiom in consumer theory as the subject does not consider all attributes of choices but rather adopts an attribute processing strategy to simplify their decision making (Bishai et al. 2007). Lexicographic behaviour tends to bias the estimated WTP and it has been mainly attributed to complicated choice-tasks (Saelensminde 2001; Rouwendal and Blaeij 2004; Bridges et al. 2011). On the contrary, lexicographic responses may not imply irrationality but simply reflect the individual's strong preference of an attribute that is not altered within the range of prices offered in the experimental rounds. This may be due to an unbalanced experiment design where either irrelevant or insufficient attributes are included, or when there is an omission of attributes that subjects value most (Lancsar and Louviere 2006; Killi et al. 2007).

Second, the chapter investigates how the use of repeated auctions (i.e., the subject bid for the same item repeatedly) prior to the main BDM experiment may affect subjects' WTP. According to the "Preference learning hypothesis" (Plott 1996), preferences are learned through experience such that the bidding behaviour in the short-run may be random. With successive bidding rounds, however, preferences are discovered and bids become more rational. In other words, with the repeated auctions, subjects may learn the incentive structure of the game according to the preference learning hypothesis.

There have been ongoing debates suggesting that the use of repeated auctions is associated with price feedback or bid affiliation, although the results have been mixed. Some researchers (Hayes et al. 1995; Plott 1996; List and Shogren 1999; Lusk and Shogren 2007) have argued that subjects tended to learn and gain experience with more bidding rounds, with the bids becoming more stable with each round, thereby reflecting preference discovery which ultimately leads to true WTP. Other researchers such as Shogren et al. 2000; Corrigan and Rousu 2006; Akaichi et al. 2011, however, have argued that such a procedure led to biased WTP estimates as subjects who were uncertain about their preferences tend to use the randomly drawn price in each round as a cue to their true value of the good. Thus, bids submitted in later rounds tend to be significantly higher than those in earlier rounds- a case of price feedback and not necessarily true WTP.

Thirdly, the chapter looked at whether experimenters did influence the subject's bidding behaviour. Literature attributes this to the subject's unfamiliarity with the experimental procedures. Unlike in developed countries where respondents in experiments are self-administered most of the time due to computer technology availability and literacy, researchers still use people to conduct the experiments in rural Africa. In doing so as revealed in a study in rural Kenya by Morawetz et al. (2011), the experimenter is more likely to influence the subjects' bidding behaviour. This may be due to the subject's unfamiliarity with the experimental procedures that may require the translating of instructions into local languages or rephrasing. Further, Morawetz et al. (2011) noted that African participants may be more familiar with the first price auction where the winner paid a price equal to their own bid than the BDM where one paid equal to the randomly drawn price. The authors further found that experimenters often found it difficult to explain the BDM's randomly drawn price to the subjects compared to the first-price auction.

The fourth issue studied is whether *order effects* influenced the subject's bidding behaviour. Order effects are known to occur if the order in which subjects received the samples in experimental auctions influences WTP. In economics, this is attributed to inadequate learning of the experimental procedure, as well as participant fatigue (Lusk and Shogren 2007; Morawetz et al. 2011). Also in sensory testing, O'Mahony (1986) finds that the order in which one tastes samples may affect the sensory scores. He attributes this to the inability of the subject to detect the differences between stimuli or "adaptation". This comes from reduced sensory acuity as one gets used to the taste of the product, especially when tasting a strong sample before a weak one. He further notes that there's almost no effect when the stimuli have different taste qualities. In what follows, an empirical analysis is done on these design variables in the WTP for biofortified orange maize in the BDM and the choice experiment, and how they impact the observed differences in the WTP estimates.

3.2 Model estimation

In this section, experimental design factors (repeated-auctions, ordering-effects, and lexicographic behaviour) and their effect on the observed WTP differences in the two valuation techniques are considered. Under classical economic assumptions, WTP is a function of product attributes and demographics. To test the hypothesis of no design effects on the WTP differences, this assumption is relaxed by allowing WTP to also depend on experimental design features.

Initially, the chapter explores the presence and effect of lexicographic preferences on the choices and WTP for orange maize relative to the yellow and white maize varieties in the nHCE. In the

BDM mechanism, the focus was on exploring the presence and effect of order of food sample testing, experimenter's effect and use of repeated auctions on WTP for orange maize, and later study their impact on the observed WTP differences in the two mechanisms. Under classical economic assumptions, maximum WTP is a function of product attributes (y) and individual characteristics (x) only as shown below:

To test the hypothesis of no design effects, WTP was also allowed to likewise depend on experimental design variables (Z) as shown below:

$$WTP = WTP\ (Y, X, Z) \quad = WTP^{*} = f(\beta X_i + Z_i + \varepsilon_i) \tag{3.2}$$

Where: Y denotes products attributes

X denotes individual characteristics

Z represents the design factors

3.3 Hypotheses

Firstly, the chapter tests the null hypothesis that none of the design variables under consideration affect WTP estimates in the BDM and nHCE. The second follow up hypothesis is that design factors such as *ordering effects*, experimenter's effect, use of repeated auctions, and lexicographic behaviour do not affect the WTP differences between the aforementioned valuation techniques. When the null is not rejected in both cases, it implies none of the design factors considered influenced WTP, and neither of them accounted for the WTP disparities in the two valuation techniques. Rejecting the null, on the contrary, implies that at least one of the design factors affected WTP estimates in at least one valuation technique, and the WTP differences between them.

3.4 Design factors

The possible effects of repeated auctions, order and experimenters' effect on consumer's bidding behaviour for orange maize are reported in Table 3.1 and each is discussed below:

3.4.1 BDM experiment: Repeated auctions

To account for possible effects of bidding rounds on WTP in the BDM mechanism, the study allows WTP to also depend on repeated rounds of auctions using results from the two treatments preceding the BDM bid. In the first treatment, the respondents were asked how much they were willing to pay for a 2.5kg of orange maize grain in a single auction before their BDM bid. The same was done for respondents in the second treatment except these were subjected to 10-repeated rounds of auction, prior to the BDM bid with an understanding that each of those rounds was potentially binding when one random draw is chosen at the end of the experiment. This, therefore, made the experiment incentive compatible.

Table 3.1 reports the characteristics of the participants in the BDM under the two treatments. A total of 60 individuals participated in a single bid while 85 participated in *repeated bidding* prior to the main BDM bidding. Results indicate that the mean characteristics of participants were similar.

Table 3.1: Mean characteristics of the BDM participants

Variables:	Single bidding round	Repeated bidding	Diff	SD	(p-value)
Age	39.47	37.94	1.53	12.07	0.48
Gender	0.53	0.60	-0.07	0.50	0.43
Marital status	0.92	0.84	0.08	0.33	0.15
Education	7.95	8.47	-0.52	2.8	0.28
Household size	8.95	8.51	0.44	4.83	0.59
No. of people sharing meals	8.80	7.76	1.04	1.29	0.13
Asset index	-0.13	-0.00	-0.13	0.99	0.44
N	60	85			

In the first treatment, respondents bid for a 2.5kg of orange maize grain in a single auction before their BDM bid. In the second treatment, the auction-rounds were increased to 10. Following Plott's (1996) preference hypothesis of learning through experience and market exposure, the study expects that subjects are more likely to reveal their true preferences in the BDM with repeated-auctions than in a single-auction. Further, it is expected that heuristics of the "buy low type" which subjects normally exhibit in a real market situation even when told to bid optimally (Drichoutis et al. 2010) will be eliminated with repeated-auctions due to learning.

Mean comparisons of round-one bids revealed that there was no significant difference (p=0.52) in the mean bids for the single-auction treatment group (1469 ZMK) and the repeated-auction group (1427 ZMK). This suggests that understanding the BDM experiment by both groups at the beginning was similar and potential differences in their final BDM bid can only be attributed to repeated bidding.

To determine whether repeated auctions had an effect on the subject's bidding behaviour, the pooled BDM bids are used as a dependent variable while controlling for repeated auctions (Table 3.2). An indicator variable "repbid" is used which takes the value of 1 if one's BDM bid was conducted after 10-auction rounds, zero otherwise. It is hypothesised that the 'repbid' coefficient should be different from zero if learning occurred with repeated auctions. Results indicate that this coefficient is positive and significant ($p<0.05$). Subjects that participated in the BDM after 10 auction-rounds on average bid 119.00 ZMK more than those who did not (column 1). This finding suggests that repeated-auctions eliminated the heuristics of wanting to "bid low", and provided a better understanding of the experiment, thus yielded more realistic results than the single-auction treatment.

3.4.2 BDM experiment: Order effects

The order of sample tasting is known to affect the sensory ranking scores (O'Mahony 1986) and since sensory attributes scores are expected to have an endogenous relationship with WTP (as they are both determined by demographics and attitudes), we tested whether this also impacted WTP for orange maize. The results are summarised in Table 3.2(2). As stated earlier, all participants evaluated the sensory attributes of the three maize varieties prior to the experiments. Six (6) different orders of sample-tasting emerged from the data. Dummy variables for 6 different orders are included in modelling bidding behaviour while controlling for repeated-auctions.

Interaction terms of order and repeated-auctions are also included to determine whether the sample tasting-order had different effects on the two treatment groups (single vs. repeated-rounds). Results show that WTP estimates for respondents who tasted maize samples following orders 3 and 4 were significantly higher ($p<0.05$) than the reference category. Both of these orders began with the familiar white-maize. This indicates that if subjects begin the sensory tasting exercise with the conventional white maize, they are more likely to bid more for orange maize. Consistent with O'Mahony's (1986) assertion, based on this result alone, the familiar white maize could have masked the subject's sensory acuity for the new product. Results, however, further revealed that participants in the repeated-round treatment were less likely to have order effects than those in a single treatment. This was true for order 3 ($p < 0.05$), orders 4 and 6 ($p < 0.1$), suggesting that some of the order effects observed could be due to inadequate familiarisation of the experiment and were reduced through learning from the repetitive treatment.

3.4.3 BDM experiment: Experimenter's-effect

The BDM is considered complex relative to the nHCE. Experimenters had to translate instructions from English to the respondent's native language, administer questionnaires and guide the entire bidding process. In light of this, the study determines whether in doing so, experimenters influenced respondents' bidding behaviour. Dummy variables for enumerators are included in the model using experimenter one as a reference category. Results suggest that the effect of experimenters on WTP outcomes for orange maize was limited, with only two experimenters (7^{th} and the 12^{th}) whose subjects bid higher than the subjects for the first experimenter at $p<0.1$ (Table 3.2 (3)).

Table 3.2: WTP estimates from the BDM auction with different design factors

	(1) Repeated auctions		(2) *Order effects*		(3) Experimenter's-effect	
Bid	**b**	**se**	**b**	**se**	**b**	**se**
Household size	4.36	(4.12)	2.52	(4.43)	1.34	(4.32)
Respondents' age	3.91	(11.69)	4.10	(11.58)	16.82	(10.84)
Age square	-0.07	(0.12)	-0.08	(0.13)	-0.22*	(0.12)
Gender	113.9*	(61.69)	131.8**	(58.91)	91.14	(55.50)
Education	-10.40	(9.84)	-16.27	(10.30)	-11.59	(8.97)
Asset index	2.23	(13.24)	2.65	(13.33)	0.19	(12.55)
Repbids	118.9**	(55.33)	282.1**	(115.2)	151.9***	(55.04)
Order2 (yellow-white-orange)			-52.45	(156.0)		
Order3 (white-orange-yellow)			281.7**	(128.3)		
Order4 (white-yellow-orange)			271.3**	(135.5)		
Order5 (orange-white-yellow)			14.04	(146.8)		
Order6 (yellow-orange-white)			192.7	(135.5)		
Order2 x Repbid			-30.99	(198.3)		
Order3 x Repbid			-373.7**	(157.8)		
Order4 x Repbid			-303.7*	(158.6)		
Order5 x Repbid			-5.34	(170.2)		
Order6 x Repbid			-348.9*	(182.1)		
Enum2					-230.4	(171.1)
Enum3					162.5	(139.9)
Enum4					-131.0	(180.7)
Enum5					130.8	(152.8)
Enum6					125.2	(155.8)
Enum7					264.6*	(146.7)
Enum8					60.51	(180.4)
Enum9					59.18	(173.1)
Enum10					76.89	(164.6)
Enum11					69.56	(158.3)
Enum12					263.7*	(150.7)
Enum13					152.4	(176.2)
Enum14					237.3	(151.1)
Enum15					165.1	(136.8)
Enum16					79.88	(164.0)
Constant	1561.3***	(254.1)	1514.6***	(265.6)	1235.5***	(286.4)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Reference order category is 1 (orange-yellow-white)

3.4.4 Choice experiment: Price insensitivity (lexicographic preferences)

In the nHCE, it was found that 31% of the respondents consistently chose one variety in all 16-choices regardless of the price offered. This was mostly observed with orange maize (21%), followed by white maize (6.54 %) and yellow maize (3.74%). The predicted value of lexicographic responses following a logit model was 28%. Reasons for such behaviour in literature as earlier stated include complex or poorly explained experiments; boredom or fatigue from repeated choice-tasks; omission of the relevant attribute. To account for lexicographic behaviour, we allowed the price coefficient associated with lexicographic responses to be zero such that the systematic component in equation (2.6) is equal to the alternative specific constant i.e., $V_{ij} = \beta_{1j}$.

Results (Table 3.3) reveal that controlling for lexicographic behaviour increased model fitness based on the AIC, BIC and log-likelihood values. The coefficient signs, significance levels, and magnitude changed on some explanatory variables. Notably, the asset-index variable no longer has an effect on orange and yellow maize choices, while education no longer has an effect on orange maize choices. Further, WTP estimates for all varieties are significantly reduced, suggesting the overestimation of these estimates when lexicographic responses are not accounted for.

Table 3.3: Parameter Estimates from the non-hypothetical choice experiment for maize variety choice after controlling for price insensitivity (lexicographic behaviour) using a mixed logit model

Choice	**No lexicographic preference control**		**Control-lexicographic preferences**	
	Parameters	**Standard errors**	**Parameters**	**Standard errors**
Price.x10^{-02}	-0.28***	(0.06)	-0.39***	(0.04)
Gender*white	0.86	(0.89)	0.90	(0.70)
Gender*yellow	0.99	(0.94)	1.21	(1.10)
Gender*orange	1.14	(0.98)	-0.12	(0.73)
Age*price.x10^{-03}	-0.025*	(0.01)	-0.01	(0.01)
Asset*price x10^{-02}	-0.03	(0.02)	-0.042**	(0.02)
Age*white	0.00	(0.06)	0.00	(0.04)
Age*yellow	0.15**	(0.06)	0.08**	(0.04)
Age*orange	0.15**	(0.06)	0.10**	(0.04)
Asset*white	0.48	(0.43)	0.19	(0.39)
Asset*yellow	-1.07***	(0.41)	-0.53	(0.49)
Asset*orange	1.88***	(0.51)	0.75	(0.46)
Education*white	0.44***	(0.16)	0.30***	(0.11)
Education*yellow	0.16	(0.17)	0.08	(0.11)
Education*orange	0.39**	(0.18)	0.07	(0.10)
ASC				
White	5.17***	(1.69)	5.89***	(1.40)
Yellow	-0.71	(1.93)	2.02	(1.93)
Orange	1.28	(2.13)	5.39***	(1.56)
SD				
Education*white	0.38***	(0.04)	0.24***	(0.04)
Education*yellow	0.60***	(0.05)	0.50***	(0.05)
Education*orange	0.77***	(0.07)	0.42***	(0.05)
N	6848		6848	
Log-likelihood	-981.51		-941.74	
AIC	2005.00		1925.50	
BIC	2148.50		2068.90	
WTP(ZMK)				
White	2430.98		2163.40	
Yellow	2003.48		1725.26	
Orange	2970.24		2378.19	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.4.4.1 Characterising individuals with lexicographic behaviour (price insensitivity)

Although one cannot clearly distinguish the reason for lexicographic responses in this study, literature suggest it can be determined whether some of the respondents were truly lexicographic (i.e., the attribute chosen is the respondent's true preference) by looking at answers to other questions besides the choice experiment questions, on the lexicographically chosen good or attribute as suggested by Killi et al. (2007). These authors posit that if answers to questions besides the choice questions indicate preferences for the attribute chosen lexicographically, then there's some indication of true lexicographic preferences, and this can occur as a result of an attribute not explicitly stated or missing in the choice tasks in the experiment.

This chapter examined the ranking of orange maize sensory attributes and conducted a logistic regression to test if sensory attributes along with individual characteristics affected lexicographic behaviour. The results in Table 3.4 indicate that the probability of just preferring orange maize throughout the choice tasks increased for respondents to whom the sensory taste attribute was very important. It is, therefore, more likely that some respondents had true lexicographic preferences as they valued the taste attributes of orange maize highly, thereby neglecting the price-ranges offered in the experiment.

Regarding the effect of individual characteristics, it was hypothesised that age, education, and income would be linked to lexicographic behaviour especially when a lack of understanding of the experiment is expected to trigger such behaviour. Thus, age was likely to have a positive relationship with older respondents more likely to be lexicographic. Economic theory predicts a positive correlation between education and income, meaning that individuals with low-income levels are also likely to have low education hence less likely to comprehend the complexity of the experiment. Hence in both of these variables, a negative relationship was expected. The rest of the characteristics were added to determine if they had any effect on lexicographic behaviour.

Results indicate that the probability of answering lexicographically was positively associated with increments in assets, the land area cultivated and age, as well as if one was male. On the other hand, increments in household size and income decreased the probability of being lexicographic at $p<0.05$. However, the education variable though negatively associated with lexicographic behaviour was insignificant. There was however no additional qualitative information in this study to help us better understand why individuals displayed lexicographic behaviour and it should be something future research should consider.

Table 3.4: Effects of product and individual characteristics on lexicographic behaviour

	(1)		
Dependent variable: Lexicographic (1=yes, 0=no)	**Parameters**	***Standard errors***	***Predicted Probability***
Sensory attribute: Taste (1=very important, zero otherwise)	0.709**	(0.285)	0.28
Asset index	0.440***	(0.0845)	
Education (in years of formal education)	-0.0287	(0.0203)	
Land area cultivated	0.0300***	(0.00464)	
Income from 3 major sources x10^{-5}	-0.0244***	(0.00284)	
Age	0.0374***	(0.00461)	
Gender	0.643***	(0.165)	
Marital status	0.172	(0.199)	
Household size	-0.0653***	(0.0166)	
Constant	-2.994***	(0.420)	
N	1712		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.5 Comparing WTP after controlling for design effects

WTP was computed in each experiment after accounting for repeated bids and lexicographic responses in the BDM and nHCE, respectively. Results (Table 3.5) revealed a WTP gap reduction by half, although the difference is still significant.

Table 3.5: Comparison of WTP estimates from the BDM and non-hypothetical Choice Experiment after controlling for design effects

WTP variable	RCE (mean in ZMK)	BDM (mean in ZMK)	Difference	SD	(p-value)
WTP statusquo	2970	1691	1279	589	0.00
WTP after controlling lexicographic responses	2378	1,747	*632*	302	0.00
N	107	138			

3.6 Conclusion

This chapter explored experimental design features affecting the BDM and the nHCE and compared WTP estimates from the two valuation techniques after accounting for significant design factors in each valuation technique. Results indicate that the BDM experiment was significantly affected by the use of repeated auctions or additional training prior to the main BDM bid. The nHCE was affected by lexicographic responses. A comparison of mean WTP estimates elicited from the BDM and the nHCE for orange maize revealed that estimates from the nHCE higher than those from the BDM experiment. However, the results further show that this disparity can be reduced by half by employing extra bidding rounds in the BDM experiment and controlling for lexicographic behaviour (choosing one maize variety regardless of price) in the choice experiment. The effect nevertheless is not statistically significant but could be meaningful from the economic point of view. Training also eliminated the effects of offering the varieties in different orders in the preliminary tasting. This may indicate that providing respondents with more training in BDM can reduce the differences in results typically encountered. These results are consistent with Banerji et al (2013) who also find that controlling for censored bids and lexicographic answering makes the estimates under the two valuation techniques more comparable.

The exact source of lexicographic behaviour was beyond the scope of this study but it is something that should be considered in experiments. Varied reasons for such behaviour have been proposed in the literature, ranging from complexity of the experiment, poorly designed experiments, to being truly lexicographic. Killi, et al. (2007) suggested adding qualitative questions covering reasons for such behaviour in anticipation. A characterisation of individuals who were lexicographic showed that lexicographic behaviour was correlated with the importance that consumers placed on the sensory taste of orange maize, suggesting that some of the lexicographic responders may have exhibited such behaviour as a result of their true preferences for the sensory taste of orange maize, and therefore disregarding the price. This indicates that eliminating lexicographic responders from the analysis of the experiment may take away some of the valid preferences, as Lancsar and Louviere (2006) noted. On the other hand, lexicographic behaviour was also correlated with individuals' personal characteristics such as age and education which may suggest a lack of understanding among some subjects who exhibited lexicographic behaviour.

Results also indicate that individuals exhibited different behaviours under the two valuations techniques. While gender explained the bidding behaviour in the BDM experiment, age influenced the choice behaviour in the nHCE for orange maize. These results suggest that the two methods lead to different conclusions about the individual characteristics influencing WTP for orange maize. Researchers, therefore, could be mindful of using a technique that minimizes the subjects' mistakes in experiments. Alternatively, providing training or recruiting participants who understand the valuation techniques could provide more reliable results.

3.7 Study limitations

Testing the hypothesis of the equivalence of willingness to pay estimates (WTP) yielded from the BDM and the nHCE requires that respondents under both experiments have similar sample characteristics. In this study, although participants under both experiments were similar in most characteristics, the participants under the nHCE were 3 years older. This could be one of the reasons why mean WTP for orange maize was higher for the nHCE given the positive effect of age. However, differences in the marginal WTP or any systematic error were not expected since there was no influence of age on other varieties in the nHCE. Differences in the respondent's average age in the two samples were as a result of the data limitation, as the data were not collected for the objectives of this study by the original researchers. In future, designing these experiments with matched samples in terms of age would result in testing such a hypothesis with greater precision.

Further, the testing of experimental design features was not exhaustive as the WTP gap remain statistically significant. Given that controlling for experimental design features has the potential to narrow the WTP gap, other design features must be considered in the analysis such the "endowment" effects and "timing"[4] effects which also have potential to bias WTP estimates in the developing country context. For example, Rutsaert et al. (2009), study WTP for quality rice in Senegal and find that willingness to pay declined if the auction experiments were conducted after participants have had their lunch.

[4] The time of the day when experiment is conducted

CHAPTER 4: GENDER DIFFERENCES IN CONSUMER ACCEPTANCE OF BIOFORTIFIED FOOD CROPS IN THREE SUB-SAHARAN AFRICAN COUNTRIES

4.1 Introduction

Increasing evidence of gender differences in various aspects of choice behaviour in economic literature has been reported (Croson and Gneezy, 2009). This chapter focuses on exploring such gender differences in the acceptance of food crops enhanced with micronutrients by the process of biofortification in three sub-Saharan African countries, i.e., Nigeria, Rwanda, and Zambia. Biofortification is a process of increasing the nutrient content of crops through conventional plant breeding or biotechnology (Nestel et al. 2006) and a new public health intervention method aimed at combating the micronutrient deficiencies problems in developing countries where females of reproductive age and children below the age of 5 years are the most affected (WHO 2007). Staple food crops have been targeted so far, so as not to affect dietary habits, thereby creating higher chances of acceptance, and alleviating the micronutrient deficiency problem.

With biofortified food crops being introduced in sub-Saharan Africa where staple food crops are targeted, it is expected that gender differences in acceptance would be minimal or non-existent since staple food crops are consumed across demographics including gender. However, the intrinsic characteristics of the crops are likely to change (De Groote et al. 2014), some of which may be unfamiliar to consumers. Prior empirical work and theory suggest that there are gender differences in factors that may affect access and acceptance of novel food. Understanding the determinants of acceptance of BFC by gender, therefore, can help design strategies for males and females to have equitable access to the nutritious food crops.

While studies of gender differences in consumption behaviour have made great strides in explaining how and why males and females have different food preferences, the focus has mainly been in the developed world. It is unclear the extent to which this can be generalised to the people residing in the developing world with different dietary habits that are characterised by staple food consumption. In biofortification research, consumer acceptance of biofortified food crops (BFC) studies have been done, focusing mainly on understanding consumer attitude and behaviour towards biofortified staple food crops and identifying demand creating strategies for them through sensory evaluations, hedonic tests, and economic experiments. Birol et al. (2015) summarised the results of these studies and came to a conclusion that BFC are more likely to be accepted in developing countries. However, most of the studies in consumer acceptance of BFC, if not all, seldom analysed the acceptance of BFC by gender, although gender was included as an intercept shifter in the analyses.

In order to inform meaningful policy directions, policymakers would not only be interested to know whether there are gender differences observed in consumer acceptance of the nutritious crop varieties but also what is causing the gender differences in the observed probability of acceptance. This might be in terms of observed characteristics such as personal endowments (education, wealth status) and product attributes perceptions. This may also be due to differences in unobserved heterogeneity, i.e., there could be missing variables that may be influencing the chances of acceptance that may matter more to females than they would to males or vice versa. On the other hand, if differences are not known where they are coming from, then it would not be possible to eliminate them, thus posing a challenge for acceptance (Williams 2009). Further, the findings of differences between those who have accepted and those who have not accepted BFC may reflect gender differences, and if gender is ignored, the conclusion from research results may be wrong.

This chapter attempts to fill this gap by looking at gender not only as a mediatory variable but will also conduct a subsequent analysis of how gender-specific differences may affect consumer acceptance of biofortified food crops. This will help researchers and policy-makers better determine how such differentiation could affect acceptance and the ultimate adoption of biofortified food crops. If a gender gap existed, there would be need to tailor specific policy interventions based on gender differences. This may involve identifying gendered pathways to encourage consumer acceptance of biofortified foods across gender such as responding to gender-specific needs in the ongoing product development and designing gender-differentiated marketing strategies. Specifically, suggesting gender-differentiated approaches in the timing, modality, point of emphasis and vehicles for behaviour change communication when promoting BFC products may be necessary. We use data that was specifically collected to determine consumer acceptance of biofortified food crops and test the robustness of the results in three locations and/ cultures by covering three sub-Saharan African countries namely, Nigeria, Rwanda, and Zambia. Acceptance was measured using both hedonic ratings of selected intrinsic attributes that are believed to matter for consumers in the region, and consumers' WTP for BFC.

The next section provides the theoretical framework, highlighting different theories that explain possible sources of gender differences in consumption behaviour. The methodology section is next which looks at data sources, conceptual frameworks and the empirical methods of analysis. The chapter will conclude with statements of hypotheses.

4.2 A theoretical review of sources of gender differences in consumer behaviour

This section provides theories that are believed to explain gender differences in consumer behaviour. Gender in these theories is considered in a broad way to include biological sex, as well as males and females' constructed roles, identity and behaviour by society (Tannenbaum and Greaves 2016). Gender differences have been observed in various aspects of consumer behaviour such as in purchasing intentions, attitude formation, judgement about products, response to advertising, and information processing, among others (Meyers-Levy 1988; Darley and Smith 1995; Putrevu 2004). A number of explanations or theories have been suggested as possible explanations for such gender differences, and each of these is explained below.

4.2.1 Socio-cultural theory

According to the sociocultural theory and in particular following the biosocial construction model by Eagly and Wood (2012) two related factors account for gender differences in consumer behaviour. These include the physical differences that are inherent between genders (such as men's physical strength and size, females' ability to bearing children) and the socio-cultural influences. These physical differences are believed to have overtime created task-efficiency differences that have resulted in the division of labour, e.g., childcare and household chores for females and obtaining resources outside the home for men. The socio-cultural theory further posits that division of labour contributed largely to formation of cultural beliefs that define men's and females behaviour in each given society. For example, females being childcare givers are considered to be more caring and communal oriented. On the other hand, males are perceived to be assertive, dominant and more skilled in leadership, competitive due to their strength and their performance of intensive tasks.

Socio-cultural influences, on the other hand, posit that gender differences in consumer behaviour stem from the way males and females are socialised. males are usually raised to be assertive or competitive, independent and rational. As a result, males are known to take on goals that are self-satisfying first. On the contrary, females are raised to be relational, interdependent –implying that other individuals' utilities enter into their own utility function (Meyers-Levy 1988; Croson and Gneezy 2009). Further, females in most societies are also stereotyped to be more risk-averse and tend to behave as such due to society's expectations (Grossman and Komai 2008).

It is believed that the social and cultural expectations for males and females influence how males and females conduct judgment on new products and the processing of information (Darley and Smith 1995). For example, the risk-averse behaviour mainly associated with females in consumer behaviour may imply resistance to the novel food products such as BFC, suggesting that females would rather stick to the tried and tested crop varieties than unknown new varieties of BFC. In advertising, this theory may explain why males and females have often related more to the brand type that matches up with their perceived gender identity. Additionally, specific gender traits have been linked to products that are considered gender-specific, with males and females identifying more with products that appeal to their own gender identity (Meyers-Levy 1988).

4.2.2 Evolutionary theory

The main claim of the evolutionary theory according to Buss (1995) is that as the human ancestors faced different environmental challenges, they found ways of adapting to these challenges and gender division of labour appeared to be one of the adaptations to the environmental challenges. With the major goals of survival and reproduction, the two sexes developed different approaches or occupied different social roles to ensure survival and reproduction successes. males often engaged in activities that provided for food at home such as hunting, gathering fruits, while females took care of household chores such as childcare, food preparation, and homecare. In ensuring reproductive success, males ensured they passed their genes to the next generations by having multiple sexual partners, while females sought out mates who could best help and support them.

This theory suggests that the roles that males took enabled them to be more aggressive, risk-taking and competitive, while those for females enabled them to be more nurturing and empathetic (Silverman 2003). This, in turn, enhanced reproductive success and avoided starvation as they faced environmental challenges (Fischer and Rodriguez Mosquera 2001). In general, this theory suggests that males and females will differ in areas in which they have experienced different adaptation challenges during evolution (Buss 1995). With regards to the acceptance of biofortified food products, the evolutionary view of origins of gender differences seems to suggest that males will be among the early adopters of novel foods given their natural competitiveness and risk-taking behaviour they undertook as they adapted to environmental challenges in evolution.

4.2.3 Hormone-Brain theory

This theory posits that gender differences in behaviour and cognitive skills can also be a result of differences in exposure of sex hormones, especially the male hormone during a critical period of human development as well as brain lateralisation. Although testosterone is present in both males and females, the amount is higher in males than in females. The converse is true for the oestrogen hormone which is more present in females. Behaviours such as aggression, competitiveness, visuospatial abilities, which are usually associated with males are attributed to higher levels of the testosterone hormone. This assertion was confirmed by Hines et al. (2002) who studied female offspring born to mothers injected with male hormones during pregnancy to avoid a miscarriage. Offspring from the treated mothers were found to be more aggressive than those in the control group and attributed this to the extra testosterone injected in the womb. The female sex hormone oestrogen exposure, however, had no feminine effect on male development. On the other hand, higher testosterone levels in some studies have been associated with weakened female sex-typed emotions such as tenderness and empathy, implying that oestrogen is the default hormone in the human being (Meyers-Levy 1988).

The hormone testosterone is also believed to influence brain development, resulting in gender differences in males and females' brain functions. According to Tian et al. (2011), in contrast to females, males tend to use their right hemisphere more efficiently which is more specialised for non-verbal and spatial skills. Additionally, it’s far argued that males’ brain hemispheres are likely to work more independently than that for females due to the testosterone hormone. This gives males a better performance in tasks requiring both insightful perception and harmonised action. On the other hand, females, are believed to use both hemispheres, thus, giving them an advantage while multitasking (Meyers-Levy 1994). In the context of consumer behaviour particularly shopping, this difference in brain structure could give an explaination for why males are mission and task-oriented shoppers, while females are discovery-oriented shoppers who can easily adjust their initial shopping goals to maximise their satisfaction in shopping (Wahyuddin et al. 2017).

4.2.4 Selectivity hypothesis

The selectivity hypothesis posits gender differences in consumption behaviour are due to differences in the way males and females process information (Meyers-Levy 1989; Meyers-Levy and Sternthal 1991). Specifically, this theory argues that males and females employ different strategies in information processing. males are perceived to be selective processors, relying mostly on heuristics (i.e., simple decision rules with minimal effort to process information) despite detailed message elaboration. Thus, they tend to use a subset of available information to come up with simple decision-making rules as opposed to using all the information available at their disposal. Females, on the other hand, take a holistic approach in processing and scrutinising all information available for its relevance and importance, and thereafter incorporate all useful information as they make their judgements (Chaiken et al. 1989).

Meyers-Levy and Sternthal (1991) further suggest that females tend to have a lower threshold for elaborate information processing, and may elaborate on message cues that require less attention (Meyers-Levy 1989). In terms of consumer behaviour, the selectivity hypothesis is thought to account for gender differences observed when responding to an advert. In this regard, females are more likely to use more detailed message content, elaborate more on message claims, and weight equally self-generated information and that from the environment (Carsky and Zuckerman 1991; Darley and Smith 1995).

4.2.5 Economics view of gender differences

The economics view recognises the existence of gender differences in many economic choices like all other theories earlier stated. However, it argues that gender differences observed in economic behaviour are not inherent but are a result of gender inequality. Becker (1981) asserts that initially everyone is equal regardless of gender, but as individuals grow and take different gender roles and specialize in them, they gain a comparative advantage in those roles and ultimately manifest different behaviours. Females' inherent capacity to bear children usually inclines them to specialize in rearing children and performing other household activities and participate less in the labour markets. Men, on the other hand, are more likely to participate in labour markets. Morrison et al. (2007) argue that males and females are fundamentally equal and behaviour differences observed are not inherent but perpetuated by inequality in having access to productive resources such as land, credit, employment, and educational opportunities, among others. They further argue that bridging the gap in all these should be able to put males and females on an equal footing. In the acceptance and adoption of new BFC, controlling for these factors implies that both males and females will have equitable access to nutritious staple food crops.

Gender differences in consumer behaviour have been also attributed to males' and females' manifestation of risk and social preferences due to socio-cultural influences. In a synthesis of experimental literature on risk, social and competitive preferences, Croson and Gneezy (2009) find that females are more risk-averse than males and they are also more likely than males to have stronger social preferences than males (other people's "utilities enter their own utility function" (Croson and Gneezy 2009: 7). Taken together, all these manifestations make a difference in the way males and females make decisions in the product and labour markets.

4.3 Methodology

4.3.1 Data and descriptive statistics

The empirical analyses use experimental data for consumer acceptance of biofortified food crops from three selected sub-Saharan African countries which were aimed at studying consumer's attitudes towards the new biofortified food crop varieties. HarvestPlus in collaboration with local authorities and universities collected data on the acceptance of BFC across several developing countries. For the analyses of this study, the data from Nigeria, Rwanda, and Zambia are used because it is in these countries where BFC will be first introduced. As shown in Table 4.1, the data were collected from incentive-compatible experiments and hedonic evaluations to determine consumer acceptance of maize biofortified with vitamin A, iron biofortified beans and vitamin A biofortified cassava available for Zambia, Rwanda, and Nigeria respectively.

Initially, consumers tasted food made from varieties of biofortified crops which they compared with conventional crops, with or without nutrition messages, from either a central location (market) or in their homes. Hedonic scores (mostly sensory) were requested from each respondent, indicating how much they liked or disliked each of the attributes that were considered in respective crops. Respondents also had an experience with food purchases using auctions or choice experiments to elicit their WTP for BFC. In Zambia, willingness to pay was elicited through both the BDM experiment and nHCE. Nigeria and Rwanda used BDM experiments only. The purpose of the experiments was to determine whether nutritional improvements of staple food crops with probable changes in intrinsic attributes through biofortification will be accepted by consumers in these countries.

Information on demographics, staple food consumption habits, and prior nutritional knowledge was also collected. Hedonic evaluations and WTP were used to determine acceptance by gender. Both methods are used to determine the perceived importance of intrinsic attributes in relation to other quality indicators such as nutrition and personal characteristics such as gender in accepting new or modified food products such as the biofortified food crops.

Table 4.1: Biofortified food crop by country, treatment and valuation technique

Country	Crop of target	Micronutrient	Product experience	Nutrition message treatment	Mode of message transmission	Valuation technique
Zambia	Maize	Vitamin A	Central location	Nutrition information	Radio	nHCE
				No nutrition information	-	BDM and nHCE
			Home	Nutrition information	Radio	nHCE
					Community leader	
				No nutrition information	-	
Rwanda	Common beans	Iron	Home	No nutrition information	-	BDM
				Nutrition information in the gain frame provided once	Radio	
				Nutrition information - gain frame- thrice		
				Nutrition information in the loss frame provided once		
				Nutrition information in the loss frame provided thrice		
Nigeria	Cassava	Vitamin A	Central location	No nutrition information	-	BDM
				Nutrition information endorsed by the Federal government	Radio	
				Nutrition information endorsed International agent		

Source: Own synthesis from HarvestPlus data

Table 4.2 presents differences in socioeconomic characteristics between males and females in each of the three sub-Saharan African countries under study. The specific information considered include age, marital status, educational attainment, wealth status, household size, number of members sharing meals, land area accessed and land area planted in the season just before the year of study. The results show that there were significant differences between males and females in most of the socioeconomic characteristics. In Nigeria, 270 males and 162 females took part in the consumer acceptance of vitamin A biofortified cassava study. On average, males were older, had more years of formal education and more assets compared to females. They also owned and cultivated more land in the year before the study, relative to females. The proportion of married males was relatively higher than that of married females. Females, on the other hand, came from relatively larger household sizes, although the number of individuals sharing meals was lower than that of males. Males on average have more children who were under 5 years compared to females.

In Rwanda, a total of 551 individuals took part in the consumer acceptance study of two bean varieties with iron biofortification. Of these, 162 were females and 389 were males. On average females (49.6 years) were significantly older than males (42.4 years) and came from households with more members sharing a meal per household than males. On the other hand, males had more years of formal education on average compared to females. They also came from wealthier households are larger family sizes relative to females. The proportion of married males was also higher than that of females. Males also cultivated and owned more land and assets at the baseline.

In Zambia, a total of 643 individuals took part in the consumer acceptance of a maize variety biofortified with vitamin A, of which 376 were males and 267 were females. On average, males and females were of the same age, had same levels of educational attainment and had equal number of members sharing meals in a household. However, males relative to females, owned and cultivated more land, owned more assets, came from larger household sizes, and the married were more compared to the female subjects. In all three countries, almost all respondents indicated the respective biofortified food crop as their main staple food crop.

Table 4.2: Baseline characteristics of participants of consumer acceptance of biofortified foods by country and gender

		Nigeria (N=432)			Rwanda (N=551)			Zambia (N=643)		
Variable	**Variable description**	**female**	**male**	**p-value**	**Female**	**Male**	**p-value**	**Female**	**Male**	**p-value**
Age	Age in years	46.07	51.28	0.00	49.57	42.41	0.00	42.44	42.83	0.75
Married	1 if married, 0 otherwise	0.74	0.90	0.00	0.13	0.95	0.00	0.66	0.90	0.00
Household size	Household size number	3.62	3.26	0.09	2.69	3.84	0.00	6.89	8.02	0.00
Education	No. of years of formal education	8.04	9.19	0.01	4.05	5.01	0.00	7.75	7.91	0.66
Meal sharing	No. of people sharing meals	6.65	7.18	0.18	3.99	4.73	0.00	6.94	7.41	0.08
Asset index	Asset index	-0.42	0.26	0.00	-0.88	0.35	0.00	-0.32	0.23	0.00
Area planted	Area planted in hectares	1.35	2.79	0.01	4.05	4.55	0.98	2.06	2.95	0.00
Land owned	Land owned in hectares	1.94	3.92	0.01	5.73	6.17	0.12	5.89	11.15	0.00
N		162	270		162	389		267	376	

4.3.2 Conceptual framework

In this section, the conceptual link between consumer acceptance of a novel food or food with new attributes, and gender are discussed. The emphasis is placed on gender differences in social-economic characteristics, product perceptions, and responses to product promotion tools. As earlier stated, acceptance of food made from biofortified food crops was measured using both hedonic evaluations and consumer's WTP. Hedonic evaluation is considered as an important part of food development because it is the critical means of determining how consumers will react to food. A particular food is evaluated by people primarily for its sensory appeal (Kearney et al. 2000; Eertmans et al. 2005; Honkanen and Frewer 2009; McCrickerd and Forde 2016).

The novelty property of biofortified food crops is in the increased nutritional value when compared to the conventional staple food crops. While the nutritional attribute of biofortified food crops may be important to some consumers, it is the intrinsic product attributes that determine the immediate consumption gratification (Xue et al. 2009). It is, therefore, necessary to assess the relative importance of intrinsic product attributes to other factors in predicting acceptance for biofortified food crops by gender. The findings will shed light on the consumer's attitudes of these attributes, identify those that are relevant, thus get an insight into potential consumers' attitudes towards the consumption of biofortified food crops.

Other hedonic attributes are also important such as cooking time, milling and cooking quality, price as well as perceived nutritional value, among others. In what follows, an analysis of how gender differences can occur in the acceptance of biofortified food crops under three possible scenarios as depicted in figure 4.1 are discussed.

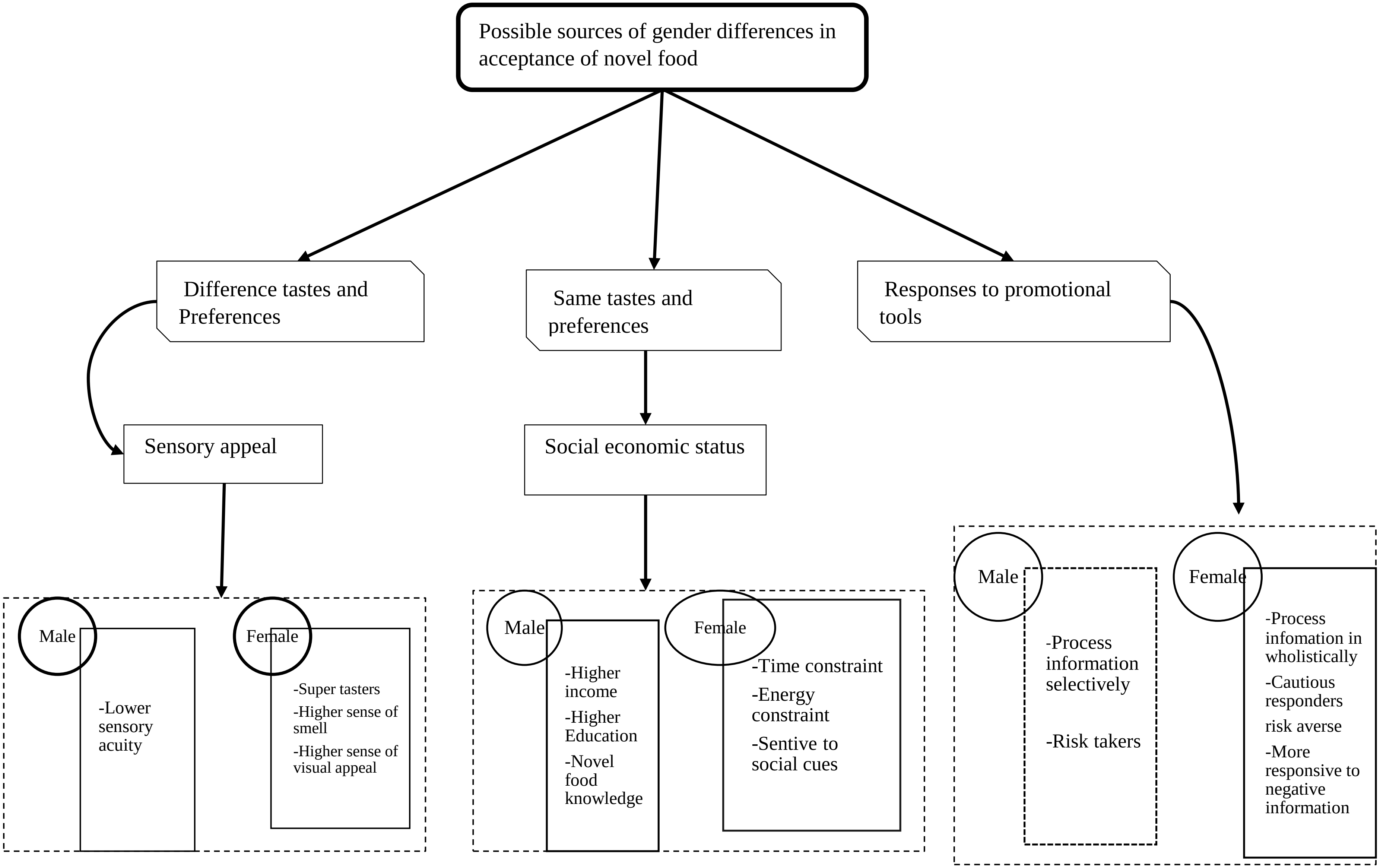


Figure 4.1: Possible sources of gender differences in the acceptance of a novel food

Source: Literature synthesis

4.3.2.1 Gender differences in preferences due to socio-economic factors (same taste)

There are a number of ways that gender differences can arise in the acceptance of a novel food product. Assuming for example that males and females have similar tastes for BFC and identical expenditure functions (this assumption is plausible because biofortification targets staple food crops which are liked and consumed across gender), it is still possible to have differences in their marginal valuations of nutritional improvements stemming from biofortification of these crops. Gender differences might arise because of differences related to resource constraints such as income or productive resources, knowledge/education, and time available for food preparation.

Access to BFC will require consumers to either purchase BFC products or seed, with that the level of income likely to play an important role in this aspect. Income differences have been observed between males and females and it is widely accepted for example in labour literature that females' earnings are usually lower than that of males even after controlling for working hours and employment type. Females are also often subjected to unpaid work in the form of household chores. According to the UN statistics (2010) estimates, females worldwide on average spend at least twice as much of their time in domestic work which is unpaid, with the prevalence being higher in developing countries (Kolev and Sirven, 2010). Additionally, rural females especially, tend to have fewer assets and productive resources than males (Deere and Doss 2006) and are often discriminated against access to credit markets, making it difficult for them to purchase productive inputs such as improved seed and fertilizer. These, in turn, may all make it difficult to access the new seed of BFC as well as purchasing food made from them.

Gender differences may also arise from the of knowledge of novel foods on the market as well as the scientific literacy of the novel food in question. According to the consumer behaviour theory, the acceptance of new food products has been positively associated with knowledge (Moerbeek and Casimir 2005), for which males more than females were likely to be knowledgeable about new food innovations. Related to knowledge is education. The level of education affects what type of social environment one inhabits and what type of food one is exposed to, among others (Risvik et al. 2006). males usually have higher formal educational attainment than females and hence for them, scientific literacy and knowledge about novel food products on the market are likely to be higher.

Hamstra (1998) on the other hand was quick to note that although knowledge about novel foods encourages people to have more objective opinions about the novel foods, results could lead to either positive or negative attitudes towards the novel foods. This view is supported by the findings of Bucchi and Neresini (2002) in their survey of Italian citizens, which revealed that more knowledge about genetic engineered products led to less acceptance compared to other products. This suggested that the theory that exposure to information or more knowledge leads to more trust and ultimate acceptance of the technology, particularly biotechnology, does not always hold, with the level of education playing a major role.

Another gender disparity in preferences for novel foods has been observed among females with children. On one hand, females with children (especially those with more education) are more likely to accept nutritious food products, especially if perceived to be of benefit to their children (Smith et al. 2003). On the other hand, Moerbeek and Casimir (2005), noted that females with children also tend to be cautious and reluctant towards food innovations when buying food for their children, as noted by Moerbeek and Casimir (2005).

Time constraint is another factor that can possibly affect the acceptance of a novel food product. Although males have also a role to play on food availability, females play a bigger role in making consumption decisions and in the preparation of food in each household. Additionally, females largely influence the diets that household members consume. While sensory attributes such as taste, smell and appearance may have no apparent gender differences in the case of staple foods, the end-use characteristics such as flour quality and ease of cooking may be gender-specific. Although there has been a campaign of gender equality in more recent years, that has promoted the sharing of gender roles and tasks, females still plan, handle and make food consumption decisions in Africa, like elsewhere. A bean variety for instance that takes longer to cook may not be preferred by females despite its perceived nutritional benefits or good taste across gender, especially if time and energy are important constraints. In the Kenyan study, for example, Otieno et al. (2011) found that the ‘ease’ of cooking was a significant factor explaining the non-adoption of pigeon peas in Kenya despite the perceived nutritional benefits. Thus, even if males may be the more accepting group insofar as BFC are concerned, as long as factors affecting food preparations are not convenient for females, the BFC will less likely be adopted.

4.3.2.2 Gender differences in food preferences based on different tastes and preferences

Gender differences in the acceptance of BFC can also be as a result of males and females having different tastes and preferences for BFC. Although staple foods are consumed across gender as indicated earlier, the addition of micronutrients (vitamins and minerals) through biofortification may affect the sensory quality and pleasantness of food made from BFC. These may, in turn, be linked to the differences in response by gender due to sex-related biological factors. Differences have been observed in gender responses towards the sensory appeal of food in the empirical literature. It has been concluded for example that more males are classified as colour blind than females, implying that females are better at discriminating among the colours than males.

Further, females have also shown to be more responsive or reactive to visual stimuli such as colour compared to males (Chao et al. 2017). With reference to the current study, the crop varieties that have been biofortified with Vitamin A, e.g., maize and cassava in Zambia and Nigeria are likely to have orange kernels and orange-fleshed tubers, respectively. Given a stronger preference for crop varieties with white products by consumers in sub-Saharan Africa, it is unclear whether gender differences will be observed with such changes. As noted by Hoppu et. al. (2018), the colour of food is important for flavour perception and the ultimate food choice, therefore gender difference in acceptance of BFC is likely to occur, should the colour of the food become a significant factor in acceptance.

Females are also considered to have superior senses of smell and taste, hence they are more likely to have a better odour memory in general, and a higher level of acuity for certain substances (Andersson et al. 2009). They are also usually classified as supertasters than males as they've been found to be significantly better than males at identifying bitter tastes and also in intensity valuations of bitter, sour and sweet tastes (Wenzel 2005). Due to the likely change in some of the intrinsic properties of the staple food crops (e.g., colour, taste, cooking quality), such differences may lead to different reactions across gender.

Males and females may also differ in the way they value a health attribute in food choice. The relative importance of the health motive in food choices has often been considered to be at odds with the taste, cost and convenient aspect of the food in general. In their food choices, consumers have often classified taste as the most important motive (Kearney et al. 2000; Eertmans et al. 2005; Honkanen and Frewer 2009). Chamber et al. (2008), and Connors et al. (2001) in their respective studies, for example, found that adult consumers perceived a healthier alternative diet as unacceptable in taste, costs more or preparation time can be longer. According to Holdago et al. (2000), being male and having low educational attainment increases the probability of resisting the change of eating habits towards a healthier one. Thus, an unacceptable taste of food made from BFC may just be a reason for not accepting these nutritious crop varieties. On the other hand, researchers have also found that consumers, especially adults can still balance conflicting motivations of taste and health in a given period, e.g., they can balance the unhealthy eating choices made during the day, with healthier food in the evening, although nothing was said whether gender differences existed or not (Connors et al. 2001).

4.3.2.3 Different responses to promotional tools

New products or products with new attributes such as BFC require extending promotional activities to consumers for biofortification to succeed in ameliorating the problem of micronutrient deficiencies in sub-Saharan Africa. Research findings suggest that males and females may differ in their response to the promotional activities of products. According to Meyers-Levy (1989), males and females often will differ in how they process the same promotion information given to them. Thus, the judgement and decisions to be made about the product in question may also differ.

In a synthesis of psychological, marketing and biomedical literature regarding sources of gender differences, Meyers-Levy and Loken (2015) conclude that, compared to males, females are more likely to respond to new information cautiously and are also more likely to be more responsive if the information is presented in the negative frame. Additionally, the authors conclude that the level of message comprehension may differ between males and females, with males preferring simpler information as they are selective processors. On the contrary, a lot of product information may be required for female consumers who are considered to be comprehensive processors. Supporting this argument, Putrevu (2004) also asserts that males responded more easily to advertisements focusing on product attributes. On the contrary, females favoured adverts that were more complex and concentrated on the product category other than product attributes. The product brand has also shown to evoke gender differences in consumption behaviour. Grohmann (2009) noted that males and females prefer brands portraying personalities that speak to their own gender identity.

4.3.3 Research questions

In light of the above potential differences between males and females in consumption behaviour, the third objective of this thesis investigates whether there are gender differences in the acceptance of biofortified food crops. We attempt to answer the following questions and hypotheses in the consumer acceptance of BFC in three sub-Saharan African countries, i.e., Nigeria, Rwanda, and Zambia. There are two related questions to be answered namely:

- Are consistent gender differences in the hedonic ratings (liking or disliking) of attributes and willingness to pay outcomes for biofortified food products?

- Do the characteristics determining these outcomes matter differently between males and females?

4.3.4 Hypotheses

The following hypotheses were framed to answer the research questions based on the theoretical and conceptual frameworks.

H1: There are no gender differences in the acceptance of BFC based on hedonic scores and WTP for BFC.

Given that biofortification targeted staple food crops that are consumed across gender in respective sub-Saharan African countries, we expect that gender differences in consumer behaviour should be non-existent or minimal. However, with the probable change in the intrinsic attributes (e.g., sensory appeal, cooking and flour quality) of staple food crops, and based on the evident gender differences in literature on sensory acuity, food choices, availability, and food preparation, there is a possibility that gender may be an important factor in consumer acceptance of biofortified foods.

H2: *Gender differences if any are explained by differences in explanatory variables.*

Literature has highlighted gender differences in the factors that affect consumer access and behaviour towards novel foods such as biofortified food products. An unequal endowment of resources such as education, income, wealth status, knowledge and perception about nutritious food, gender roles or chores such as childcare, among others, as well as intrinsic attributes of the novel foods could lead to different outcomes in the acceptance of biofortified food products. As noted in the literature, for example, males usually are classified to be in the higher education, wealth and income category compared to females, and with these being drivers of consumer acceptance of novel food, the effect of these variables may be different for males and females.

We specifically expected that interaction of gender and social-economic status variables (asset, education) to have a positive effect on acceptance in favour of males. It is also expected that having children under the age of 5 years would have a positive effect on acceptance as parents might be more interested to feed their children with nutritious varieties. Given that other individuals' payoffs are more important to females than they are to males (Meyers-Levy and Loken 2015), this may imply that females with children are more likely to be concerned about children's welfare than males of the same status. The opposite may also be true, as females may be cautious of feeding their children novel foods as suggested by Moerbeek and Casimir (2005).

The age of the consumer may either have a positive or negative effect on acceptance. On one hand, acceptance can be negative with age as older consumers are less likely to accept the new biofortification technology compared to the younger consumers who may be more accepting of the same technology. The converse can also be true in that the nutritional value of the products may appeal more to older consumers than younger ones as attributes such as the taste of the food may override the importance of the nutritional aspect of the BFC products among younger consumers. Prior knowledge about micronutrients and their sources is likely to negatively affect acceptance of BFC in that, consumers may have knowledge of other inexpensive substitute sources of micronutrients, thus less willing to accept BFC based on the nutritional value alone. The opposite also can be true if consumers consider more affordable the BFC products when compared to the other sources of micronutrients such as fortified foods and pharmaceutical supplementation. Like any new technology, biofortified food choices are expected to be made in the expected utility framework, where the element of risk cannot be overlooked. Females are considered more risk-averse than males as discussed in literature, thus less likely to accept novel foods.

H3: Males and females will not respond the same way to nutritional campaign messages/tools

While product and personal characteristics may be important in acceptance, it is expected that consumers with different levels of nutritional information will also tend to differ in the way they value the biofortified crops. Consumers provided with nutritional information, on one hand, may attach greater importance to the knowledge about the health value of more nutritious crop varieties. On the other hand, consumers with no nutrition information may accept the novel food only due to their own hedonic satisfaction.

Research findings suggest that customer responses to nutrition information may be different based on gender. Different perceptions of health foods by gender have been reported in the literature, suggesting that females more than males usually respond favourably to the health messages. Further, with regards to response to message framing, ambigous effects are reported in literature. One one hand, assuming that accepting BFC is a risk venture, the prospect theory (Kahneman and Tversky, 1981) seem to suggest that with females being risk-averse and males risk-takers, females will respond more favorably when promotional messages are framed as gains, while males will respond more when the messages are framed as losses. On the other hand in the pschological literature (Meyers-

Levy and Loken, 2015), females are expected to increased acceptance of BFC in the "loss framed messages".

4.3.5 Empirical analysis

In the analysis of gender differences in the acceptance of BFC from both hedonic ratings and WTP for BFC, we assume that an individual i has an unobserved true acceptance/WTP for a BFC good that depends on the attributes of the BFC, gender and the sociodemographic variables as shown in equation (4.1).

$$Acceptance_i\ (Hedonic\ score/WTP) = f\left(x_i\beta, \beta_g G_i, G_i(x_i\beta) + \varepsilon_i\right) \quad (4.1)$$

Where:

Acceptance/ WTP_i is the unobserved level of acceptance/WTP for the i^{th} respondent

x_i denotes the attributes of BFC considered by respondent i as well as socio-demographics of respondent i

G_i represents a dummy variable taking on the value of 1 if the i^{th} respondent is male, and 0 otherwise

$G_i(x_i\beta)$ is the interaction term of gender with each of the x_i

ε_i is the error term

In the following two chapters, gender differences are explored using hedonic preferences and willingness to pay for BFC for three sub-Saharan African countries. Specifically, Nigeria, Rwanda, and Zambia data were used, as it is in these countries where biofortified food crops will be first introduced. The datasets were collected in each country using virtually identical survey instruments. As location or culture is one of the determinants of behaviour towards novel food, this study provided a unique opportunity to conduct a cross-country comparative analysis of consumers' attitudes and behaviour towards biofortified staple food crops in sub-Saharan Africa. Additionally, the country-specific findings provided an opportunity to test the robustness of the results in three countries and cultures, thereby, providing an increased understanding of what product and personal characteristics contributed to gender differences in the acceptance of biofortified food crops in sub-Saharan Africa. It further provided an increased understanding of how males and females responded to various biofortified product promotion tools that were employed in each of these countries.

Specifically, the question of whether gender differences existed in hedonic preferences and WTP for respective biofortified food crops in each country is addressed. We later explore whether the factors determining hedonic preferences and WTP for BFC are different for males and females. In particular, we determine the extent to which gender differences in hedonic preferences and WTP for BFC vary with socio-economic characteristics and various promotional tools used in respective countries. As shown in the previous section, prior empirical work and theory suggest that males and females may differ in their attitudes towards novel food based on their demographic characteristics such as education, having young children, socioeconomic status (Moerbeek and Casimir 2005; Smith et al. 2003; Holgado et al. 2000) and on how they respond to nutritional promotions (Meyers-Levy and Sternthal 1991; Grohmann 2009). For example, males and females tend to place different utility values on the nutrition aspect of food (Moerbeek and Casimir 2005). They will also respond differently to the way the nutrition message was framed (Meyers-Levy and Sternthal 1991; Putrevu 2004; Meyers-Levy and Loken 2015) and on the brand that matches their gender identity (Grohmann 2009). Additionally, males and females' attitudes towards novel food may differ based on different sensory acuity towards foods (Andersson et al. 2009; Wenzel 2005).

CHAPTER 5: EXPLORING GENDER DIFFERENCES IN HEDONIC PREFERENCES FOR BIOFORTIFIED FOOD CROPS IN NIGERIA, RWANDA, AND ZAMBIA

5.1 Introduction

This chapter examines gender differences in the hedonic preferences for biofortified food crops in Nigeria, Rwanda, and Zambia. For each country, the effects of personal characteristics, product attributes, and promotion tools on males' and females' hedonic preferences for biofortified food crops were examined. First, the characteristics of males and females are compared. Second, the mean-differences and the distribution of responses are examined by variety and gender. Lastly, the determinants of hedonic preferences for the BFC are examined by gender. Each country study ends with a summary and conclusion of whether or not, gender differences were prevalent in the hedonic preferences for respective BFC.

The study used HarvestPlus data, comprising of hedonic ratings of food made from biofortified staple food crops in respective countries. The micronutrient deficiency problem considered in Zambia was vitamin A deficiency, which affected 54 percent of preschool children (FAO 2009). The crop targeted for biofortification was maize- the country's main staple food crop. In Rwanda, the micronutrient considered was iron. There were approximately 30 percent of the children below 5 years and 17 percent of females of reproductive age (DHS 2010) affected by micronutrient deficiencies in this country. Of these, 50 percent was due to iron deficiency (De Benoist et al. 2008). The crop targeted for iron biofortification was beans, a staple food crop among Rwandan households (Mulambu et al. 2017).

In Nigeria, the micronutrient considered was also Vitamin A, where 30 percent of children under the age of 5 years were deficient in vitamin A (Maziya-Dixon et al. 2006). Cassava was the crop used for biofortification, a staple food for the southern region of Nigeria. The alleviation of micronutrient deficiency is dependent on individuals consuming the biofortified food products constantly over a lengthy period of time (Birol et al. 2015), and females typically making decisions on what is consumed. It is, therefore, critical to determine whether there are gender differences in the attitudes of consumers towards biofortified food products. In what follows, gender differences in hedonic preferences are determined by each country.

5.2 Hedonic preferences by gender for Vitamin A biofortified orange maize in Zambia

This section presents the results of gender differences in sensory preferences for a new maize variety that has been biofortified with vitamin A. Gender differences were explored in the sensory preferences for a maize variety biofortified with Vitamin A in Zambia, referred to as "orange maize" in this study, based on its orange coloured kernels. The biofortified orange maize was compared to the conventional white maize variety, consumed by the majority of Zambians, and to the yellow maize variety, also available on the Zambian market at a discount.

Yellow maize, in particular, was included as one of the standards of comparison to orange maize to determine whether the negative perceptions associated with yellow maize can also be found in the new biofortified maize variety, which is likely to have orange kernels. Historically, yellow maize was introduced in Zambia as food aid from the United States government during hunger times in the 1980s, and it was believed to be exclusively for cattle feeding, and not for human consumption in the country of origin. Since then, yellow maize has been perceived and stigmatised as food for bad times when citizens had to eat cattle food to survive. Additionally, yellow maize was found repugnant by a majority of consumers because of the unpleasant taste and aroma (Meenakshi et al. 2012).

5.2.1 Data description and sampling

A total of 643 respondents took part in the sensory evaluation either at a central location or in the respondent's own home. Of these, 290 respondents took the sensory testing exercise at home, while 335 respondents did the same test at a central location. The survey was done in the Central and Southern provinces of Zambia, on account of having the highest production and consumption rates of maize, as well as the highest poverty levels in the country based on the 2010 census. The descriptions of sampling and sensory procedures can be found in Meenakshi (2012), and are summarised per study location in the following sections.

Central location

The central location is a central venue where consumers are called and asked to test the already prepared food samples, under a controlled environment (Tomlins et al. 2007). In addition to being a relatively less expensive method for conducting surveys (Meenakshi et al. 2012), it is the most suitable venue when one wants to assess how a product might be accepted in the marketplace (Mason and Nottingham 2002). Two districts were randomly selected for this study site, i.e., one in Southern province, and another in Central province namely, Monze and Chibombo, respectively. For each district, 2 villages were selected. A day before the survey, messages were sent to the selected villages, asking members to come and participate in the surveys at an agricultural training centre. Participants who were believed to be farmers, aged 18 years and above, were recruited and asked to take part in the studies. Each participant was allocated to one of the treatment groups, i.e., one with nutrition information about the new orange maize variety, and the other without nutrition information. Nutrition information was received through audio players.

Sensory evaluations were done on a maize product known as "*nsima"* (thick maize meal porridge) made from either orange maize, white maize or yellow maize flours. *Nsima* is the most common form of maize grain utilisation in Zambia. All participants regardless of treatment were provided with samples of *nsima* made from each of the three maize varieties (i.e., the new biofortified orange maize, conventional white maize, and yellow maize), in random order. Each subject was asked to look, feel, smell and taste each *nsima* sample, and thereafter rate the extent to which they liked or disliked the taste, texture in the mouth, aroma, appearance and the overall *nsima* product. The possible responses ranged from 1 ("dislike very much") to 5 ("like very much").

Home testing

In home-use testing, consumers are given the food products to prepare for themselves with their recipes. In this way, consumers get to use the product in the real-life setting of their homes. It is argued that this method produces more valid evaluations of product assessments, and product satisfaction, given that participants have all the time to experience the product, and evaluate it more extensively (see Meenakshi *et al* 2012; Tomlins *et al*. 2007). The sample selection for home use testers was slightly different from the one used for central location testers. In each province, a random selection of one district was done, and a second nearest district was selected for logistics purposes. Three agricultural blocks and 8 camps from the blocks were randomly selected in each of the districts. Thus, Chibombo and Kapirimposhi districts in the Central province; and Choma, and Kalomo districts in Southern province were selected. At the camp level, 10 households were selected in each camp. Households were further allocated randomly to one of the two nutrition information treatment groups, and to a control group that did not receive nutrition information.

The nutrition information treatment (provided before sensory evaluations) assessed the mode of delivery of information in two main ways, i.e., using a simulated radio message, and using the community leader who verbally gave the nutrition message to the participants. The community leader informed selected households about the new nutritious orange maize variety, three times during the experimental period, at three intervals, i.e., just before the enumerators delivered each of the three the maize flour samples.

The two methods are the common media in Zambia used to convey agricultural and health information among rural households (Meenakshi et al. 2012). Community leaders used were agricultural extension officers who were usually accessible, and lived within communities. While the poor may not own a radio, access to information is readily available from just one community member who owned a radio, as information is also spread through the word of mouth. Respondents in the "radio" medium treatment were given audio players for the 10-day experimental period. Monitoring the length and number of times respondents listened to the audio message was therefore not done. Households were given three maize flour samples each of which was made from one of the three maize varieties. Flour samples were given one at a time, in three-day intervals, for 10 days. At each three-day interval, sensory evaluations for appearance, taste, aroma, and texture in the mouth were done per sample tasted. In the analysis, the results of the two nutrition treatments were combined due to high levels of correlation.

Sample characteristics

First, we determined whether the socio-economic characteristics of the participants from the two research locations were similar. Results indicate that in these two groups of participants there were significant statistical variations in socio-economic characteristics, suggesting that the two groups were not similar (see Appendix 5.1). Therefore, separate statistical analyses for each study site were carried out.

The personal characteristics are shown in Table 5.1 by gender and study location. Males made up a larger proportion of the sample in both study locations (58 % at home and 59% at a central location). Significant gender differences were observed in most characteristics at both study locations. At a central location study site, male respondents were older, owned more assets, accessed and cultivated more land in the year before the study. Males were also older, they came from relatively larger households, and the proportion of married males was larger than that of married females. However, there were no statistical gender differences in the amount of schooling, number of people sharing meals and the number of children below the age of five years.

All the personal characteristics differed by gender for respondents who were surveyed in their own homes, except for the levels of wealth. Females were older than males by at least 4 years. On the contrary, males had more schooling, more children under the age of 5 years, more land area owned and planted. males also came from larger households with more members sharing meals, and married males were more compared to married females.

Table 5.1: Consumer characteristics by gender and study location in Zambia.

Variables	Central location						Home					
	All	F	M	Diff	SD	p-value	All	F	M	Diff	SD	p-value
Age	40.28	37.67	42.11	-4.44	14.07	0.00	45.58	48.15	43.73	4.42	15.89	0.02
Married	0.82	0.73	0.88	-0.14	0.39	0.00	0.77	0.57	0.92	-0.36	0.42	0.00
Education	8.22	7.42	8.77	-1.35	2.78	0.00	6.74	6.15	7.09	-0.95	2.55	0.00
Household Size	8.51	8.75	8.34	0.42	4.81	0.43	7.04	6.57	7.39	-0.83	4.1	0.09
Meal share	7.84	7.69	7.95	-0.26	3.55	0.50	6.46	6.05	6.75	-0.70	2.83	0.04
Asset index	0.48	0.01	0.8	-0.79	1.53	0.00	-0.58	-0.72	-0.48	-0.24	1.34	0.13
Area planted	2.95	2.39	3.32	-0.93	2.88	0.00	2.16	1.67	2.51	-0.83	1.94	0.00
Land owned	10.96	7.41	13.26	-5.85	18.7	0.00	6.76	4.25	8.59	-4.34	8.48	0.00
No. of Children	1.88	1.84	1.91	-0.06	1.40	0.68	1.51	1.02	1.86	-0.84	1.38	0.00
N	353	145	208				290	122	168			

Note: Mean differences are males' subtracted from females' means

5.2.2 Gender differences in hedonic ratings of nsima by maize variety, gender and study location

In this section, we determined whether the mean-scores of the five sensory attributes for the three maize varieties showed statistical gender differences. Specifically, a two-sample T-test was used to determine whether males and females differed in their taste, aroma, texture in the mouth, appearance and overall liking of *nsima* made from three different maize varieties at each of the two study locations i.e., central place and home.

Table 5.2 presents the mean sensory liking ratings of *nsima*, by variety, gender and study location, and associated p-values. At both study sites, the results generally indicate no significant gender differences in the hedonic attributes. However, at a central location study site, weakly significant gender differences ($p < 0.1$) were observed in yellow maize taste, white maize aroma, and the orange maize nsima's overall liking. In each of these attributes, males submitted higher scores. These results are not a surprise because *nsima* made from maize is a staple food consumed across gender. They are not conclusive, however, as they do not take into account variables that influence sensory preferences such as nutrition information, and consumers' characteristics.

Table 5.2: Mean hedonic scores of *nsima* by variety, gender and study location in Zambia

		Central Testing (N=353)				Home testing (N=290)			
Attribute	Variety	Female	male	SD	(p-value)	female	male	SD	(p-value)
Appearance	White	4.43	4.37	0.86	0.46	4.66	4.70	0.64	0.67
	Yellow	3.88	3.75	1.19	0.28	4.44	4.43	0.87	0.89
	Orange	4.41	4.47	0.93	0.53	4.70	4.75	0.53	0.48
Taste	White	4.14	4.16	1.02	0.85	4.49	4.49	0.86	0.98
	Yellow	3.43	3.65	**1.27**	**0.10**	4.33	4.37	0.97	0.72
	Orange	4.29	4.35	0.96	0.59	4.70	4.76	0.67	0.41
Texture	White	4.10	4.13	1.05	0.80	4.49	4.52	0.75	0.77
	Yellow	3.50	3.57	1.24	0.60	4.28	4.29	1.00	0.95
	Orange	4.15	4.23	0.98	0.46	4.65	4.61	0.70	0.63
Aroma	White	4.02	4.21	**1.06**	**0.10**	4.47	4.43	0.88	0.71
	Yellow	3.30	3.44	1.42	0.36	4.01	3.92	1.27	0.55
	Orange	4.26	4.38	0.99	0.23	4.70	4.70	0.71	0.98
Overall liking	White	4.21	4.27	0.97	0.57	4.48	4.56	0.74	0.34
	Yellow	3.46	3.62	1.22	0.21	4.23	4.10	1.04	0.30
	Orange	4.26	4.43	**0.91**	**0.07**	4.63	4.75	0.63	0.11

Determining respondents' preferences all sensory attributes of maize by gender

In the following section, using ordinal logistic regression, we examined whether there were significant differences in the preferences for all the attributes of maize, by gender. To begin with, we estimated short separate models using each of the five sensory attributes as dependent variables, with crop variety type as an independent variable in all the models. The purpose was to obtain an insight into the overall preferences of respondents in the three maize varieties and possible gender disparities. Table 5.3, lists the estimates of this model for central location tasters. For space, the threshold estimates were not included.

As shown in models (1), (3), (5), (7) and (9), for its taste and aroma, orange maize was the most preferred variety ($p < 0.05$). Additionally, there were no significant differences in the appearance, and texture liking scores of nsima made from orange maize compared to that made from the conventional white maize variety. On the contrary, yellow maize was disliked in all the sensory attributes. In the second model, the gender variable (coded 1 if male, 0 otherwise) was introduced, and results are displayed in models (2), (4), (6), (8) and (10). Results indicate no gender differences in all the sensory attributes at a 95 percent confidence level. Table 5.4 shows estimates of the same model for home use tasters. With the exception of the appearance attribute, the sensory scores for all the attributes for orange maize were significantly higher at $p<0.05$ compared to that of white maize, similar to the results found at the central location study site. The findings also indicate no gender differences in all hedonic attributes.

Table 5.3: Hedonic factors affecting the liking of nsima by maize and gender: Central location

	(1) overall	(2) overall	(3) taste	(4) taste	(5) appear	(6) appear	(7) texture	(8) texture	(9) aroma	(10) aroma
Orange maize variety	0.242	0.174	0.384***	0.320	0.290*	0.221	0.138	0.057	0.412***	0.475**
	(0.148)	(0.231)	(0.144)	(0.224)	(0.155)	(0.242)	(0.144)	(0.226)	(0.145)	(0.227)
Yellow variety	-1.256***	-1.312***	-0.931***	-1.120***	-1.138***	-0.997***	-1.027***	-1.058***	-1.083***	-1.025***
	(0.148)	(0.226)	(0.142)	(0.219)	(0.150)	(0.230)	(0.145)	(0.225)	(0.145)	(0.224)
Gender		0.120		0.016		-0.070		0.004		0.244
		(0.216)		(0.202)		(0.226)		(0.222)		(0.209)
Gender x orange maize		0.111		0.109		0.118		0.138		-0.106
		(0.300)		(0.291)		(0.316)		(0.294)		(0.295)
Gender x yellow maize		0.092		0.321		-0.239		0.051		-0.100
		(0.288)		(0.281)		(0.295)		(0.288)		(0.286)
Obs.	1058	1058	1059	1059	1059	1059	1059	1059	1059	1059

Standard errors are in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

Table 5.4: Hedonic factors affecting the liking of nsima by maize and gender -Home

Variables:	(1) overall	(2) overall	(3) taste	(4) taste	(5) appear	(6) appear	(7) texture	(8) texture	(9) aroma	(10) aroma
Orange maize variety	0.713***	0.544*	0.929***	0.752**	0.142	0.133	0.439**	0.464	0.935***	0.714**
	(0.196)	(0.287)	(0.209)	(0.303)	(0.215)	(0.323)	(0.185)	(0.287)	(0.204)	(0.304)
Yellow variety	-0.856***	-0.444*	-0.370**	-0.193	-0.900***	-0.624**	-0.468***	-0.308	-0.959***	-0.922***
	(0.175)	(0.269)	(0.176)	(0.274)	(0.203)	(0.311)	(0.175)	(0.276)	(0.176)	(0.271)
Gender		0.212		0.101		0.156		-0.014		-0.157
		(0.281)		(0.278)		(0.350)		(0.278)		(0.285)
Gender x orange maize		0.334		0.332		0.013		-0.042		0.395
		(0.391)		(0.414)		(0.433)		(0.374)		(0.406)
Gender x yellow maize		-0.701**		-0.298		-0.468		-0.263		-0.064
		(0.351)		(0.357)		(0.406)		(0.355)		(0.348)
	(0.268)	(0.272)	(0.265)	(0.264)	(0.468)	(0.468)	(0.262)	(0.261)	(0.293)	(0.293)
Obs.	870	870	870	870	870	870	870	870	870	870

Standard errors are in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

5.2.3 Factors influencing the sensory preferences for nsima by gender and study location

Factors that predict sensory acceptance including gender were explored. Given high positive correlations among hedonic preference measures (see Appendix 5.2), Perez-Elortondo et al. (2001) suggest that the overall sensory rating be used as a food acceptance measure. Thus, the overall liking score of nsima made from three maize varieties was used as a dependent variable. It was measured on a 5-point Likert scale, coded as 1= dislike it very much; 2=dislike; 3= neutral; 4=like; and 5= like it very much.

Figure 5.1 shows the distribution of the overall liking scores of nsima by gender, variety, and study location evaluated on a 5-point Likert scale. As can be seen, the distribution of overall liking scores across all the three varieties is highly skewed towards the two last categories (the second-highest, and the highest level of liking). Focusing on the biofortified orange maize, the results indicate that at both study sites, a greater percentage of males at both research locations stated that they either liked or liked very much, food products made from orange maize. The pattern was similar for females at both study sites, although, the proportions were generally lower than those of males. Furthermore, the percentage of males and females who either liked or liked *nsima* very much when made from orange maize flour was higher than those observed in the *nsima* made from white maize and yellow maize varieties.

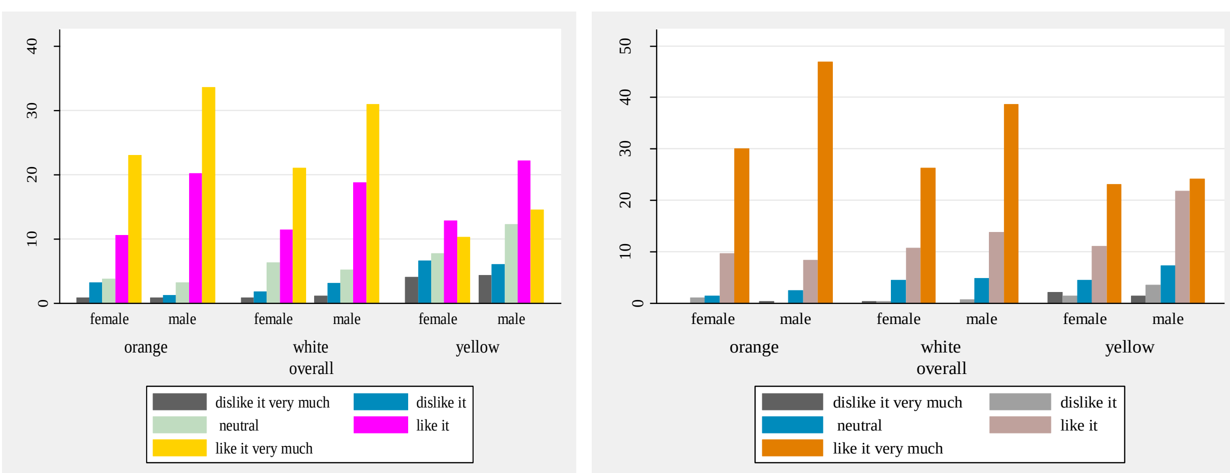


Figure 5.1: Distribution of overall liking scores by gender, variety and study location

Variable descriptions

Separate regression models were estimated for each study location. The independent variables as shown in Table 5.5 below included; gender measured 1 if male, 0 otherwise (a key independent variable under consideration). The study also controlled for other factors that affect consumer acceptance earlier identified in the literature. These include age of the respondent in years, age2, the respondent's socio-economic status such as their education level (number of years of formal education) and wealth level (the first principle component of productive and household assets), having children below 5 years equal to 1, 0 otherwise; and product-related features, as measured by variety type, and having received nutrition information for the biofortified orange maize equal to 1, 0 otherwise.

Table 5.5: Variable description

Variable	Definition
Overall liking	1= dislike very much 2=dislike 3 neutral 4 like 5= like it very much.
Education	Years of educational attainment
Age	The age of the respondent in years
Age 2	Square of age
Asset index	Average household and productive assets of the first principle component
Children	Coded 1 if the respondent has children of 5 years and below, 0 otherwise
Gender	1 if male, 0 otherwise
Variety	1 if variety used to prepare *nsima* was biofortified orange maize
	1 if variety used to prepare *nsima* was the conventional white maize
	1 if variety used to prepare *nsima* was yellow maize
Information	0 if the respondent received no nutrition information before the experiment
scenario	1 if the respondent received nutrition information either through radio or community leader

Testing the distribution assumptions of the ordered logit model

As hedonic attributes are often ranked on a Likert scale, showing how much a respondent likes or dislikes a given attribute, ordered regression models such as the ordered logit and ordered probit models are often applied in econometric analysis.

Empirical model

The ordered logit model analyses data with a dependent variable of J ordered categories, where the probability associated with each category j can be denoted by π_i with its sum equal to 1. The cumulative logit model is formed from the logits of cumulative probabilities. The probability of a response to be less than or equal to an arbitrary category j is given by

$$P(y \geq j/x) = \left(\frac{P(Y \geq j/x)}{P(Y < j/x)}\right) \tag{5.1}$$

The dependent variable Y is composed of J ordinal categories where one category is the reference category, and there are J-1 cut-off points estimated in this way, with estimations providing information for every consecutive category about the cumulative probability (O'Connell, 2006). The probability is calculated as the sum of the category probabilities as shown below:

$$(Y \leq j/x) = \pi_1(x) + \pi_2(x) + \cdots + \pi_j(x) \qquad j = 1, \ldots, J \tag{5.2}$$

The cumulative logit model derived from the logit link function according to Long and Cheng (2004) is as shown below:

$$logit[(Y \leq j/x)] = \log \frac{P(Y \leq j/x)}{1 - P(Y \leq j/x)} \quad \text{= cumulative odds for J dependent variable}$$

$$= \log \left[\frac{\pi_1(x) + \pi_2(x) + \cdots + \pi_j(x)}{\pi_{j+1}(x) + \cdots + \pi_j(x)}\right] \; j = 1, \ldots, J \tag{5.3}$$

These models, however, have strong assumptions of homoscedasticity and parallel regression which if not upheld provide estimates that are biased and inefficient (Williams 2009). Specifically, the consistency of the ordered logit model requires that the residuals are homoscedastic and the proportions or parallel line assumptions hold (Long and Freese 2006; Williams 2006). Additionally, group comparisons in a study as this one require that the two groups have equal variances (Williams 2009; Allison 1999). The parallel line assumption, on the other hand, requires that parameters should not change with the dependent variable's categories, as well as cut-off points (Brant, 1990).

Both Williams (2009) and Allison (1999) caution about the use of logit models to compare coefficients across groups when there are group differences in the error term, as doing so can lead to erroneous conclusions. The violated assumptions lead to both biased standard errors and biased estimates. The two authors argued that “naïve” comparisons can be made, implying that there is a high possibility that insignificant differences can appear significant while the opposite can also be true. Thus, the conclusion of group differences can be made where there were none or disregarded where there were group differences. Long and Freese (2006) recommend that when these assumptions are violated, an alternative model should be considered to get consistent results. Following Williams (2010), we model the following equations to account for possible heteroscedasticity.

$$y_i^* = \gamma_0 + \gamma_1 x_{i1} +, \dots \gamma_k x_{ik} + \sigma\varepsilon_i \quad (5.4)$$

Where:

y_i^* is the latent variable indicating how much the respondent *i* like the overall attributes of *nsima*

X_s are the explanatory variables

γ_s are parameters associated with each explanatory variables

ε_i is the error term assumed to have either a logistic distribution $\left(\frac{\pi^2}{3}\right)$ or a normal distribution $(0, 1)$

σ is a parameter that allows an adjustment to the variance

Given that the outcome variable y* is latent, the γ_s are not estimated, instead, the βs are estimated whose relationship to γ is as shown in the following equation:

$$\beta_k = \frac{\gamma_k}{\sigma} \forall = 1, \dots K \quad (5.5)$$

When σ is the same for all observations, the error term is considered to be homoscedastic. Heteroscedasticity, on the other hand, will be present when σ differs across each observation. The heterogeneous choice model relaxes the homoscedastic assumption by estimating both the choice equation (factors explaining the outcome variable) and the variance equation (factors explaining the residual variance) concurrently (Williams 2009).

The choice equation can be written as:

$$y_i^* = \sum_k x_{ik}\beta + \varepsilon_i \qquad (5.6)$$

Where:

y_i^* is the outcome variable of interest such overall liking

X is a column of vectors (explanatory variables) that are determinants of the outcome

β are coefficients associated with each explanatory variable

The variance equation, on the other hand, is written as follows:

$$\sigma_i = e^{\left(\sum_j z_{ij}\gamma\right)} \qquad (5.7)$$

According to Williams (2009), the variance equation shows how the latent variable of interest is scaled for each observation, reflecting variations in the residuals which, if left unaccounted for, would lead to heteroscedasticity.

Parallel line and homoscedastic assumption results

A Brant test (Brant 1990) was used to perform the parallel line hypothesis test in each dataset. Results from the central location dataset revealed that some of the explanatory variables in the model do not meet the parallel line assumption. Specifically, the nutrition information variable yielded a $X^2_{df\,(3)}$ =9.80, p = 0.02 and gender $X^2_{df\,(3)}$ =7.11, p= 0.068 failed to meet the parallel lines assumption at 10 percent for individuals who did the experiment at a central location.

However, this was not the case for individuals who did the experiment at home, as none of the covariates were significant at 10% and below (see Appendix 5.3).

In Table 5.6, we compare the results of the homoscedastic logit to the heterogeneous choice model. According to Williams (2009), the heterogeneous choice model will identify residual variations across groups if any, and carry out more reliable comparisons even in its presence. A user-written Stata command "oglm" by William (2006) was used to estimate a heterogeneous choice model which also relaxes the parallel line assumption. Results for the central location study site show that the variance equation, identified as insigma in Table 5.6(2), indicates that the variables for nutrition information, gender, age and having children below the age of five years failed to uphold the homoscedastic assumption. These variables were only significant in the variance equation, and not in the choice equation.

The negative standard deviation on the gender variable suggests that males were less variable than females in their sensory preferences for *nsima*, while individuals with children less than five years were more variable in acceptance than those without. Both results seem plausible in that there could be other reasons that females and individuals with children below five years considered in sensory ratings that were not captured by the covariates considered. For example, females being food handlers, some of them may not only have considered the sensory attributes but also had in mind other attributes such as the cooking quality of maize meal.

A positive standard deviation for a dummy variable for individuals with children suggests a higher residual variability among individuals with children than those without. This was not a surprise either. As noted earlier, perceptions towards a novel food by individuals with children may either be positive or negative. Some may have considered the riskiness of feeding the new and untested maize variety to their younger children, while others would have liked it more given than it was nutritious for them and their children. According to Smith et al. (2003), females with children were more likely to accept nutritious food products, especially if perceived to be of benefit to their children. On the other hand, Moerbeek and Casimir (2005), noted that females with children also tend to be cautious and reluctant towards food innovations when buying food for their children. Both of these views could have been at play, thus causing variability in the residuals.

Residual variability observed among the older respondents is also supported by the literature. On one hand, the older respondents were less likely to embrace the new technology in the form of the new maize variety. On the other hand, the older respondents were more likely to accept the nutritious food product, regardless of its sensory appeal (Connors et al. 2001). Variability was also observed among individuals who did not receive nutrition information at a central location study site. One possible explanation for this residual variability among the respondents at a central location could be as a result of less exposure (less than an hour) to the new biofortified maize variety. It could be that some respondents without nutrition information were unsure of their preferences for the new maize variety. On the other hand, those with nutrition information would easily make a better judgment, based on this additional nutrition information on the new variety. On the contrary, this behaviour was not observed among home-use tasters who had the product for a few days before indicating their preferences.

Concerning the dataset of respondents for a home-based study site, the homoscedastic test failed with respect to the dummy variable representing whether one had children under the age of five years or not (Table 5.6 (4)). Contrary to the observation at the central location study site, this variable was negative, suggesting that the variability of hedonic scores was higher among the individuals without children (as indicated by a negative standard deviation). As stated earlier, this variable can have an ambiguous relationship with food preferences. A negative relationship, in this case, suggested that respondents with younger children were more certain about their preferences than those without, probably due to the perceived benefits the nutritious maize variety would have to their children. On the other hand, variability was higher among respondents without younger children as some may have had a positive attitude towards the nutritious varieties for themselves, even when they did not have younger children who would benefit. Yet, others may have considered other attributes to be more important than the nutrition value of the biofortified maize.

A comparison of the homoscedastic model with the heteroscedastic was made using a likelihood ratio test for both study locations. The model fit significantly improved with the addition of the four heteroscedastic parameters (LR chi2(4) = 27.2, p=0.00)) in favour of the heterogeneous choice model for the central location study site, and one heteroscedastic parameter for home tasting individuals (LR chi2(1) = 5.67. p= 0.0173)). A heterogeneous choice model, therefore, was selected to determine whether sensory preferences differed by gender. Going by these results, future studies should not only consider the intrinsic sensory attributes in explaining the sensory preferences for maize, as the significant variance equation suggests that other factors that influenced food choice existed in the study by various consumer groups.

Table 5.6: Homoscedastic and heterogeneous choice models for the overall liking of nsima in Zambia

	Central location		Home	
	(1) **ologit**	**(2)** **Oglm**	**(3)** **Ologit**	**(4)** **oglm**
Education	-0.0468*	-0.0539	-0.0306	-0.0259
	(0.0259)	(0.0400)	(0.0320)	(0.0258)
Age	0.00612	-0.00247	-0.0770**	-0.0684**
	(0.0255)	(0.0364)	(0.0330)	(0.0273)
Age 2	-0.0000784	0.0000361	0.000826**	0.000735**
	(0.000290)	(0.000417)	(0.000347)	(0.000290)
Asset index	0.0781*	0.100	0.0798	0.0712
	(0.0454)	(0.0705)	(0.0606)	(0.0492)
Nutrition information	-0.0255	-0.196	0.991***	0.786***
	(0.135)	(0.199)	(0.160)	(0.154)
Orange maize	0.207	0.332	0.673***	0.573***
	(0.151)	(0.231)	(0.200)	(0.168)
Yellow maize	-1.228***	-1.979***	-0.801***	-0.688***
	(0.149)	(0.458)	(0.178)	(0.152)
children < 5 years	0.0201	0.220	-0.270	-0.412**
	(0.176)	(0.234)	(0.192)	(0.182)
Gender	0.206	0.188	0.0665	0.0470
	(0.135)	(0.221)	(0.167)	(0.136)
Constant 1	-3.769***	-6.070***	-5.945***	-5.133***
	(0.595)	(1.333)	(0.875)	(0.785)
Constant 2	-2.671***	-4.243***	-4.971***	-4.348***
	(0.582)	(1.079)	(0.842)	(0.731)
Constant 3	-1.669***	-2.652***	-3.574***	-3.215***
	(0.578)	(0.918)	(0.823)	(0.685)
Constant 4	-0.131	-0.250	-1.951**	-1.889***
	(0.575)	(0.812)	(0.815)	(0.661)
Lnsigma				
Children < 5 years		0.435***		-0.282**
		(0.113)		(0.121)
Gender		-0.224***		
		(0.0820)		
Age		0.00656**		
		(0.00313)		
Information		-0.160*		
		(0.0873)		
N	971	971	762	762
Log likelihood	-1220.2	-1206.6	-712.5	-709.6

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2.4 Results

The results of the heterogeneous choice model for the prevalence of gender differences in the ov erall liking of nsima from three maize variety samples are shown in Table 5.7. Each dataset is analysed separately below.

Central location

Table 5.7(1), shows estimates of a short model for consumers' general preferences among the three maize varieties. The results show that consumers' liking for orange maize was similar to that of the conventional white maize variety, and higher than that of yellow maize ($p< 0.01$). Table 5.7, model 2, shows estimates from factors affecting consumer's liking of nsima made from the three maize varieties that include gender, nutrition information, education and having children under the age of five years. The results show no statistical gender differences in the overall liking scores for nsima made from orange maize in the choice equation, suggesting that hedonic scores of *nsim*a for males and females were comparable.

However, given the gendered nature of food decisions shown in the literature, it is still possible that some of the determinants of hedonic scores for maize may differ for males and feamles. Thus, we examine whether the effect of education, having children under the age of five years, and nutrition information all had a different effect for males and females in their preferences for orange maize. The results (Table 5.7(3)) show none of these characteristics varied by gender in explaining the hedonic preferences of orange maize. However, in the variance equation, gender, nutrition information, and the dummy variable representing having young children remain statistically significant. This indicates that unmeasured variables influenced sensory preferences that had a different impact on males and females, respondents with and without children, and nutrition information recipients and non-recipients. A likelihood ratio test for the constrained and unconstrained model yielded a chi2(8) = 12.41, p = 0.13 sugdesting that gender differences were insignificant in the choice model. However, gender differences exist only in the variance equation (denoted as insigma in Table 5.7). Thus, future studies may try to assess possible variables that may be important in determining sensory preferences beyond the considered variables such as as cooking and flour quality.

Table 5.7: Determinants of sensory preferences for orange maize by gender at a central location

	(1)	(2)	(3)
Overall liking: Central location	**Short model**	**Constrained model**	**unconstrained model**
Orange maize	0.228	0.260	-0.00474
	(0.145)	(0.299)	(0.989)
Yellow maize	-1.194^{***}	-1.355^{***}	-0.982
	(0.143)	(0.340)	(0.976)
Gender		0.0950	-0.0437
		(0.247)	(0.906)
Education (years)		-0.0226	-0.00836
		(0.0240)	(0.0781)
Nutrition information		-0.171	-0.951^{**}
		(0.144)	(0.431)
Children < 5 years		0.176	0.0925
		(0.162)	(0.461)
Orange x male		0.0829	0.184
		(0.357)	(1.288)
Yellow x male			-0.716
			(1.260)
Male x education			0.0321
			(0.0918)
Male x information			0.245
			(0.521)
Male x children < 5 years			-0.212
			(0.574)
Orange x education			-0.0263
			(0.111)
Yellow x education			-0.155
			(0.108)
Orange x information			0.853
			(0.601)
Yellow x information			2.048^{***}
			(0.622)
Orange x kids			0.178
			(0.642)
Yellow x kids			0.00268
			(0.631)
Male x orange x education			0.00429
			(0.130)
Male yellow x education			0.0986
			(0.127)
Male x orange x information			-0.329
			(0.739)
Male x yellow x information			-1.393^{*}
			(0.745)
Male x orange x children			-0.0880
			(0.809)
Male x yellow x children			0.675
			(0.793)
Lnsigma			
Gender		-0.200^{**}	-0.173^{**}
		(0.0801)	(0.0802)
Info		-0.174^{**}	-0.232^{***}
		(0.0876)	(0.0875)
Children < 5 years		0.372^{***}	0.352^{***}
		(0.109)	(0.112)
N	1058	971	971
Log likelihood	-1321.6	-1210.1	-1198.0
LR chi2(15) = 24.15 P> chi2 = 0.0626			

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Home

Results for home use testing are as shown in Table 5.8. The short model showing (Table 5.8(1)) general preferences of respondents for the three maize varieties revealed that orange maize was significantly preferred over the conventional white maize ($p<0.01$). On the other hand, yellow maize was less liked than white maize as expected ($p<0.01$). In Table 5.8(2), we test whether there were gender differences in the overall liking of *nsima* made from orange maize. Results show that the preferences for the biofortified orange maize differed by gender, with males on average showing a stronger preference than females. As previously mentioned, a heterogeneous ordered logistic model was used to control for the variance in the dummy variable representing whether the individual had children under the age of five years or not.

In Table 5.8(3), we examined whether the determinants of sensory preferences for orange maize were the same for males and females, focusing on the effect of education, nutrition information and having children under the age of five. The results show that the gender gap in sensory preferences for orange maize was eliminated when the effect among individuals having children under the age of five years on hedonic preferences was allowed to vary by gender ($p<0.05$). A likelihood ratio test was done on the equality of the constrained model (Table 5.9 (3)) and the unconstrained model (Table 5.8 (2)) to determine whether the effect of at least one explanatory variable on overall liking truly differed by gender. Results revealed a chi-square value (chi2(8) = 23.53, p=0.0027) for the likelihood ratio test was significant at $p < 0.01$ in favour of the unconstrained model. This suggests that there were gender differences in the overall acceptance of *nsima* made from orange maize flour in at least one of the coefficients of the explanatory variables. Specifically, female respondents with children were less likely to score higher on orange maize compared to males of the same status.

Table 5.8: Gender differences in sensory preferences using the heterogeneous choice model at a home-use study site

Overall liking	(1) Short model	(2) Constrained model	(3) Unconstrained model
Orange maize	0.598***	0.455*	1.410*
	(0.183)	(0.267)	(0.837)
Yellow maize	-0.752***	-0.212	0.852
	(0.164)	(0.249)	(0.791)
Education		-0.0154	0.104
		(0.0255)	(0.0756)
Information		0.847***	0.797**
		(0.157)	(0.402)
Children < 5 years		-0.444**	-0.0587
		(0.173)	(0.410)
Gender		-0.403*	1.610*
		(0.220)	(0.857)
Orange x male		0.981***	-2.078
		(0.342)	(1.289)
Yellow x male			-0.977
			(1.176)
Male x education			-0.0975
			(0.0970)
Male x information			-0.290
			.50779
Male x children			-0.607
			(0.598)
Orange x education			-0.201*
			(0.116)
Yellow x education			-0.157
			(0.107)
Orange x information			1.282**
			(0.613)
Yellow x information			0.536
			(0.554)
Orange x children			-0.412
			(0.615)
Yellow x children			-0.621
			(0.573)
Male x orange x education			0.175
			(0.153)
Male x yellow x education			0.0650
			(0.134)
Male x orange x information			-0.640
			(0.786)
Male x yellow x information			-0.499
			(0.697)
Male x orange x children			1.928**
			(0.878)
Male x yellow x children			0.290
			(0.821)
Lnsigma			
Children		-0.237*	-0.128
		(0.121)	(0.123)
N	870	762	762
Ll	-830.2	-708.7	-694.1
	LR chi2(15) = 29.20	Prob > chi2 = 0.0152	

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2.5 Summary

The question of whether or not, there were systematic gender differences in the sensory preferences for a maize variety that has been biofortified with vitamin A, relative to two local maize varieties, i.e., conventional white maize variety and yellow maize variety was considered. The study used HarvestPlus datasets that elicited sensory preferences for *nsima*- a commonly consumed product of maize, Zambia's staple food crop. Two datasets were used. In the first dataset, sensory preferences were elicited in a market setting at a central location, while, in the second data set, sensory preferences were elicited from consumers who tested and evaluated food products in their own homes.

A robust heterogeneous choice model that accounted for variability in both the choice equation and the residuals did not reveal any gender differences sensory in the choice model for central location consumers. Instead, residual variability existed in the gender variable. The negative variability in gender suggested that males were less variable in their sensory preferences compared to females. In other words, females were more variable in their overall acceptance of *nsima* attributes, suggesting that there were other factors influencing females' preferences that were not accounted for by the covariates in the model. For example, females as food handlers may have been concerned about other maize attributes beyond sensory appeals, such as cooking quality.

A heterogeneous choice model for home testing consumers revealed that residual variability existed among individuals with children in the sensory acceptance of *nsima*. This also suggested that there were unmeasured variables that impacted individuals with children differently from those without children, in their sensory preferences for *nsima*. Females with younger children were less likely to score high in the liking of orange maize compared to males of the same status.

This study also provided new insights as to whether the length of exposure to the novel product in an experiment mattered differently for males and females when forming attitudes towards the novel food. A comparison of gender sensory preferences by study location revealed that sensory preferences were similar for males and females in the choice equation but differed in the variance equation at a central location study site, where exposure to the food product was shorter. On the other hand, research carried out among respondents in their own homes where exposure to food samples was longer, revealed that gender sensory preferences for orange maize differed by gender where men's preferences for orange maize were stronger than that of females. The plausible explanation for this outcome is that product exposure might have played a role in shaping males' and females' preferences for the BFC. In particular, exposure to the product samples could have made a difference in females compared to males because it was the females who were more likely to handle and prepare the food samples. Thus, at the home study site, females could have been more certain about their preferences for the orange maize than they would have been at a central location as they had a longer exposure to food samples. On a cautionary note, however, the samples at these study sites as earlier shown were not comparable in personal characteristics. As such, this explanation cannot be conclusive, and thus requires further investigation.

5.3 Hedonic preferences by gender for biofortified iron beans in Rwanda

5.3.1 Introduction

This study uses part of the dataset in Oparinde et al. (2015) that examined consumers' acceptance of two iron-biofortified bean varieties and the effect of the nutrition messaging tools in promoting acceptance. Specifically, the authors examined whether nutrition information framing and the frequency with which nutrition information was given to consumers, affected consumer behaviour. Nutrition message framing, in particular, assessed whether the attitudes of consumers towards biofortified beans differed when the nutrition message was presented in the "loss" frame compared to the "gain" frame. In the "loss" frame, the nutrition message stressed the disadvantages of lacking iron in respondents' diets, and the importance of iron-biofortified beans in mitigating iron deficiencies. The nutrition message in the "gain" frame, on the other hand, highlighted the benefits or paybacks of having adequate iron in respondents' diets, and the importance of iron-biofortified beans in that role. The frequency of providing nutrition messages to participants was assessed to determine whether there were significant differences in the attitudes of consumers when nutrition information was provided once, at the beginning of the experiment, compared to thrice, during the experiment (i.e., after testing each bean variety).

In the current study, we examine gender-specific hedonic preferences for the two types of iron-biofortified bean varieties, relative to one another, and to a local most popular red-spotted bean variety. The local bean variety was 40 percent lower in iron concentration than the new iron biofortified varieties (Oparinde et al. 2015). The two biofortified beans in the current study are referred to as "red iron bean" and "white iron bean" varieties (based on the colour of the beans), and the local popular variety as "local variety".

5.3.2 Sampling and evaluation procedure

A multistage cluster-sampling was followed in the selection of households to evaluate the red iron beans and white iron beans, relative to the popularly consumed red-spotted bean variety. The district was divided into 19 sectors that were grouped into quartiles. Of these, one fourth (1/4) of the sectors were randomly selected. Among the selected sectors, one fifth (1/5) of the villages were selected. From the selected villages, 10 households were randomly selected, representing a final sample of 572 respondents (Oparinde et al. 2015). Respondents per household were given one kilogram of uncooked beans, from each of the three varieties of beans for them to cook and state their preferences for the hedonic attributes that were important among Rwandan consumers. Respondents were to cook and test each bean variety at a time and evaluate its hedonic preferences before trying another bean variety.

The study took place at individuals' homes among 572 respondents, grouped under five information scenarios. The first group was a control group with no dietary information given on the new bean varieties. The second group received a "one" minute-recorded audio message once before the first sample was received. The nutrition message was offered in the "gain" or positive frame, emphasised the gains of having ample amounts of iron in respondents' diets, and the importance of the new iron beans varieties in that role. The third group received the same message, three times during the experimental period, and, the message was offered before the hedonic testing in each of the three varieties. The fourth group received nutrition information offered in the "loss" frame that stressed the disadvantages of lacking iron in the diet and how iron-biofortified beans can be an important source of iron, once at the beginning of the experiment. The fifth group received the same negatively framed message, but repeated three times during the experimental period, with each message given before the hedonic testing exercise for each of the three varieties. Each of the nutritional messages lasted for one minute.

While crops biofortified with vitamin A showed visible colour changes of either orange or yellow, iron biofortification had no known visual attributes or colour changes that were different from that found among local bean varieties. Thus, expected changes in the biofortified bean varieties were explored in hedonic attributes such as bean dryness, size, colour and cover hardness in their raw form. Other bean attributes considered were, bean size when cooked, taste, and taste when mixed with staple food, as well as cooking time, overnight cooking quality and the overall liking of bean attributes. In the next section, we examine whether there were gender differences in the raw scores of hedonic ratings.

5.3.3 Gender differences in the hedonic ratings among the three bean varieties

In Table 5.9, gender differences in the preferences for the hedonic attributes of the three bean varieties were examined using an independent T-test. As can be seen, there were gender differences in all three bean varieties in at least three or more attributes. The prevalence was higher in the red iron bean variety than in the other two bean varieties. In the local bean variety, this was reflected in the hedonic ratings of staple-mix taste ($p<0.05$), overnight cooking quality ($p<0.01$), ease of cooking ($p<0.1$) and the overall liking of the bean qualities ($p<0.01$). Females provided higher ratings in all these attributes. Gender differences in the preferences for the red iron bean variety were observed in almost all the attributes, except for the dryness and colour of beans in their raw form. Specifically, females liked the red iron beans more than males for its cover hardiness ($p<0.01$), taste ($p<0.01$), taste when mixed with staple ($p<0.01$), cooking time ($p<0.01$), ease of cooking ($p<0.01$), bean size when cooked ($p<0.01$), overnight cooking quality ($p<0.1$) and overall attributes (0.01). On the other hand, males expressed a higher liking for the size of the raw red iron beans ($p<0.01$) compared to females. The white iron variety revealed gender differences in the liking of the bean size in its raw form ($p<0.1$), bean size when cooked ($p<0.1$) and cooking time ($p<0.05$). Specifically, females rated higher the size of the bean when cooked and the cooking quality, while, males rated the raw size of the bean higher.

Table 5.9: Gender differences in the hedonic ratings of beans varieties in Rwanda

Bean Attributes	(1) Local bean (mean difference)	(1) Red iron bean (mean difference)	(1) White iron bean (mean difference)
Dryness – raw	-0.0395	0.0344	0.0547
	(-0.84)	(0.88)	(0.95)
Colour – raw	-0.0103	0.0301	-0.00376
	(-0.24)	(0.98)	(-0.04)
Size raw	-0.00806	-0.111***	0.0822*
	(-0.20)	(-2.97)	(1.74)
Size cooked	0.0215	0.0715**	0.0994*
	(0.48)	(2.45)	(1.83)
Cover hardness	0.0634	0.197***	0.0797
	(1.20)	(4.27)	(1.02)
Taste cooked	0.0686	0.179***	0.00794
	(1.56)	(4.93)	(0.12)
Taste when mixed with staple	0.0775**	0.123***	0.0805
	(2.17)	(5.04)	(1.29)
Cooking time	0.0579	0.123***	0.105**
	(1.24)	(2.68)	(2.26)
Overnight cooking quality	0.168***	0.0657*	0.0433
	(3.76)	(1.84)	(0.50)
Ease of cooking	0.0773*	0.0691*	-0.0576
	(1.82)	(1.92)	(-0.66)
Overall liking	0.103**	0.104***	0.0631
	(2.54)	(3.94)	(0.76)
N	1716	1716	1716

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Note: Differences defined as female-male averages

Determining respondents' preferences for hedonic attributes of beans by gender

Gender-specific hedonic preferences for all the attributes of beans were examined using the ordinal logistic regression. Short separate regression models were estimated for each bean attribute, with bean variety type as an independent variable, and also with gender interaction. The results are listed in Table 5.10, and they suggest that the red iron variety was the most prefered variety in all the attributes (p<0.05). On the contrary, the white iron bean was disliked in all its attributes (p<0.05). The results, however, showed no evidence of gender differences in all of the bean variety attributes (as displayed in the interaction models) at p<0.05. At p <0.1, however, the females exhibited a stronger preference for the red iron bean variety compared to men, when the red-iron beans were mixed with a portion of the respondent's staple food. In the following section, factors that influence hedonic preferences for novel food were also considered in the analysis.

Table 5:10: Hedonic factors affecting the liking of beans by gender in Rwanda

	Overall liking		**dryness**		**color**		**Size when raw**	
	Short model	Interaction	Short model	interactions	Short model	interactions	Short model	interactions
Red iron bean variety	1.988***	2.121***	0.925***	1.037***	1.360***	1.431***	0.324***	0.259*
	(0.130)	(0.184)	(0.114)	(0.156)	(0.124)	(0.170)	(0.113)	(0.153)
White iron bean variety	-1.047***	-1.091***	-0.293***	-0.229	-1.676***	-1.687***	-0.479***	-0.422***
	(0.114)	(0.153)	(0.110)	(0.149)	(0.117)	(0.153)	(0.114)	(0.153)
Gender		-0.248*		0.102		-0.022		0.075
		(0.149)		(0.154)		(0.153)		(0.162)
Gender x red		-0.255		-0.242		-0.151		0.138
		(0.257)		(0.228)		(0.245)		(0.228)
Gender x white		0.090		-0.142		0.024		-0.127
		(0.219)		(0.221)		(0.218)		(0.227)
Obs.	1706	1706	1712	1712	1711	1711	1707	1707

	size when cooked		**cover hardness when cooked**		**Taste**		**Taste when mixed with staple**	
	Short model	Interaction	Short model	Interaction	Short model	Interaction	Short model	Interaction
Red iron bean variety	1.584***	1.646***	0.452***	0.553***	1.231***	1.388***	1.167***	1.456***
	(0.127)	(0.174)	(0.109)	(0.148)	(0.115)	(0.157)	(0.136)	(0.203)
White iron bean variety	-0.276**	-0.147	-0.451***	-0.398***	-0.351***	-0.363**	-0.752***	-0.798***
	(0.111)	(0.151)	(0.110)	(0.150)	(0.110)	(0.151)	(0.115)	(0.158)
Gender		-0.019		-0.094		-0.133		-0.183
		(0.155)		(0.152)		(0.153)		(0.163)
Gender x red		-0.132		-0.219		-0.331		-0.534*
		(0.253)		(0.218)		(0.226)		(0.275)
Gender x white		-0.281		-0.114		0.026		0.096
		(0.222)		(0.221)		(0.220)		(0.229)
Obs.	1706	1706	1699	1699	1694	1694	1692	1692

	Cooking time		**Overnight cooking quality**		**Ease of cooking**	
	Short model	Interaction	Short model	Interaction	Short model	Interaction
Red iron bean variety	0.313***	0.372**	0.808***	0.791***	0.615***	0.615***
	(0.111)	(0.150)	(0.121)	(0.168)	(0.114)	(0.155)
White iron bean variety	0.915***	0.901***	-1.547***	-1.664***	-1.083***	-1.174***
	(0.115)	(0.155)	(0.117)	(0.157)	(0.114)	(0.153)
Gender		-0.104		-0.326**		-0.146
		(0.155)		(0.159)		(0.154)
Gender x red		-0.134		0.044		0.000
		(0.223)		(0.243)		(0.227)
Gender x white		0.032		0.245		0.197
		(0.229)		(0.223)		(0.222)
Obs.	1691	1691	1681	1681	1704	1704

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3.4 Factors influencing hedonic ratings of beans varieties by gender

Gender-specific determinants of the hedonic preferences of iron-biofortified beans are explored. Specifically, the impact of socio-economic characteristics and nutrition information on the attitudes of males and females towards iron-biofortified beans were examined. The expected results were as hypothesised in the previous chapter. We also explored the presence of the "loss aversion" behaviour among males and females towards the acceptance of iron-biofortified beans by comparing their preferences when nutrition messages were presented in both positive and negative frames. Rau (2014); Meyers-Levy and Loken (2015) assert that females have a higher temperament than males, and express a risk aversion behaviour comparatively. Thus, the hypothesis that females were likely to respond more favourably in the liking of iron-biofortified beans in the negatively framed nutrition information than in the positive frame, was tested. The overall-liking measure of the hedonic preferences of beans was used as a dependent variable due to very high positive correlations among hedonic attributes (see appendix 4). The distribution of the overall-liking variable is shown in figure 5.2.

Distribution of overall liking scores for the three Bean varieties in Rwanda by gender

Figure 5.2 displays the distribution of the overall-liking scores of beans, by gender and variety, among Rwandan households in the Gankenke district. The distributions of the overall liking scores for males and females were similar across the three-bean varieties. Specifically, the results showed that a larger proportion of females gave the highest liking score for the red iron bean variety. The pattern was similar for men, although the proportion for males was lower. Further, the red iron bean variety attracted the largest proportions of respondents in the highest liking category for both genders, among the three bean varieties. On the contrary, the proportion of respondents in the highest liking category was the lowest in the white iron bean variety among the three bean varieties. Additionally, variability in the degree of liking of the white bean variety was higher for both males and females.

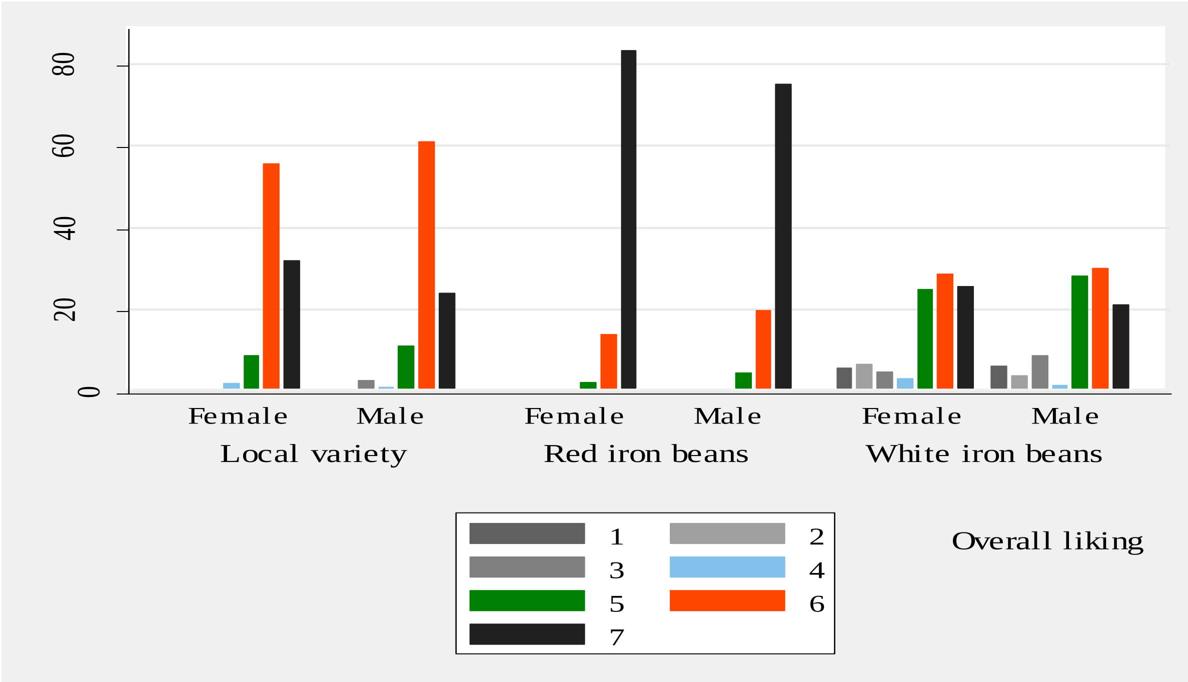


Figure 5.2: Distribution of overall liking of beans by variety and gender

Variable descriptions

The explanatory variables included years of educational attainment, age, age squared, asset index, nutrition information receipt by message framing and frequency, variety type, whether one has children of 3 years and below, knowledge about anaemia, and gender which is the independent variable of key interest. Table 5.11 below shows a description of each of these variables and how they were measured in the analysis. Given that the response variable is ordered, an ordered logit model was used in the analysis. As in the previous section, the assumptions of the ordered model were first tested.

Table 5.11: Variable descriptions

Variable	Definition
Overall liking	1= dislike very much 2=dislike 3 dislikes moderately 4 neutral 5 like moderately 6 like 7= like it very much.
Education	Years of educational attainment
Age	The age of the respondent in of years
Age 2	Square of age
Asset index	Average household and productive assets of the first principle component
Children	Coded 1 if the respondent has children of 3 years and below, 0 otherwise
Anaemia	1, if had knowledge of anaemia before the study, 0 otherwise
Gender	1 if male, 0 otherwise
Variety	1 if local
	2 if red iron biofortified beans
	3 if white iron biofortified beans
Information	A column of information treatment dummy coded as:
scenario	1 if the respondent received no nutrition information during the experiment
	2 if the respondent received the gain frame information once in the experiment
	3 if the respondent received the gain frame information thrice in the experiment
	4 if the respondent received the loss frame information once in the experiment
	5 if the respondent received the loss frame information thrice in the experiment

Specification test for the ordered logit model

As in the previous section, the parallel regression and the heteroscedasticity assumptions were tested using a Brant test, and the ordinal generalised linear model, respectively. Results showed that both the parallel regression and the homoscedastic assumptions do not hold. A Brant test yielded a chi2(26) = 94.77, p=0.00 with the red iron bean and white iron bean varieties variables failing to uphold this assumption (Appendix 5.5). Similarly, as shown in Table 5.12 the heteroscedasticity assumption does not hold. This was shown in all the nutrition information treatment variables at $p<0.01$, and the white bean variety ($p<0.01$). This suggested that the ordered logit model will be inconsistent in parameters.

Residual variability, in particular, was higher among individuals who did not receive nutrition information on the iron biofortified bean varieties, when compared to those who did, regardless of the treatment. The results are plausible, suggesting that respondents in the control group were not certain about their preferences for the new bean varieties since there was no dietary information given to them. Residual variability in the white iron bean variety suggested a conflicted perception of the inferior hedonic attributes experienced (as previously reported), and its nutrition value. Thus, respondents could have been divided based on the choice between their sensory experience and the perceived nutrition value for the white bean variety. Comparing the two models using a Likelihood ratio test, yielded a chi2(6) = 99.51, p-value = 0.000, suggesting that the ordered logit model was rejected, in favour of the heterogeneous choice model. The heterogeneous ordinal regression was therefore used to interpret the results.

Table 5.12: Comparing the homoscedastic and heterogeneous choice models for beans in Rwanda

Variables: Overall liking	(1) Ordered logit	(2) Heterogeneous choice model
Education	0.0330*	0.0224
	(0.0187)	(0.0188)
Age	-0.0280	-0.0332
	(0.0204)	(0.0204)
Age 2	0.000302	0.000329
	(0.000207)	(0.000206)
Asset index	-0.101***	-0.0866**
	(0.0365)	(0.0374)
Information positive-once	-0.00871	-0.0539
	(0.158)	(0.178)
Information positive-thrice	-0.0999	-0.166
	(0.169)	(0.191)
Information negative-once	-0.125	-0.159
	(0.158)	(0.175)
Information negative-thrice	-0.0742	-0.149
	(0.174)	(0.193)
Red iron beans variety	2.063***	2.114***
	(0.140)	(0.273)
White iron beans variety	-1.115***	-1.243***
	(0.121)	(0.164)
Children	-0.182	-0.180
	(0.118)	(0.120)
Anaemia knowledge	-0.201*	-0.155
	(0.107)	(0.107)
Gender	-0.244**	-0.267**
	(0.107)	(0.110)
Constant 1	-4.900***	-6.204***
	(0.531)	(0.727)
Constant 2	-4.218***	-5.200***
	(0.518)	(0.652)
Constant 3	-3.638***	-4.364***
	(0.511)	(0.601)
Constant 4	-3.432***	-4.082***
	(0.510)	(0.588)
Constant 5	-2.215***	-2.493***
	(0.504)	(0.531)
Constant 6	-0.175	-0.343
	(0.499)	(0.499)
Lnsigma		
Information positive-once		-0.295***
		(0.0906)
Information positive-thrice		-0.234**
		(0.0972)
Information negative-once		-0.383***
		(0.0908)
Information negative-thrice		-0.275***
		(0.0997)
Red iron beans variety		0.218*
		(0.119)
White iron beans variety		0.647***
		(0.0726)
N	1527	1527
Log likelihood	-1728.2	-1678.4

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3.5 Results

Table 5.13 shows regression estimates for consumer preferences for the two biofortified bean varieties relative to a local popular bean variety. Table 5.13 (1), displays results for the short model showing respondents' preferences for the three bean varieties. Results suggested that respondents preferred the red iron biofortified bean variety over the local bean variety ($p<0.01$). On the other hand, the white iron biofortified variety was not preferred over the local variety, and this relationship was significant at $p <0.01$. Table 5.13(2), displays the basic model of regression estimates for factors that influence the average sensory scores of beans. As can be seen, the red iron beans and the white iron beans varieties dummy variables have maintained their significance and signs, as in the short model. Additionally, assets levels ($p<0.01$) and gender ($p<0.05$) were negatively related to the overall liking scores. Specifically, the probability of being in the higher liking category was lower for males than for females. Similarly, as the levels of assets increased, the probability of being in the higher liking category of beans reduced. The full Table of this analysis is displayed in Appendix 5.6.

We further determined whether the gender gap was variety-specific in model Table 5.13(3). Results revealed that there were no gender differences in sensory scores of beans based on bean variety type as shown by the interaction of gender and variety type, where both biofortified bean varieties had insignificant p-values. In Table 13, model 4, factors influencing bean variety-specific scores were examined by gender. Results indicate that the probability of being in the higher liking category of the red iron bean variety was lower for males with children under the age of 3 years, compared to females of the same status. In other words, female respondents with children were more likely to be in the higher liking category of the red iron bean variety. Literature report ambiguous effects on how mothers with children will respond to novel food. Following Smith et al. (2003), a higher score suggested that females with children relative to men, liked the red bean variety having in mind how beneficial it may be to their children. Additionally, compared to men, females' payoffs were more intertwined with that of their children (Meyers-Levy and Loken 2015).

Table 13(5) reports results of gender differences among the recipients of nutrition information only. Specifically, gender differences were examined in the hedonic preferences for biofortified beans based on nutrition message framing during the experiment. We expected females, relative to males to be in the higher liking category when the message is presented in the negative frame (Meyers-Levy and Loken 2015). We find gender differences in the males' and females' responses when the message is offered in the negative frame in the preferences for the white iron bean variety (p<0.05). However, this was not reflected in the overall liking of the red iron beans.

Table 5.13: Factors affecting the overall liking of iron biofortified beans by gender

	(1)	(2)	(3)	(4)	(5)
VARIABLES: Overall Liking	**Short model**	**Basic model**	**Variety gender**	**Variety gender x IV**	**Framing x variety x gender**
Red iron beans	1.991***	1.996***	2.098***	2.283***	2.999***
	(0.130)	(0.267)	(0.318)	(0.482)	(0.696)
White iron beans	-1.034***	-1.164***	-1.184***	-0.853**	-1.645***
	(0.114)	(0.155)	(0.193)	(0.367)	(0.622)
Gender	-	-0.241**	-0.214	-0.496*	-0.632
		(0.102)	(0.132)	(0.268)	(0.444)
Gender x red iron beans			-0.165	0.346	0.114
			(0.253)	(0.540)	(0.828)
Gender x white iron beans			0.0374	-0.226	0.594
			(0.255)	(0.533)	(0.896)
Asset index		-0.0905***	-0.0910**	-0.0967	-0.127
		(0.0351)	(0.0353)	(0.0598)	(0.0892)
Education		0.0204	0.0207	0.0253	0.0393
		(0.0167)	(0.0168)	(0.0298)	(0.0438)
Negative frame					-0.0996
					(0.267)
Children < 5 years		-0.155	-0.156	-0.224	-0.244
		(0.108)	(0.109)	(0.206)	(0.308)
Aneamia knowledge		-0.163	-0.164	-0.182	-0.296
		(0.101)	(0.101)	(0.182)	(0.272)
Gender x assets				0.0986	0.207
				(0.0965)	(0.148)
Gender x education				-0.00784	-0.0698
				(0.0448)	(0.0666)
Gender x negative frame					0.185
					(0.400)
Gender x children < 3 years				0.250	0.493
				(0.291)	(0.439)
Red iron beans x education				-0.0375	-0.0791
				(0.0606)	(0.0827)
White iron beans x education				0.0185	0.0167
				(0.0606)	(0.0917)
Gender x white iron beans x negative frame					-1.998**
					(0.809)
Gender x red iron beans x children				-1.254**	-1.238
				(0.607)	(0.812)
Observations	1,706	1,536	1,536	1,536	1,212
Number of id	572				
chi2	459.6	659.1	659.6	677.1	622.6
Ll	-1766	-1515	-1515	-1506	-1142

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.3.6 Summary

Hedonic preferences were analysed by gender for two nutritious bean varieties with data from a field experiment, collected by HarvestPlus, among rural Rwandan households in Gankeke district. Consumers evaluated hedonic attributes of the two new bean varieties biofortified with iron, meant to alleviate iron deficiencies. Eleven (11) traits of a bean variety were evaluated that included; dryness of raw beans, colour of raw beans, size of raw beans, size of cooked beans, cover hardness of raw beans, taste of cooked beans, taste of cooked beans when mixed with staple food, cooking time, overnight cooking quality, ease of cooking and overall liking. Mean comparison tests revealed gender differences in hedonic responses in both biofortified bean varieties. The red iron bean variety exhibited gender differences in most hedonic attributes, with females, submitting higher scores for the red iron beans' cover hardiness, taste when cooked, taste when mixed with staple, cooking time, ease of cooking, bean size when cooked, overnight cooking quality, and in the overall liking. Men, on the other hand, liked the size of the red iron beans in their raw form.

Gender differences in hedonic preferences in the white iron beans variety were revealed in the bean size when raw, bean size when cooked, and the time it took to cook the beans. Females rated higher the size of the bean when cooked and the cooking quality, while, males rated higher the raw size of the bean than females. These results suggested that males and females searched for different attributes when evaluating attributes of beans, based on the gender roles they occupied in the food supply chain. The bean attributes favoured by females, for example, were linked to the food preparation, while males searched for market-oriented attributes of the beans, such as bean size when raw. Factors influencing the overall liking of beans by gender include, having young children, whose probability of being in the higher liking category for the red iron beans was higher among females. Additionally, females' scores were likely to be higher for the white red beans, (whose attributes were not preferred over the conventional bean variety) when the nutrition information was presented in the negative or loss frame. The result confirmed the assumption of the psychological literature according to Meyers-Levy(2015) and Rau (2014), where females were believed to be more responsive to the negative message than the positive messages. These results suggest that females' preferences were shaped in response to nutrition information presented in the "loss" frame.

5.4 Hedonic preferences by gender for Vitamin A biofortified cassava in Nigeria

5.4.1 Introduction

This study examined gender differences in hedonic preferences for two new cassava varieties biofortified with vitamin A in the southern part of Nigeria where vitamin A deficiency was highly prevalent, and cassava was a staple food crop. The biofortified cassava varieties were expected to be yellow-fleshed, from the biofortification process, and, two states, in particular, were selected based on their culturally distinct preferences for the colour of cassava food products (Oparinde et al. 2014). Specifically, the Nigerian state of Oyo, located in the southwest, and known for its preferences for white cassava products, and Imo state, in the southeast, known for its preferences for yellow cassava products were selected. The yellow colour from cassava products in the state of Imo was obtained after adding palm oil to the white cassava product. A study by Oparinde et al. (2014) examined how consumers would react to such changes in their cassava diets. The current study uses a subset of this data to examine preferences by gender.

Study design and sampling

HarvestPlus collected data in Imo and Oyo states of southern Nigeria, selected on account of having a higher prevalence of vitamin A deficiency, and culturally distinct populations in the preferences for the colour of cassava products. Multi-stage sampling was conducted, following state selections. From the state of Imo, a total of 30 enumeration units were selected, while only 21 enumeration units were available in Oyo state. In each enumeration area selected, 30 to 40 households were randomly selected, resulting in 450 participants (Oparinde et al. 2014).

The selected participants in each state were invited to participate in a hedonic testing exercise, at a central location, and were allocated to either one of the two nutrition information treatment groups, or to the control group. The nutrition treatments, using simulated radio messages, not only assessed the importance of nutrition information in shaping consumer preferences for the two new cassava varieties but also assessed the importance of the mode of distributing cassava planting materials. One nutrition treatment arm was given nutrition information, along with the message indicating that the federal government of Nigeria was responsible for delivering cassava planting materials. The other treatment arm contained the same nutrition information, except the agency responsible for delivering the material was going to be an international agency or a non-governmental organisation. The justification for this treatment arm was the non-existence of formal cassava distribution channels at the time of the study (Oparinde et al.2014). Further, Hartmann and Viard (2008), also argued that channels used to introduce a brand new product may influence consumers' attitudes and perceptions. Hedonic tests focused on sensory attributes such as taste, feel, and colour. This was done in the most common form of cassava utilisation products known as "*gari*" (i.e., cassava flour obtained by roasting and grating cassava) and "eba" (a cooked porridge form of *gari*). These food products were made from the two vitamin-A biofortified cassava, i.e., a light yellow coloured and dense yellow coloured fleshed tubers, and compared to the conventional versions made from a popular local variety in each of the two states.

The current study uses a subset of this dataset as earlier stated to determine whether gender differences were prevalent in the acceptance of the biofortified cassava varieties, relative to the popular conventional variety in each region. Consumer characteristics based on gender and state were analysed first. An analysis of gender differences in both hedonic attributes and the determinants of sensory preferences followed next.

5.4.2 Respondent's characteristics by gender and state

Table 5.14, lists social-economic characteristics by gender in the two states of Nigeria. In Oyo state, a total of 93 respondents took part in the consumer acceptance of cassava varieties that were biofortified with vitamin A, comprising 43 percent females and 57 percent males. Imo state had 339 respondents for the same study, of which 34 percent were females and 64 percent were males. In Oyo state, males and females were similar in most characteristics except in land-area owned, and household size. On average females owned less land area than males ($p<.0.01$), and also came from smaller household sizes ($p<0.1$).

Among respondents from Imo state, gender differences were observed in all characteristics except in the average number of household members sharing meals from the same pot. Females were younger in age ($p<0.01$), had lower educational attainment ($p<0.01$), came from smaller sized (p<0.1) and poorer households (p<0.01) compared to men. They also owned and planted less land in the year before the baseline study (p<0.05). The married among them were fewer than the married among males (p<0.01), and also had fewer children under the age of five years (p<0.05).

Table 5.14: Respondents' gender differences in socio-economics characteristics by state

	Nigeria
Variables:	**Mean diff.**
Respondent's age	-5.208^{***}
	(1.565)
Education in years	-1.788^{***}
	(0.495)
Household size	-1.156^{***}
	(0.435)
Household members sharing meals	-0.523
	(0.392)
Asset index	-0.189
	(0.132)
Land area owned	-1.976^{***}
	(0.718)
Land area planted	-1.443^{**}
	(0.578)
Married	-0.159^{***}
	(0.0357)
No. of children	-0.251^{*}
	(0.138)
N	432

Standard errors in parentheses Note: Differences defined as female-male * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.4.3 Gender differences in hedonic ratings of biofortified cassava by state

In the hedonic testing exercise, three attributes were considered and these included the colour, feel and taste of the two cassava variety products, i.e., *gari* (cassava flour), and "eba" which is a cooked form of "*gari*" into porridge. A Likert scale ranging from 1= dislike very much, to 5= like very much, was used. Gender differences in hedonic ratings of biofortified cassava varieties were first explored using an independent T-test in each state without accounting for independent variables. The results are reported in Table 5.15 for both states, revealing no statistically gender differences in all the hedonic ratings of biofortified cassava varieties under consideration. In the section that follows, factors that determine acceptance of the taste of gari by gender are examined.

Table 5.15: Gender differences in the hedonic attributes of cassava by state

	Oyo state			Imo state		
Attribute	**Local variety. Cassava variety**	**Light yellow biofortified cassava**	**Dense yellow biofortified cassava**	**Local variety. Cassava variety**	**Light yellow biofortified cassava**	**Dense yellow biofortified cassava**
Gari colour	-0.608**	-0.136	-0.00708	0.159*	-0.0576	0.113
	(0.248)	(0.118)	(0.235)	(0.0914)	(0.182)	(0.141)
Eba colour	0.167	0.0830	0.217	0.122	-0.0109	0.0581
	(0.304)	(0.0961)	(0.205)	(0.0948)	(0.171)	(0.129)
Gari color feel	-0.0618	0.0968	0.304	0.135*	0.00695	-0.106
	(0.266)	(0.0983)	(0.185)	(0.0791)	(0.174)	(0.130)
Eba color feel	0.0827	0.202*	0.179	0.0757	0.0357	-0.0987
	(0.306)	(0.105)	(0.179)	(0.0931)	(0.152)	(0.129)
Gari taste	0.0973	0.0273	0.341	0.0961	-0.0965	-0.202
	(0.240)	(0.0987)	(0.231)	(0.0959)	(0.177)	(0.142)
N	93	93	93			

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Note: Differences are men's mean scores subtracted from females' scores

5.4.4 Factors influencing biofortified cassava by gender

In this section, we test the hypothesis of having no gender differences in the sensory preferences for *gari* (which is the commonest food product of cassava). The sensory attributes under consideration were found to be highly correlated (see appendix 5.7), and the overall liking variable is usually recommended as a measure of acceptance in such a case, as noted earlier. However, this variable was not considered in the hedonic testing exercise. The *gari* taste variable was instead used to determine acceptance of biofortified cassava variety in relation to the most popular local variety in each state. In literature, the taste has been ranked as the important attribute that consumers considered in making food choices (Kearney, et al., 2000; Eertmans, et al., 2005; Honkanen & Frewer, 2009), hence the choice of the taste variable is justified in the absence of the overall liking variable.

Figure 5.3 reports the distribution of respondents by gender and variety, in the evaluation of the taste of gari made from two biofortified cassava varieties, relative to the local popular variety on a 5-point Likert scale. The results showed that most of the respondents submitted higher liking scores for the taste of gari (either liked or liked very much) in all varieties in both states. In Oyo state, (a state that prefers white cassava varieties), the majority of females and males (above 70%) gave the highest scores for the taste of gari made from the light yellow biofortified cassava variety. The pattern was similar for females in the rating of the deep yellow cassava biofortified variety. Although the majority of males indicated that they liked the taste of the very much deep yellow cassava, the proportion was lower than that of females.

The results for Imo state whose consumers prefer yellow cassava products suggest that although the majority of respondents had a stronger preference for the taste of gari across the three cassava varieties, the proportions were the higher in the taste of their own local palm oil variety, relative to the two biofortified cassava varieties. Of the two biofortified cassava varieties, the deep yellow variety had more male respondents in the highest liking category than females. The light yellow variety was the least preferred by both males and females with only 40 percent and less, submitting highest scores for the taste of gari made from this variety. The light yellow cassava variety also attracted variable responses although there was a substantial proportion of females and males that attracted the lowest score (dislike it very much) for the taste of gari.

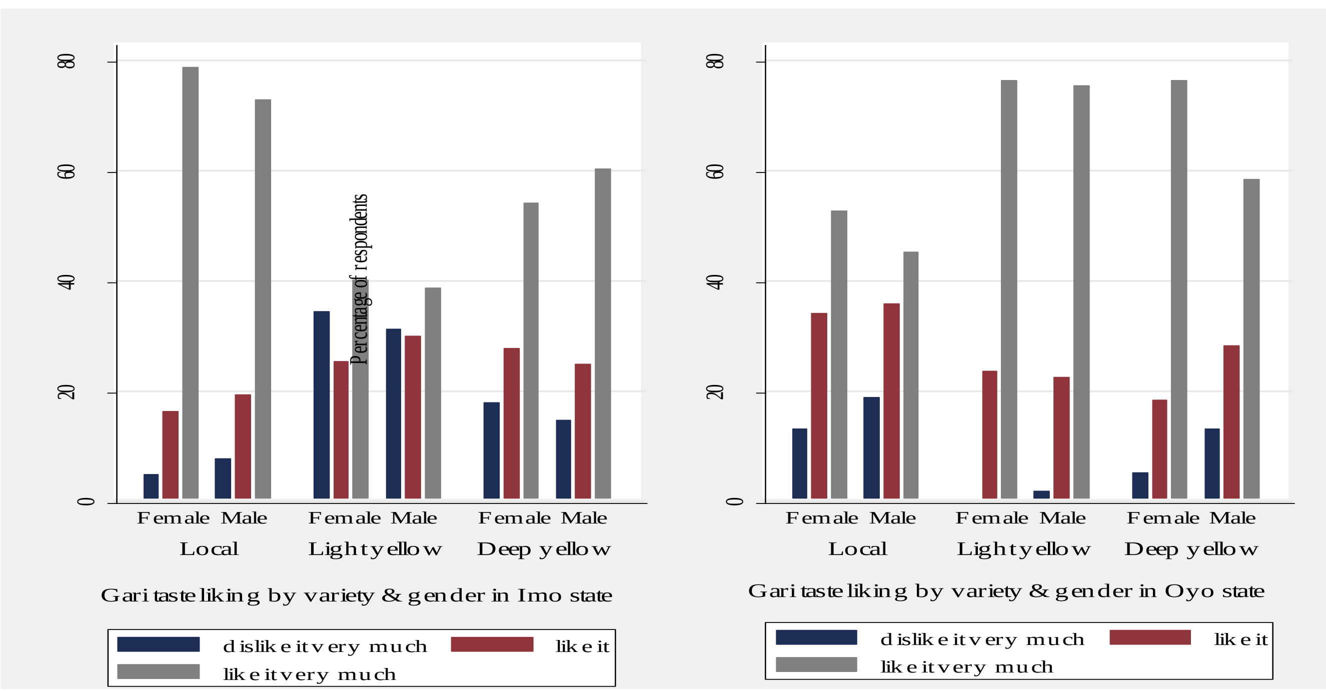


Figure 5.3: Proportion of respondents by gender in the liking of the taste of gari

Variable descriptions

The explanatory variables included in the analysis were; years of educational attainment, age, age squared, asset index, nutrition information receipt by endorsing agent, variety type, whether one has children of 5 years and below, knowledge about vitamin A, and gender. Table 5.11 below shows descriptions of these variables and how they are measured. Given that the response variable, taste liking, is ordered, an ordered logit model was used in the analysis. As in the previous section, the assumptions of the ordered model were first tested.

Table 5.16: Variable descriptions

Variable	Definition
Taste liking	1= dislike very much 2=dislike 3= neutral 4= like 5= like it very much.
Education	Years of educational attainment
Age	The age of the respondent in of years
Age 2	Square of age
Asset index	Average household and productive assets of the first principle component
Children	Coded 1 if the respondent has children of 5 years and below, 0 otherwise
Vitamin-A knowledge	1, if had knowledge of vitamin A before the study, 0 otherwise
Gender	1 if male, 0 otherwise
Variety	1 if local cassava variety
	2 if light yellow vitamin A biofortified cassava variety (LY)
	3 if dense yellow vitamin A biofortified cassava (DY)
Information scenario	A column of information treatment dummy coded as:
	1 if the respondent received no nutrition information during the experiment
	2 if the respondent received nutrition information endorsed by the Federal government of Nigeria
	3 if the respondent received nutrition information endorsed by and international agency

Specification tests of the ordered logit

As earlier stated, for the ordered logit model to provide valid estimates, the parallel regression and homoscedastic assumptions must be upheld. A Brant test was used to test the parallel line regression assumption, while a user-written Stata command "oglm" by Williams, (2010) was used to test the homoscedastic assumption. Results for both Imo and Oyo states were combined into one dataset as Oyo state had very few observations (93). Specification tests for the parallel regressions and homoscedastic assumptions were upheld, suggesting that the ordered logit model was the best model to be used.

5.4.5 Regression results using the random effects ordered logit model

In this section, we determine to what extent the overall liking of the taste of gari made from two biofortified cassava varieties, differed by gender. First, we estimated a short model for the taste of gari against the cassava variety type (without other covariates) to determine the general preferences of respondents (Table 5.17, model 1). Second, we added interaction terms of covariates with the cassava variety dummy variables to determine which factors affected the probability of liking the taste of gari made from the biofortified varieties (Table 5.17, model 2). Lastly, we investigated whether there were any gender differences in the probability of liking the taste of gari for the biofortified cassava varieties based on differing levels of independent variables in Table 5.17 (3).

As can be seen in Table 17 model 1, respondents preferred the taste of gari made from their own local varieties, relative to the one made from the two biofortified varieties ($p < 0.05$). After adding interactions (Table 17, model 2) of the socioeconomic characteristics and prior knowledge about vitamin A, the factors driving the probability of liking the taste of gari of the biofortified varieties were education, age, and whether one had received nutrition information or not. Our variable of interest gender did not show any significance at $p < 0.05$ in the probability of liking the taste of gari, suggesting that males and females in the sample liked gari the same way. At $p < 0.1$, however, the impact of age on males and females' preferences for the light yellow cassava for weakly significant, indicating that as one's age increased, males had a stronger preference for the light yellow cassava than older females (Full Table is shown in Appendix 5.9).

Table 5.17 Factors influencing gender differences in the acceptance of the taste of *gari* cassava in Nigeria

Variables: Gari taste liking	(1)	(2)	(3)
.LY variety	-1.009***	-5.145***	-3.212**
	(0.138)	(0.933)	(1.633)
DY variety	-0.433***	-4.957***	-3.337**
	(0.140)	(0.955)	(1.673)
Age		-0.002	0.023
		(0.010)	(0.021)
Education		-0.079**	-0.053
		(0.032)	(0.054)
Gender		-0.326	1.379
		(0.302)	(1.592)
Information- Federal government		-1.121***	-0.594
		(0.353)	(0.644)
Information- International agency		-1.341***	-0.932
		(0.353)	(0.601)
Vitamin A knowledge		0.364	0.040
		(0.354)	(0.587)
LY variety x age		0.024*	-0.017
		(0.013)	(0.026)
DY variety x age		0.035***	0.004
		(0.013)	(0.027)
LY variety x education		0.132***	0.120*
		(0.041)	(0.069)
DY variety x education		0.128***	0.132*
		(0.042)	(0.070)
LY x Info Fed government		1.902***	1.748**
		(0.434)	(0.789)
LY x Info international agency		2.385***	1.903***
		(0.436)	(0.730)
DY x Info Fed government		1.806***	1.417*
		(0.441)	(0.790)
DY x Info international agency		2.444***	2.071***
		(0.449)	(0.738)
Gender age			-0.032
			(0.024)
Gender x education			-0.036
			(0.067)
Gender x LY variety x age			0.058*
			(0.030)
Gender x DY variety x age			0.038
			(0.031)
Gender x LY variety x education			0.021
			(0.086)
Cut1:constant	-2.157***	-3.987***	-2.692**
	(0.119)	(0.725)	(1.314)
Cut2:constant	-0.839***	-2.594***	-1.290
	(0.103)	(0.720)	(1.312)
Sigma2_u:_cons	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Obs.	1290	1011	1011

Standard errors are in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

5.4.6 Summary

Gender differences were examined in the acceptance of the two cassava varieties biofortified with Vitamin A from Oyo and Imo states of southern Nigeria where cassava was a staple food, and the preferences for the cassava products between the two states varied by the colour of the cassava product. In particular, consumers from the state of Imo preferred the yellow coloured cassava products, while, consumers from Oyo state preferred the white cassava varieties. The vitamin A cassava biofortified variety products were likely to be yellow in colour from the biofortification process. Thus, the study assessed how consumers would react to such differences in their staple food and whether preferences would vary by gender.

Acceptance was measured using the sensory preferences for a commonly consumed cassava product locally known as *gari*, under different nutrition information treatments. Results show that males and females had similar levels of liking the sensory attributes of the three cassava varieties under consideration using an independent T-test. Regression estimates for the taste preferences for *gari* using a random effect ordered logit revealed no gender differences in the sensory preferences for *gari* made from biofortified cassava varieties in both states. These results imply that males and females have similar preferences for the intrinsic attributes of cassava, thus, it may not be necessary to target biofortified food consumers by gender, based on sensory preferences for cassava. We, however, note that this study was conducted only at a central location where respondents had less exposure to the new varieties. It may be necessary, however, to test gender differences in other intrinsic attributes that may matter differently for males and females, such as flour and cooking quality with longer exposure to the product.

Appendices for Chapter 5

Appendix 5.1: Personal characteristics by study location in hedonic preferences for vitamin A biofortified maize in Zambia

Characteristics	home	central	Difference	(p-value)
Age	45.58	40.28	5.29	0.00
Married	0.77	0.82	-0.04	0.17
Household size	6.74	8.22	-1.48	0.00
Education	7.04	8.51	-1.46	0.00
People sharing meals	6.46	7.84	-1.39	0.00
Asset index	-0.58	0.48	-1.05	0.00
Area planted	2.16	2.95	-0.78	0.00
Land owned	6.76	10.96	-4.20	0.00
Number of children	1.51	1.88	-0.37	0.00
Gender (1=male, 0 otherwise)	0.58	0.59	-0.01	0.80

Appendix 5.2: Pairwise correlations of sensory attributes of *nsima* made from three maize varieties in Zambia

Variables	Taste	Texture	Appearance	Aroma	Overall liking
Taste	1.000				
Texture	0.670*	1.000			
Appear	0.592*	0.559*	1.000		
Aroma	0.650*	0.586*	0.516*	1.000	
Overall liking	0.789*	0.727*	0.662*	0.763*	1.000

* shows significance at the .01 level

Appendix 5.3: Brant test of parallel regression assumption in the determinants of nsima made from three maize varieties in Zambia

	Central location			Home		
	Chi2	**p>chi2**	**df**	**Chi2**	**p>chi2**	**df**
All	35.82	0.119	27	34.67	0.148	27
Education	2.78	0.427	3	2.57	0.462	3
Age	0.99	0.804	3	2.58	0.461	3
Age 2	0.94	0.816	3	2.94	0.402	3
Asset index	3.74	0.290	3	5.23	0.156	3
Nutrition information	9.80	0.020	3	6.09	0.107	3
Orange maize	1.57	0.667	3	1.23	0.745	3
Yellow maize	1.06	0.787	3	4.89	0.180	3
Has children	5.97	0.113	3	0.46	0.928	3
Gender	7.11	0.068	3	2.20	0.531	3

A significant test statistic provides evidence that the parallel regression assumption has been violated

Appendix 5.4: Brant test for the parallel line assumption for the determinants of overall acceptance of beans in Rwanda

	chi2	p>chi2	df
All	94.77	0.000	26
Education	4.34	0.114	2
Age	1.13	0.567	2
Age 2	0.63	0.731	2
Asset index	0.03	0.985	2
Information positive-once	2.14	0.344	2
Information positive-thrice	1.48	0.478	2
Information negative-once	2.48	0.289	2
Information negative-thrice	0.67	0.716	2
Red iron beans	14.48	0.001	2
White iron beans	75.79	0.000	2
Children < 5 years	0.92	0.631	2
Anaemia knowledge	0.82	0.663	2
Gender	2.45	0.294	2

Appendix 5.5: Pairwise correlations for the beans attributes in Rwanda

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) dry	1										
(2) colour	0.431*	1									
(3) size- raw	0.257*	0.296*	1								
(4) size- cooked	0.360*	0.402*	0.357*	1							
(5) coverhard-cooked	0.332*	0.456*	0.218*	0.338*	1						
(6) taste- cooked	0.500*	0.514*	0.245*	0.441*	0.415*	1					
(7) tastes mix	0.402*	0.520*	0.268*	0.450*	0.391*	0.638*	1				
(8) cooking time	0.281*	0.109*	0.210*	0.201*	0.240*	0.244*	0.164*	1			
(9) overnight quality	0.344*	0.560*	0.283*	0.359*	0.439*	0.438*	0.444*	0.123*	1.		
(10) ease cook	0.391*	0.601*	0.277*	0.361*	0.548*	0.454*	0.475*	0.147*	0.594*	1	
(11) overall	0.465*	0.745*	0.291*	0.456*	0.525*	0.582*	0.609*	0.160*	0.609*	0.685*	1

* shows significance at the .01 level   Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix 5.6: Preferences for Iron biofortified bean varieties in Rwanda by gender

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES: Overall Liking	Basic model	Main effects	Variety gender	Variety gender x IV	Framing effects x gender	Framing x variety x gender
Red iron beans	1.991***	1.996***	2.098***	2.283***	2.750***	2.999***
	(0.130)	(0.267)	(0.318)	(0.482)	(0.402)	(0.696)
White iron beans	-1.034***	-1.164***	-1.184***	-0.853**	-1.802***	-1.645***
	(0.114)	(0.155)	(0.193)	(0.367)	(0.286)	(0.622)
Gender	-	-0.241**	-0.214	-0.496*	-0.358*	-0.632
		(0.102)	(0.132)	(0.268)	(0.201)	(0.444)
Gender x red iron beans			-0.165	0.346	-0.0180	0.114
			(0.253)	(0.540)	(0.357)	(0.828)
Gender x white iron beans			0.0374	-0.226	0.162	0.594
			(0.255)	(0.533)	(0.400)	(0.896)
Asset index		-0.0905***	-0.0910**	-0.0967	-0.0948*	-0.127
		(0.0351)	(0.0353)	(0.0598)	(0.0525)	(0.0892)
Education		0.0204	0.0207	0.0253	0.0164	0.0393
		(0.0167)	(0.0168)	(0.0298)	(0.0247)	(0.0438)
Negative frame					-0.0306	-0.0996
					(0.148)	(0.267)
Children < 5 years		-0.155	-0.156	-0.224		-0.244
		(0.108)	(0.109)	(0.206)		(0.308)
Aneamia knowledge		-0.163	-0.164	-0.182		-0.296
		(0.101)	(0.101)	(0.182)		(0.272)
Gender x assets				0.0986		0.207
				(0.0965)		(0.148)
Gender x education				-0.00784		-0.0698
				(0.0448)		(0.0666)
Gender x negative frame						0.185
						(0.400)
Gender x children < 5 years				0.250		0.493
				(0.291)		(0.439)
Gender x aneamia				0.337		0.371
				(0.273)		(0.408)
Red iron beans x assets				0.00721		0.163
				(0.117)		(0.171)
Red iron beans x assets				-0.119		-0.223
				(0.116)		(0.178)
Red iron beans x education				-0.0375		-0.0791
				(0.0606)		(0.0827)
White iron beans x education				0.0185		0.0167
				(0.0606)		(0.0917)
Red iron beans x negative frame						0.106
						(0.504)
White iron beans x negative frame						0.653
						(0.537)
Red iron beans x children				0.642		0.551
				(0.460)		(0.603)
White iron beans x children				-0.444		-0.661
				(0.405)		(0.617)
2.variety#1.aneamia				-0.224		-0.176
				(0.394)		(0.537)
3.variety#1.aneamia				-0.499		-0.656
				(0.369)		(0.559)
Gender x red iron beans x assets				-0.124		-0.376

Appendix 5.6: Preferences for Iron biofortified bean varieties in Rwanda by gender

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES: Overall Liking	Basic model	Main effects	Variety gender	Variety gender x IV	Framing effects x gender	Framing x variety x gender
				(0.177)		(0.259)
Gender x white iron beans x assets				-0.0153		-0.0965
				(0.186)		(0.286)
Gender x red iron beans x education				0.0215		0.143
				(0.0861)		(0.120)
Gender x white iron beans x assets				0.0240		0.0891
				(0.0904)		(0.137)
Gender x red iron beans x negative frame						0.0640
						(0.724)
Gender x white iron beans x negative frame						-1.998**
						(0.809)
Gender x red iron beans x children				-1.254**		-1.238
				(0.607)		(0.812)
Gender x white iron beans x children				0.196		-0.0279
				(0.575)		(0.883)
Gender x red iron beans x anaemia				-0.274		-0.382
				(0.542)		(0.756)
Gender x white iron beans x anaemia				0.278		0.581
				(0.540)		(0.827)
Positive info-once		-0.0752	-0.0751			
		(0.170)	(0.171)			
Positive info-thrice		-0.173	-0.172			
		(0.183)	(0.183)			
Negative info-once		-0.164	-0.162			
		(0.168)	(0.168)			
Negative info-thrice		-0.141	-0.140			
		(0.186)	(0.186)			
Observations	1,706	1,536	1,536	1,536	1,212	1,212
Number of id	572					
chi2	459.6	659.1	659.6	677.1	598.9	622.6
Ll	-1766	-1515	-1515	-1506	-1154	-1142

Appendix 5.7: Pw correlations of Cassava attributes in Nigeria

	Gari colour	Eba colour	*Gari* feel	Eba feel	*Gari* taste
Gari colour	1				
Eba colour	0.716***	1			
Gari feel	0.743***	0.720***	1		
Eba feel	0.502***	0.678***	0.628***	1	
Gari taste	0.666***	0.680***	0.751***	0.641***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 5.8 Brant test of parallel regression assumption (Nigeria)

	chi2	p>chi2	df
All	14.31	0.282	12
Age	1.21	0.271	1
Age 2	0.56	0.454	1
Education	3.76	0.053	1
Household size	2.94	0.086	1
Asset index	0.22	0.641	1
Children < 5 years	0.87	0.352	1
Sex	0.22	0.641	1
Light yellow cassava variety	3.1	0.078	1
Dense yellow cassava variety	1.21	0.272	1
Nutrition information with govt.support	0	0.953	1
Nutrition information with international support	1.28	0.257	1
Vitamin-A knowledge	0.96	0.328	1

Appendix 5.9: Preferences for vitamin A biofortified cassava varieties in Nigeria by gender (full model)

Variables: Gari taste liking	(1)	(2)	(3)
.LY variety	-1.009***	-5.145***	-3.212**
	(0.138)	(0.933)	(1.633)
DY variety	-0.433***	-4.957***	-3.337**
	(0.140)	(0.955)	(1.673)
Age		-0.002	0.023
		(0.010)	(0.021)
Education		-0.079**	-0.053
		(0.032)	(0.054)
Children < 5 years		0.074	
		(0.267)	
Gender		-0.326	1.379
		(0.302)	(1.592)
Information- Federal government		-1.121***	-0.594
		(0.353)	(0.644)
Information- International agency		-1.341***	-0.932
		(0.353)	(0.601)
Vitamin A knowledge		0.364	0.040
		(0.354)	(0.587)
LY variety x age		0.024*	-0.017
		(0.013)	(0.026)
DY variety x age		0.035***	0.004
		(0.013)	(0.027)
LY variety x education		0.132***	0.120*
		(0.041)	(0.069)
DY variety x education		0.128***	0.132*
		(0.042)	(0.070)
LY variety x children		-0.330	
		(0.344)	
DY variety x children		0.198	
		(0.351)	
LY x gender		0.098	-2.782
		(0.386)	(2.021)
DY x gender		0.346	-1.232

Appendix 5.9: Preferences for vitamin A biofortified cassava varieties in Nigeria by gender (full model)

		(0.390)	(2.070)
LY x Info Fed government		1.902***	1.748**
		(0.434)	(0.789)
LY x Info international agency		2.385***	1.903***
		(0.436)	(0.730)
DY x Info Fed government		1.806***	1.417*
		(0.441)	(0.790)
DY x Info international agency		2.444***	2.071***
		(0.449)	(0.738)
LY variety x kids		-0.018	0.078
		(0.451)	(0.722)
DY variety x kids		-0.355	-0.121
		(0.461)	(0.729)
Gender age			-0.032
			(0.024)
Gender x education			-0.036
			(0.067)
Gender x info-Fed govt.			-0.749
			(0.774)
Gender x info-international agency			-0.592
			(0.746)
Gender x vitamin A knowledge			0.662
			(0.741)
Gender x LY variety x age			0.058*
			(0.030)
Gender x DY variety x age			0.038
			(0.031)
Gender x LY variety x education			0.021
			(0.086)
Gender x DY variety x education			-0.019
			(0.088)
Gender x LY variety x info-Fed govt			0.181
			(0.948)
Gender x LY variety x info-international agency			0.653
			(0.912)
Gender x DY variety x info-Fed govt			0.541
			(0.955)
Gender x DY variety x info-international agency			0.480
			(0.933)
Gender x LY variety x vitamin A knowledge			-0.424
			(0.937)
Gender x DY variety x vitamin A knowledge			-0.552
			(0.954)
Cut1:constant	-2.157***	-3.987***	-2.692**
	(0.119)	(0.725)	(1.314)
Cut2:Constant	-0.839***	-2.594***	-1.290
	(0.103)	(0.720)	(1.312)
Sigma2_u: Constant	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Obs.	1290	1011	1011

Standard errors are in parenthesis *** p<0.01, ** p<0.05, * p<0.1

CHAPTER 6: EXPLORING GENDER DIFFERENCES IN WILLINGNESS TO PAY FOR BIOFORTIFIED FOOD CROPS IN NIGERIA, RWANDA AND ZAMBIA

6.1 Introduction

This chapter examines the gender-differentiated acceptance of BFC using willingness to pay (WTP) elicited from the Becker-DeGroot-Marshack mechanism (BDM) in Nigeria, Rwanda, and Zambia. WTP is one way of determining whether consumers will have access to BFC, and at what pricing level. In sub-Saharan Africa, as discussed in chapter 4, males and females were subject to different socio-economic conditions that may affect access and acceptance of BFC. Thus, examining men's and females' variability in WTP for BFC is a critical step in determining whether males and females will have equitable access to BFC. Results from previous studies (Meenakshi et al. 2012; Oparinde et al. 2014; Oparinde et al. 2015) suggest that consumers will be willing to pay more for the food's health attributes of the BFC. Using the part of the datasets used in the aforementioned studies, we determine whether WTP for biofortified food products is the same across gender in each of the three countries named above.

Figure 4.1, shown earlier, displays the procedures undertaken in eliciting WTP for BFC in respective countries, by study site, treatment, and valuation technique. Consumers in all the three countries had an opportunity to taste samples of BFC so as to familiarise themselves with the new BFC varieties, with or without nutrition information. For each country, the effects of personal characteristics, product attributes, and promotion tools on males' and females' WTP in respective biofortified food crops are examined.

6.2 Willingness to pay for vitamin A biofortified maize in Zambia by gender

Part of the datasets used to examine gender-differentiated WTP for orange maize in this section are drawn from chapter three and Hamukwala et al. (2019). As previously indicated, WTP was measured as the direct BDM bid made by each respondent for a 2.5kg bag of a vitamin A-biofortified orange maize variety at a central location, without nutrition information. Unlike in the hedonic preferences study where orange maize was compared with two conventional varieties, the BDM experiment only elicited WTP for orange maize variety without nutrition information.

A total of 145 respondents consisting of 83 males and 62 females, participated in the BDM experiment, either in one round or ten (10) repeated rounds of first-price auctions before the BDM. We examine gender differences in WTP for the biofortified orange maize variety, and whether characteristics determining WTP also differed by gender in the absence of nutrition information. Fig 6.1 below shows the distribution of bids for orange maize by gender. As can be seen, the data shows censorship at 2000 ZMK for both males and females, with males being more of those that had censored data.

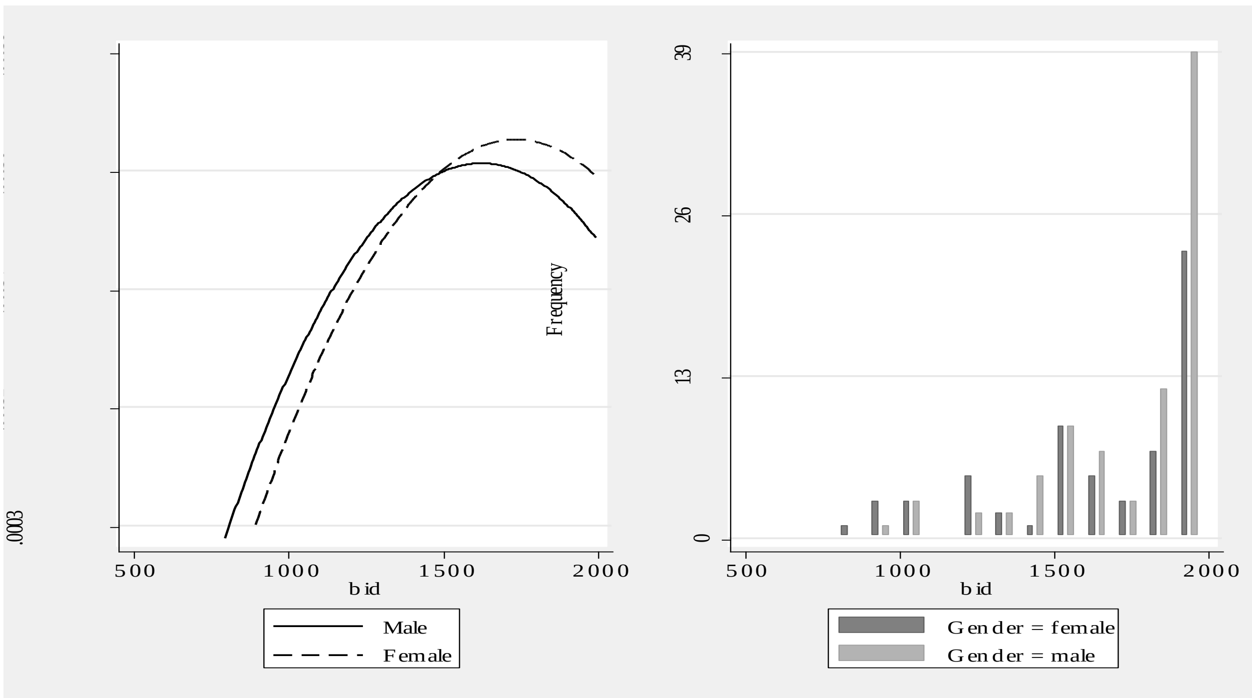


Figure 6.1: Distribution of bids for biofortified orange maize by gender in Zambia

6.2.1 Data description and sampling

The BDM data was collected at the central location, and sampling of data was done as discussed in 2.3.1. Table 6.1 presents the means for males and females on their WTP (bids) for orange maize, personal characteristics, and the associated p-values, following an independent T-test. Results show that males were willing to pay more for orange maize than females in the full sample (p=0.04) and repeated auction treatment sample (p=0.02). On the other hand, there were no gender differences in the bidding behaviour for respondents in single training treatment (p=0.7). Generally, in the full sample and sub-samples, males were also older, had more assets and more years of formal education than females. On the other hand, the household size and number of children for the average male and female were the same.

Table 6.1: Bids and personal characteristics by gender in the BDM experiment

	Single Training n=60				Repeated Training n=85				All n=145			
Variables	F	M	SD	(pval)	F	M	SD	(pval)	F	M	SD	pval
Bid	1,600	1,635	352.4	0.7	1,654.38	1,807.69	288.5	0.02	1,629.82	1,741.11	321	0.04
Gender	0	1		-	0	1		-	0	1		-
Age	34.89	43.47	13.5	0.01	33.94	40.61	12.1	0.01	33.66	41.42	12.7	0.00
Education	6.93	8.84	3.18	0.02	7.67	8.98	2.5	0.02	7.31	8.93	2.8	0.00
Household size	7.89	9.88	5.3	0.15	8.5	8.51	4.4	0.99	8.23	9.04	4.8	0.32
No. of children	1.68	1.88	1.32	0.57	1.8	1.98	1.28	0.55	1.74	1.94	1.4	0.38
Asset index	-0.92	0.2	2.45	0.07	-1.1	0.72	2.4	0.00	-1.02	0.52	2.4	0.00

6.2.2 Estimation procedure

Factors influencing the observed group difference in the WTP for orange maize grain were examined. Two datasets in the BDM experiment were considered where WTP was elicited in the biofortified orange maize variety only. As noted earlier, respondents either bid in the first-price auction once before the main BDM, or bid in the first-price auctions for 10 times before the main BDM bid. This analysis uses part of the dataset in chapter 3 and in Hamukwala et al. (2019) as previously indicated, that came to a conclusion that bids from individuals who bid 10 repeated rounds for the biofortified orange maize provided better estimates of WTP. Thus, the dataset with repeated rounds of the first-price auction was used for this analysis. This data was right-censored, with 25% of respondents submitting WTP values of K2000 per 2.5 kilograms of orange maize grain. A Tobit model, therefore, as specified in equation 2.10 was used to estimate WTP by gender. The BDM bid submitted by each individual was used as a dependent variable. The independent variables include gender, age, education, asset levels, household size and number of children below the age of 5 years (see Table 6.2 below). Specification tests for homoscedasticity and normality assumptions for the Tobit model revealed that the assumption of normality could not be upheld at $p<0.05$. Thus, the logarithm of the bid was used to circumvent this problem.

Table 6.2: Variables Used for the Tobit model

Variable	Definition
Bid	Bid submitted to buy a 1 kg of the dry grain of biofortified orange maize in Zambia kwacha
Education	Years of educational attainment at the baseline
Age	The age of the respondent in of years at the baseline
Age 2	Square of age
Asset index	Average household and productive assets of the first principle component
Gender	Coded 1 if male, 0 otherwise
Children	Coded 0 if one has children below the age of 5 years, 0 otherwise

6.2.3 Results

A constrained Tobit regression model using the logarithm of bids for orange maize as a dependent variable (assuming gender differences in the intercepts only) was estimated and compared to the unconstrained model (which allows gender differences to vary across coefficients). Table 6.3 (1) shows estimates of the unconstrained model, with results indicating that gender was the only significant factor explaining the bidding behaviour ($p<0.05$) of respondents for the orange maize variety. Specifically, males' bids for orange maize were 12.2 percent higher than that of females.

Results in the unconstrained model as shown in Table 6.3 (2) indicate that allowing the determinants of WTP to vary by gender, the gender gap in the WTP for orange maize was explained by respondent's age ($p<0.01$) and education ($p<0.1$). In particular, males were willing to pay more for orange maize than females as one's age increased. On the other hand, males' WTP reduced with increases in educational attainment compared to their female counterparts. A likelihood ratio, testing the equivalence of the two models was also significant in favour of the unrestricted model. These results, therefore, suggest that gender differences in WTP with respect to age and education indeed existed. The negative effect of education may be due to the absence of nutritional information about the new maize variety which allowed room for uncertainty. On the other hand, older males' higher WTP for orange maize is plausible and in agreement with what theory would predict. In general, older respondents are considered to be risk-averse to new technology. As females tend to be risk-averse to the new technology, older females may have taken more of the risk-averse attitude of the new variety than older males. These results are however inconclusive, given the smaller sample size.

Table 6.3: Gender differences in willingness to pay for biofortified orange maize

Variables: Log bid	(1) Constrained model	(2) Unconstrained model
Household size	0.007	0.000
	(0.006)	(0.006)
No. of children	0.016	0.039
	(0.023)	(0.036)
Age	0.008	0.011
	(0.011)	(0.011)
Age square	-0.000	-0.0003*
	(0.000)	(0.000)
Gender	0.122**	0.022
	(0.051)	(0.306)
Education	-0.004	-0.037
	(0.010)	(0.041)
Asset index	-0.010	-0.004
	(0.011)	(0.016)
Education square		0.003
		(0.003)
Gender x household size		0.006
		(0.012)
Gender x age		0.013***
		(0.005)
Gender x education		-0.042*
		(0.021)
Gender x assets		-0.013
		(0.022)
Gender x no. children		-0.031
		(0.046)
Constant	7.194***	7.310***
	(0.247)	(0.312)
Sigma: constant	0.177***	0.159***
	(0.015)	(0.013)
Obs.	72	72
Likelihood ratio-test chi2(6)	15.77***	

Standard errors are in parenthesis *** p<0.01, ** p<0.05, * p<0.1

6.2.4 Summary

This study examined gender differences in the WTP for a new maize variety biofortified with vitamin A in Zambia and also to address what lies behind gender differences in WTP in the absence of nutrition information. Data is from the BDM experiment conducted in the absence of nutrition information. Results revealed that males were significantly willing to pay more for orange maize than females. This was prominent among older males who were WTP more than older females. On the other hand, males with more years of schooling were less willing to pay for orange maize compared to females, although this relationship is weak statistically.

6.3 Gender differences in the willingness to pay for biofortified iron beans in Rwanda

Gender differences were explored in the WTP for two iron-biofortified bean varieties, in comparison to a popular local variety that is 40 percent lower in iron in the Gankeke district of Rwanda. As in the previous section (5.3), the study uses the dataset in Oparinde et al. (2015) which investigated consumers' WTP for iron biofortified bean varieties and the effect of the nutrition messaging tools in promoting consumer acceptance. The current study examines whether WTP for iron-biofortified beans differed by gender, based on product and personal characteristics, nutrition information framing (i.e., "gain" versus "loss" frame), and the frequency of nutrition information provision to consumers during the experimental process.

6.3.1 Mean willingness to pay of beans by bean variety, gender and information scenario

Table 6.4 shows consumers' mean bids in Rwandan Franks (RF) for beans by gender and variety from an independent T-test, under five information scenarios (explained in Table 6.5). As shown in Table 6.4(1), sample WTP averages in all of the five information scenarios generally show that consumers submitted higher bids for the red iron bean variety, seconded by the local bean variety, while, the white iron bean variety had the lowest mean bid.

The comparison of WTP by gender, variety and information scenarios is as shown in the mean difference column of Table 6.4. Results indicate generally that bids were not significantly different for males and females in each of the varieties and nutrition information scenarios. The only exception was observed in the biofortified red iron bean variety where females' bids were higher than men's. This was observed when nutrition information was presented in the negative frame, three times during the experiment, with females bidding 43.35 RF higher than males of the same status($p<0.1$).

Table 6.4: Gender differences in mean willingness to pay for one kilogram of beans, by variety and nutrition information

Treatment	Variety	(1) All	(2) Male	(3) Female	Mean Difference.	Std. Er	Obs.
	Local beans	476.06	493.38	457.90	-35.48	23.07	127
No information	Red iron beans	509.13	513.85	504.19	-9.65	21.43	127
	White iron beans	430.16	448.28	411.45	-36.83	24.53	126
	Local beans	424.77	422.46	426.53	4.08	18.44	132
Positive info-once	Red iron beans	488.41	473.68	499.60	25.92	19.77	132
	White iron beans	378.03	372.28	382.40	10.12	19.23	132
	Local beans	399.79	409.78	390.41	-19.37	21.57	95
Positive info-thrice	Red iron beans	479.05	480.00	478.16	-1.84	24.84	95
	White iron beans	371.68	389.13	355.31	-33.82	24.72	95
	Local beans	412.97	404.26	419.32	15.07	16.47	128
Negative info-once	Red iron beans	476.56	462.04	487.16	25.13	18.83	128
	White iron beans	363.83	347.59	375.68	28.08	19.65	128
	Local beans	413.11	407.50	417.60	10.10	21.76	90
Negative info-thrice	Red iron beans	495.78	471.75	515.00	43.25*	23.54	90
	White iron beans	388.88	384.50	392.45	7.95	26.88	89
All respondents	Local beans	427.54	431.79	423.94	-7.86	9.32	572
	Red iron beans	489.97	482.06	496.65	14.58	9.59	572
	White iron beans	387.00	390.65	383.92	-6.74	10.34	570

*** p<0.01, ** p<0.05, * p<0.1

6.3.2 Factors influencing bidding behaviour for biofortified beans by gender

WTP differences for males and females were examined, as well as the effect of covariates on males and females' WTP for biofortified iron beans (personal characteristics, product attributes, and nutrition information treatments). Data description and sampling are as shown in 5.3.1. The BDM experiment as stated earlier consisted of three bean varieties and five information scenarios where respondents bid in each of the three varieties of beans, following a hedonic taste experience. Bidding of participants in each of the three varieties implied that three WTP observations were collected from each participant, giving a total of 1716 observations (572 respondents x 3 varieties). The resulting pooled data set were likely to have cross-sectional heterogeneity as a result of multiple bidding by the same individual across the three bean varieties. As such, a random parameter model for the ordinary least squares was specified to account for the unobserved heterogeneity of bids, within and across individuals as recommended by Lusk, et al. (2004). Further, the Breusch and Pagan Lagrangian multiplier effect test for random effect over pooled ordinary least squares was highly significant $\chi^2_{df(1)} = 554.59, p = 0.000$, in favour of the random-effects model.

The random-effects model can account for the error correlations across equations, given that the three WTP values from the three different bean varieties come from the same respondent. The distributions of bids (WTP) by gender in the overall (pooled) sample is as shown in figure 6.2 below. The results suggest that the distribution of bids were similar across gender, especially at higher prices. At lower prices, however, females' bids were slightly elevated.

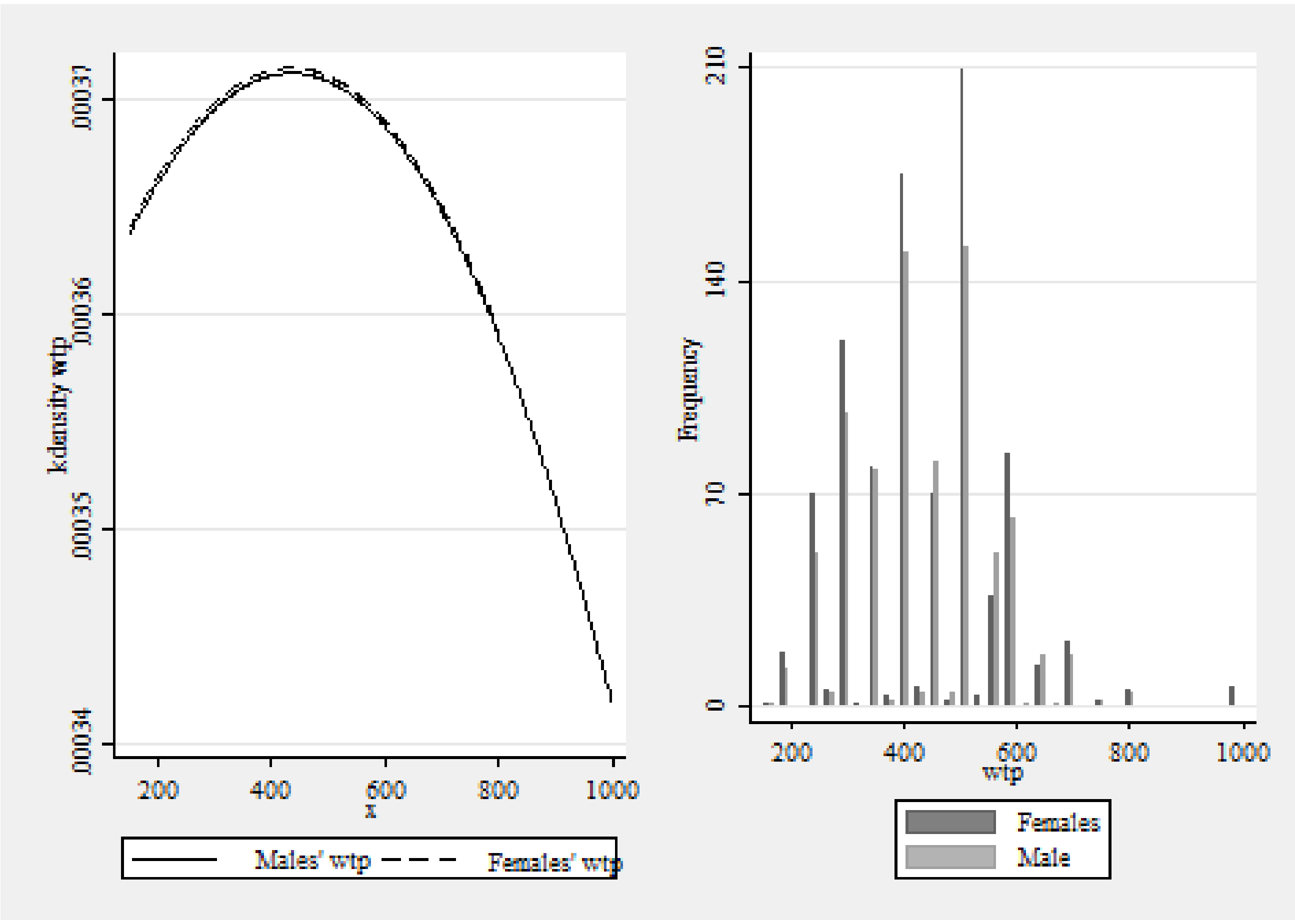


Figure 6.2: Distribution of bids for beans in Rwanda

6.3.3 Model Specifications

The following random effect model was specified to explain bidding behaviour in the three varieties of beans by gender.

$$Bid_{ij=}WTP_{ij=}f\left(X'_{ij}\beta + Z'_{i}\delta + GK'_{ij}\gamma + \mu_i + \varepsilon_{ij}\right) \quad (6.3)$$

where: $\mu_i \sim IID\ (\sigma, \sigma_{\mu}^{2})$ and $\varepsilon_i \sim IID\ (\sigma, \sigma_{\varepsilon}^{2})$

WTP is the individual's bid in bean variety j.

X'_{ij} is a set of variety varying explanatory variables (variety type, i.e., local beans, red iron beans, and white iron beans)

Z'_{i} is a vector of variety invariant explanatory variables such as gender, age, assets, education, and dietary information.

K' is a set of explanatory variables that interacted with the gender of the decision-maker.

G is equal to 1 if male, zero otherwise

β, γ, and δ are coefficients in Xs, Zs, and Ks respectively

ε is a vector of random error terms

μ is a vector of unobserved individual effects.

Table 6.5 below shows a description of the variables used in the econometrics model. Gender differences were tested using interactions with explanatory variables that were believed to matter in the WTP outcomes of males and females as discussed in the literature.

Table 6.5: Variables used in the determinants of WTP for biofortified beans

Variable	Definition
Bid	The logarithm of the bid submitted to buy a 1 kg of dry grain beans in Rwandan Franks
Education	Years of educational attainment at the baseline
Age	The age of the respondent in years at the baseline
Age 2	Square of age
Asset index	Average household and productive assets of the first principle component
Anaemia	Coded 1, if the subject had knowledge of anaemia before the study, 0 otherwise
Gender	Coded 1 if male, 0 otherwise
Variety	Coded 1 if local
	Coded 2 if red iron biofortified beans
	Coded 3 if white iron biofortified beans
Information scenario	Is a vector of dummy variables representing 5 levels of information treatment, and is equal to;
	1 if the respondent received no nutrition information during the experiment
	2 if the respondent received the gain frame information once in the experiment
	3 if the respondent received the gain frame information thrice in the experiment
	4 if the respondent received the loss frame information once in the experiment
	5 if the respondent received the loss frame information thrice in the experiment

6.3.4 Results

A random effect ordinary list squares model was used to estimate the determinants of WTP for the three bean varieties under consideration, and the results are as shown in Table 6.6. To begin with, a short model was estimated (without covariates) to determine how much respondents, in general, were willing to pay for the two biofortified beans relative to the local bean variety. The results of this model are listed in Table 6.2 (1)). As can be seen, consumers were willing to pay a premium for the red iron biofortified variety. On the contrary, consumers were only willing to pay for the white iron beans when offered at a discount. Both results are significant at $p < 0.01$.

In Table 6 (12), we estimate factors that affected WTP for the iron-biofortified bean varieties using interactions. We find that education, gender, assets, and nutrition information, all influenced how much respondents were willing to pay for the two iron-biofortified bean varieties. In particular, increases in educational attainment positively impacted WTP for the white iron bean variety ($p<0.05$). The same, however, did not apply to the red iron bean variety. A gender difference was observed only in the WTP for the red iron bean variety, where men's bids were lower by 22 Rwandan franks ($p<0.05$). WTP for the white iron beans also decreased as one's asset increased. This suggests that the poor were the more accepting group for the white iron bean variety, and if that was the case, then biofortification would be self-targeting.

Nutrition information offered in a positive frame, regardless of frequency of presentation, and that presented in the negative frame, three times during the experiment, all significantly increased respondents' WTP for the red iron bean variety ($p< 0.05$). However, the same did not apply for the white iron bean variety, as none of the nutrition information variables were significant at $p<0.05$. This may imply that other factors were important in determining WTP for the white iron beans beyond its perceived nutrition value. Additionally, this variety was also the least preferred in its hedonic attributes as shown in the previous chapter. The contrast in these results suggests that, while nutrition value may be necessary for acceptance, this attribute is not sufficient to guarantee acceptance, as it was conditional on consumers accepting other preferred characteristics as well. This also suggested the need to further develop the attributes of this bean varieties as consumers were not willing to pay extra for the nutrition attributes.

In Table 6(3), we examine whether the effect of covariates on willingness to pay for beans had a different effect on men's and females' WTP for iron-biofortified beans. We find no evidence of gender differences in most of the covariates, implying that they all had the same effect on males and females' WTP for biofortified bean varieties. The exception was, however, observed among the respondents who had some knowledge about anaemia compared to those that did not. As can be seen, this variable is negative, suggesting that males with knowledge about anaemia submitted lower bids for the red iron bean variety, compared to females of the same status. A Wald statistic yielded a chi-square (2) of 6.16 and a p-value of 0.0459, suggesting a significant relationship at $p<0.05$. Additionally, the gender difference in WTP for the red iron been varieties was no longer significant.

We also tested whether males and females responded differently to nutrition messages as hypothesized in the literature (Table 6, model 3). Without being variety specific, results suggested that there were gender differences in consumers' bidding behaviour for beans based on nutrition messages, regardless of how the messages were framed, in comparison to the absence of nutrition messages. In particular, males were less responsive than females as shown by their lower WTP when nutrition messages were offered in a “gain” frame once in the experiment, and also in the “loss” frame, regardless of the frequency with which information was received.

Thus, message framing, whether in the loss or gain frame did not show any gender differences in WTP for biofortified beans. Specifically, males ‘s mean WTP was lower than that of females, regardless of how the message was framed. While results, on one hand, are according to the “loss aversion” hypothesis predictions where females would be more responsive to promotional messages offered in the negative frame, thus, expected to submit higher bids, females were also more responsive in the “gain” frame messaging when compared to men. A possible explanation could be that nutrition messages mattered more to females than it did for males, thus masking the message framing effect.

Table 6.6: Gender differences in willingness to pay for iron beans

	(1)		(2)		(3)	
Variables: WTP	**Short model**		**Variety interactions**		**Gender x variety interactions**	
Red iron variety	62.43***	(4.296)	-16.34	(42.36)	58.89***	(9.435)
White iron variety	-40.46***	(4.301)	-111.1***	(42.39)	-40.85***	(9.435)
Education			2.170	(1.829)		
Age			-0.474	(2.157)		
Asset index			0.593	(3.778)		
Hh size			0.692	(3.254)		
Gender			2.027	(10.58)	32.52	(21.46)
No. of children < 5 years			-7.831	(9.434)		
Anaemia knowledge			-15.15	(10.52)	-10.06	(13.34)
Iron bean info			-26.00	(21.81)		
Positive info-once			-40.69***	(15.54)	-21.73	(16.65)
Positive info-thrice			-65.55***	(16.85)	-50.04***	(18.56)
Negative info-once			-58.22***	(15.53)	-30.74*	(16.76)
Negative info-thrice			-58.57***	(17.07)	-16.42	(18.46)
Red iron x education			-0.0602	(1.610)		
White iron x education			3.908**	(1.610)		
Red iron x age			2.050	(1.898)		
White iron x age			1.366	(1.899)		
Red iron x assets			-4.222	(3.325)		
White iron x assets			-6.964**	(3.332)		
Red iron x hh size			2.954	(2.864)		
White iron x hh size			0.750	(2.865)		
Red iron x gender			-22.16**	(9.314)	-1.141	(13.52)
White iron x gender			1.605	(9.315)	-3.386	(13.54)
Red iron x children			9.433	(8.304)		
White iron x children			10.97	(8.307)		
Red iron x +ve info-once			24.79*	(13.68)		
Red iron x +ve info-thrice			46.26***	(14.83)		
Red iron x -ve info-once			32.02**	(13.67)		
Red iron x -ve info-thrice			55.09***	(15.02)		
White iron x +ve info-once			6.685	(13.68)		
White iron x +ve infothrice			18.97	(14.83)		
White iron x -ve info-once			0.780	(13.67)		
White iron x -ve info-thrice			26.69*	(15.06)		
Red iron x anaemia			4.049	(9.257)	22.20*	(11.96)
White iron x anaemia			1.110	(9.263)	1.292	(11.97)
Red iron x ironbeaninfo			33.17*	(19.20)		
White iron x ironbeaninfo			13.64	(19.20)		
Gender x anaemia					2.821	(19.51)
Gender x red iron x anaemia					-35.18**	(17.49)
Gender x white iron x anaemia					4.472	(17.51)
Gender x +ve info-once					-40.25*	(24.24)
Gender x +ve info-thrice					-8.159	(26.36)
Gender x -ve info-once					-48.75**	(24.53)
Gender x -ve info-thrice					-47.88*	(26.86)
Constant	427.5***	(4.854)	486.0***	(48.13)	453.3***	(15.53)
Sigma _u cons	90.55***	(3.277)	89.68***	(3.429)	87.60***	(3.203)
Sigma _e cons	72.65***	(1.520)	71.31***	(1.581)	72.17***	(1.510)
N	1714		1526		1714	

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.3.5 Summary

The purpose of this study was to determine whether there were gender differences in the WTP for two bean varieties that were biofortified with iron. Using a BDM field experiment, the data were collected by HarvestPlus among rural households in Rwanda's Gankeke district. Respondents were asked to value two new iron-biofortified bean varieties namely; red iron beans and white iron beans, as a possible way to alleviate the problem of iron deficiencies in Rwanda. A popular local variety that is 40 % lower in iron was used as a standard of comparison. Although there were no apparent visual differences of the iron-biofortified beans from the local bean varieties, researchers were unsure whether the increase in iron content could have led to changes in other intrinsic attributes that may pose a challenge in consumer acceptance.

A random effect ordinary least square regression was specified while accounting for gender differences in WTP for iron-biofortified beans. Results revealed a gender difference in the WTP in the red iron bean variety where females' bids were significantly higher than that of men. Allowing covariates to vary by gender, this gap was explained by the anaemia knowledge variable where females who had prior knowledge or incidence of anaemia, expressed a higher WTP for the red iron bean variety. This is not surprising since prevalence rates of anaemia for females are considerably higher than for males.

The study also found that females were likely to increase their bids for beans in the presence of nutrition information compared to males. These findings are according to the predictions of both the selectivity hypothesis and the brain lateralisation theory. Both theories recognise gender differences in the processing of information. The brain lateralisation theory claims that females are leftward lateralised and thus have a linguistic advantage over males. On the other hand, the males are believed to be rightward lateralised, hence they are more likely to have visuospatial abilities advantage over females (Clements, et al., 2006). This implies that males were less likely to respond favourably when promotional messages were presented in a verbal form alone, as was the case in this study (where only audio messages were given to respondents). Thus, gender differences in nutritional message responses could have arisen from the way the messages were presented to respondents, disadvantaging men. Future advertising, therefore, may consider other methods to attract men's attention, such as adding reinforcements to verbal nutritional messages such as pictures, drama, and music.

According to Meyers-Levy and Sternal (1991), the selectivity hypothesis distinguishes males' and females' responses to adverts based on how they process information. Specifically, females are regarded as extensive processors, needing a lot of information before making a purchase decision. Men, on the other hand, are selective processors of information and would only make a purchase decision using a subset of available information. Given that females responded positively to promotional messages compared to males in this study, gender-differentiated advertising may be appropriate. Specifically, gender differences in styles of information processing suggest that future advertising should also consider messages intended to capture men's attention. According to Putrevu (2004), messages targeted to males should be streamlined and focused on just one theme, while females should be provided with a lot of information about the product.

Another plausible explanation for gender differences in nutrition messages responses could be a result of gender differences in the attitudes towards the health attributes of beans. As previously noted in the literature, females are more likely than males to be concerned about the nutrition aspect of food (Holgado et al. 2000). These results suggest that researchers should consider taking a gendered approach to promote biofortified beans.

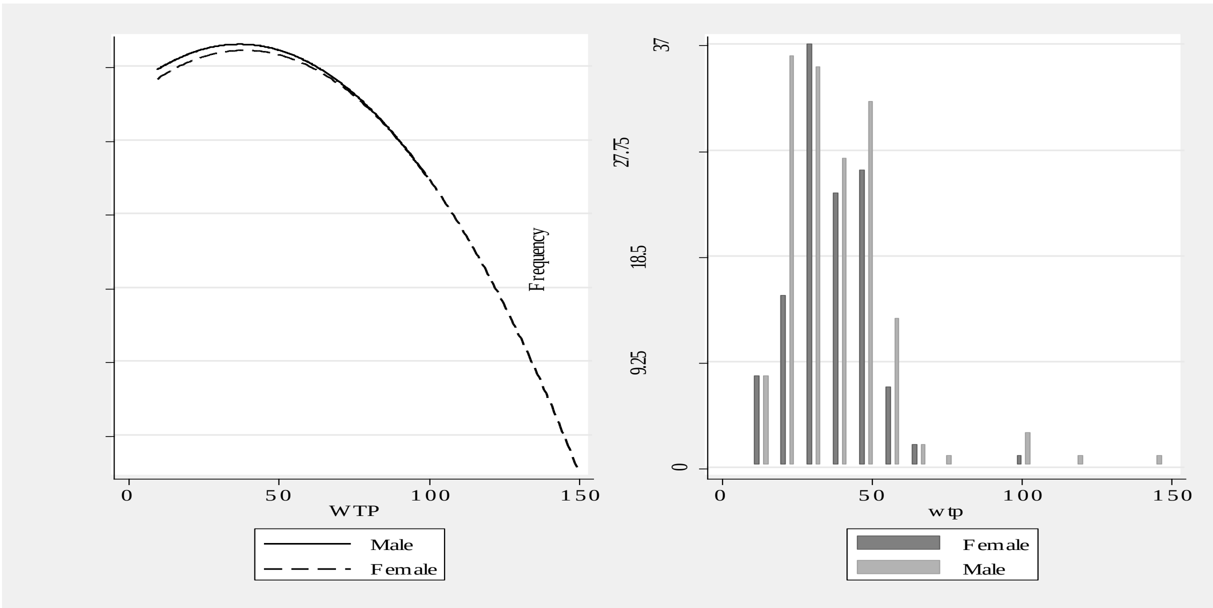
6.4 Gender differences in willingness to pay for vitamin A biofortified cassava in Nigeria

6.4.1 Introduction

Willingness to pay (WTP) for cassava varieties biofortified with vitamin A was elicited from the BDM experiment. Respondents were asked to bid on each of the three cassava varieties in Imo and Oyo states of southern Nigeria, under three nutrition information scenarios. As stated in the previous chapter, the data used were part of the larger dataset used by Oparinde et al. (2014) that evaluated WTP for two new cassava varieties, and how WTP was impacted by nutrition information associated with the channel of distributing cassava planting material. The nutrition information treatment came in three forms. The first group was a control group where no nutrition information about the biofortified cassava varieties was provided. The second group received nutrition information, along with a statement indicating that the Federal government of Nigeria would be responsible for delivering cassava planting materials. The third group received the same message, with a statement indicating that an international organisation would be delivering the cassava planting material. Study design and sampling are as reported in 5.4.1

Packaging measures commonly used in each state were used for selling a cassava product known as *gari* during experiments. In the state of Imo, respondents were asked to bid for a 300-gram pack of *gari*, while respondents from Oyo bid for a 500-gram pack of *gari*. The distribution of aggregate bids of *gari* for both Imo and Oyo state shown in Figure 6.3 indicates that males and females had a similar WTP distribution in both experimental locations.

Willingness to pay for cassava gari: Oyo state



Willingness to pay for cassava gari: Imo state

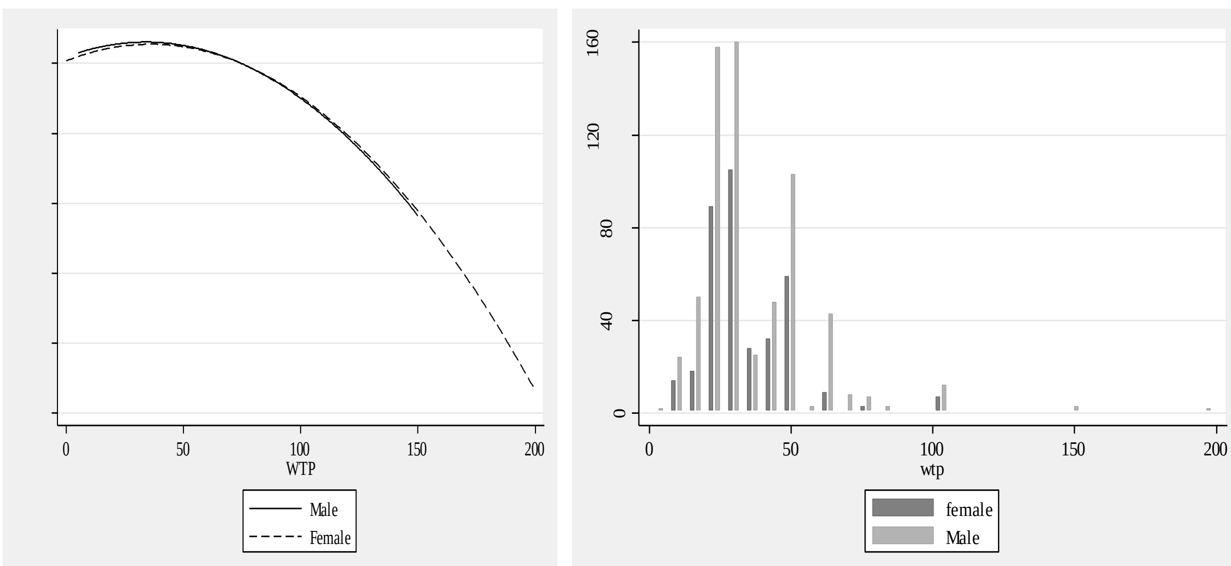


Figure 6.3: Distribution of aggregate bids for gari cassava in Southern Nigeria

Table 6.7 reports gender differences in the mean bids by variety, information treatment, and state, based on an independent T-test. These results are just a first look at the mean bids comparison between male and female respondents without controlling for any of the variables that could possibly explain the differences. The results indicate that there were no gender differences in respondents' bids in all the cassava varieties and treatments for both states. In the following section, we determine whether WTP determinants differed by gender.

Table 6.7: Mean bid price differences by gender, cassava variety, and treatment in Nigeria

	Treatment	Variety	All	Female	Male	Diff.	Std. Error	N.
Oyo state	No information	Local	40.33	38.75	41.39	-2.64	(7.04)	30
		Light yellow	45.17	45.00	45.28	-0.28	(10.76)	30
		Dense yellow	38.33	40.00	37.22	2.78	(6.61)	30
	Information-federal govt	Local	28.85	26.07	32.08	-6.01	(4.42)	26
		Light yellow	38.85	37.86	40.00	-2.14	(5.73)	26
		Dense yellow	38.46	35.36	42.08	-6.73	(6.72)	26
	Information-inter agent	Local	31.11	32.31	30.43	1.87	(3.75)	36
		Light yellow	42.08	42.31	41.96	0.35	(5.41)	36
		Dense yellow	41.25	40.38	41.74	-1.35	(4.84)	36
	All	Local	33.49	32.13	34.53	-2.40	(3.06)	93
		Light yellow	42.26	41.75	42.64	-0.89	(4.24)	93
		Dense yellow	39.52	38.50	40.28	-1.78	(3.32)	93
Imo state	No information	Local	39.41	37.40	40.58	-3.18	(3.20)	122
		Light yellow	30.80	29.96	31.29	-1.33	(3.23)	122
		Dense yellow	34.93	33.11	35.99	-2.88	(3.81)	122
	Information-federal govt	Local	36.36	36.09	36.47	-0.38	(4.10)	111
		Light yellow	34.65	34.89	34.55	0.34	(4.07)	111
		Dense yellow	41.34	39.44	42.14	-2.70	(6.49)	111
	Information-inter agent	Local	33.05	31.93	33.84	-1.91	(2.81)	106
		Light yellow	31.75	30.20	32.84	-2.63	(3.09)	106
		Dense yellow	34.92	34.09	35.52	-1.43	(3.17)	106
	All	Local	36.42	35.07	37.18	-2.11	(1.96)	339
		Light yellow	32.36	31.38	32.90	-1.52	(1.99)	339
		Dense yellow	37.03	35.18	38.06	-2.89	(2.65)	339

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.4.2 Determinants of willingness to pay for biofortified cassava in Nigeria by gender

In order to explore gender differences in WTP for vitamin A-biofortified cassava, data were treated as a panel since every respondent provided three bids, i.e., one in each of the three cassava varieties under auction. The submitted bids were taken as a dependent variable in each of the datasets, yielding 279 (3x93) in Oyo state and 1017 (3x339) observations in Imo state. The explanatory variables included dummies for the cassava variety type, dummies for the nutrition information treatments as well as personal characteristics at the baseline, such as age, wealth status, educational attainment, number of children under the age of five years, and household size. A dummy variable representing whether or not one had gari at home was also included to determine if an endowment effect could possibly bias WTP for vitamin A-biofortified cassava. In order to control for non-normality, data transformation was done on the variables representing respondent's age and number of years of education by taking their logarithms. Additionally, as a respondent could not submit a negative bid, a logarithm of bids was used as a dependent variable (see Table 6.8 below for variable description).

Table 6.8: Variables used in the Econometric Analyses

Variable	Definition
Log bid	The logarithm of the bid submitted to buy a 300g/500g pack of cassava *gari* in Naira
Log education	The logarithm of years of educational attainment at the baseline
Log age	The logarithm of the age of the respondent in years at the baseline
Asset index	Average household and productive assets of the first principle component
Anaemia	Coded 1, if the subject had knowledge of anaemia before the study, 0 otherwise
Gender	Coded 1 if male, 0 otherwise
Cassava endowment	Coded 1 if a respondent had *gari* at home, 0 otherwise
Variety	Coded 1 if local
	Coded 2 if light yellow cassava (LY)
	Coded 3 if dense yellow cassava (DY)
Information	1 if the respondent received no nutrition information during the experiment
scenario	2 if the respondent received information endorsed by the federal government
	3 if the respondent received information endorsed by NGOs or international agent

6.4.3 Model Specification

The following random effect regression model was specified to explain bidding behaviour in the three cassava varieties by gender in each of the two states:

$$Bid_{ij=}WTP_{ij=}f\left(X'_{ij}\beta + Z'_{i}\delta + \mu_i + \varepsilon_{ij}\right) \quad (6.1)$$

with: $\mu_i \sim IID\ (\sigma, \sigma_\mu^2)$ and $\varepsilon_i \sim IID\ (\sigma, \sigma_\varepsilon^2)$

Where:

WTP is the individual's bid in a cassava variety j.

X'_{ij} is a set of variety varying explanatory variables (variety type, i.e., local cassava, light yellow cassava, and dense yellow cassava)

Z'_i is a vector of variety invariant explanatory variables such as gender, age, assets, education, and dietary information.

β and δ are coefficients in Xs and Zs respectively

ε is a vector of random error terms

μ is a vector of unobserved individual effects.

6.4.4 Regression results by State

To begin with, a short model was estimated in each state indicating the general WTP for the two biofortified cassava varieties, over the state-specific conventional variety. In Oyo state (Table 6.9, model 1), respondents were willing to pay a premium for the light yellow cassava variety ($p<0.01$), but indifferent in their WTP for the dense yellow variety, as shown by the insignificant p-value. On the contrary, respondents in Imo state were willing to pay for the light yellow cassava variety when offered at a discount ($p<0.01$) and were also indifferent between the dense yellow cassava variety and the conventional cassava variety. As earlier stated, Oyo state inhabitants had a stronger preference for the white cassava products, while those in Imo state preferred the yellow cassava products. Thus, each group of respondents preferred the biofortified cassava variety with attributes closer to their local variety.

The covariates for WTP were added to the short model in each of the states and the results are displayed in Table 6.9 model 2, for Oyo state and model 4 for Imo state. Results for Oyo state indicate that educational attainment, household size, and the nutrition information treatments all influenced WTP for cassava. Educational attainment decreased consumers' WTP for cassava in general, while the household size, and nutrition information with an endorsement from an international agency, all increased respondents' WTP. In Imo state, WTP for cassava reduced as one's wealth increased ($p< 0.01$).

Cassava variety-specific effects were estimated in the third model in each state (i.e., model 3 for Oyo state, and model 6 for Imo state). Results revealed that WTP for the biofortified varieties by respondents in Oyo state was influenced by ones' age, education, assets, gender, number of younger children, gender, nutrition information, prior knowledge about vitamin A, household size, and the amount of gari one had at home. In particular, older respondents bid significantly more for the dense yellow variety ($p<0.01$). This gave some credence to the idea that older consumers were more willing to accept food products with nutritional benefits than younger consumers.

The effects of educational attainment and assets were ambiguous. Increases in wealth positively affected WTP for the light yellow variety, while impacting negatively on the WTP for the dense yellow cassava variety ($p<0.05$). As earlier noted in the literature, the perception about the nutrition value, based on wealth status can be also ambiguous. A negative relationship of wealth and WTP, imply that poorer individuals may have found cassava as the most inexpensive source of vitamin A. On the contrary, the positive relationship implies that wealthier individuals can afford to pay more for nutritious cassava varieties than poorer individuals as noted by Palma et al. (2017).

The interaction term for gender and the light yellow cassava variety was negative and significant, indicating that males submitted lower bids for the light yellow cassava compared to females ($p<0.01$). This suggested that males and females were looking for different attributes when valuing the light yellow cassava varieties. Similarly, the effect of the amount of schooling was negative on the WTP for the light yellow cassava variety, whereas, the amount of schooling, increased WTP for the dense yellow variety ($p<0.01$). A significant positive relationship between WTP and the amount of schooling is consistent with the literature. As earlier stated, respondents with higher education levels also have higher scientific literacy and knowledge about novel food products on the market. On one hand, the more educated were more likely to understand and appreciate the perceived nutritional benefits. On the other hand, respondents with higher education were also more likely to judge or question the nutrition value claims. While, individuals with lower education levels may not be very much aware and knowledgeable about nutritional dietary requirements, especially for micronutrients, as would be those with more education.

Respondents with young children were willing to pay more for the two biofortified versions of cassava ($p<0.05$). This outcome was expected, as individuals with children may have considered the benefits that nutritious cassava varieties would have for their children. Nutrition information had a significant and positive impact on WTP for both biofortified cassava varieties, regardless of an endorsing agent. WTP also increased when one had prior knowledge about vitamin A for the light yellow cassava variety. On the other hand, WTP decreased if one had *gar*i at home for both biofortified cassava varieties, and for the dense yellow cassava variety as family size increased.

In rural Africa, family size is a symbol of wealth. In some societies, family size is positively related to wealth, as wealthier households are perceived to have the capacity of supporting a larger family. Yet in others, the relationship can be negative, as larger households sometimes have less wealth per capita. Thus, household size can be a proxy for wealth status, hence the relationship of household size with WTP could either be positive or negative. A positive relationship of WTP with the variable representing whether or not a respondent had knowledge about vitamin-A prior to the survey, suggested that respondents with prior knowledge were more willing to pay for the light yellow cassava variety ($p<0.01$) than those without. Such consumers may have found biofortified cassava as a possible inexpensive source of vitamin A compared to other substitutes.

Factors that impacted WTP for the two biofortified cassava varieties for Imo state were nutrition information variables, and a variable representing the amount of gari the respondent had at home. In particular, nutrition information regardless of an agent to be engaged in the cassava planting materials distribution had a positive impact on WTP for both biofortified cassava varieties. The interactions for gender and cassava variety types were insignificant, suggesting that WTP outcomes for cassava for males and females were similar. A negative relationship was observed between the amount of gari one had at home and their WTP for both cassava biofortified varieties. This implied that increasing amounts of gari at home lowered how much an individual was willing to pay for a given biofortified variety. A possible explanation for such behaviour could be drawn from the "endowment effect" often observed in experiments. Kahneman et al. (1991) assert that this occurs when individuals tend to overprize something they own, regardless of its true market value, of which the authors alluded to as "loss aversion".

We also considered the possible impact of cash constraints since participants were not compensated for participating in the experiment, hence used their own money, either by cash or credit to make purchases. This might imply that rational bidding could have been compromised by some participants who had cash constraints although results in the literature on this aspect have been mixed. Results showed that 11 % of individuals in Imo state and 6% in Oyo state did not want to make the actual payment despite having won the auction. A logit regression model used to characterize such individuals found that none of the individual characteristics could explain their behaviour (not shown here). Observations for such individuals were therefore dropped from the analysis since nothing could be said about their market behaviour.

These results suggest that factors influencing WTP may differ depending on the variety of the biofortified crop and study characteristics of respondents. However, the sample size in Oyo was smaller, as such the results may not be conclusive. In the next section, we combined the two datasets due to the fewer observations in Oyo and examined whether any of the covariates varied by gender in influencing WTP for biofortified cassava varieties.

Table 6:9: Factors influencing WTP for cassava in Nigeria by state

	Oyo state						Imo state					
	(1)		(2)		(3)		(4)		(5)		(6)	
	Short model		Basic model		Variety interactions		Short model		Basic model		Variety interactions	
Log bid	β	se	β	se	β	se	β	se	β	β	β	se
LY variety	0.219***	(0.0511)	0.208***	(0.0611)	0.543	(0.448)	-0.141***	(0.0210)	-0.140***	(0.0222)	-0.585**	(0.298)
DY variety	0.164*	(0.0859)	0.155	(0.101)	-0.209	(0.192)	-0.0271	(0.0173)	-0.0273	(0.0174)	-0.0612	(0.210)
Log age			-0.0496	(0.0919)	-0.0309	(0.0516)			-0.0758	(0.0590)	-0.116	(0.0905)
Log education			-0.0482**	(0.0199)	-0.0155	(0.0120)			0.0370	(0.0387)	0.0245	(0.0363)
Asset Index			-0.0176	(0.0177)	-0.0145**	(0.00584)			-0.0384**	(0.0174)	-0.0336***	(0.0120)
No. children			0.0131	(0.0574)	-0.0322	(0.0471)			-0.0172	(0.0106)	-0.000819	(0.0108)
Sex			-0.0563*	(0.0340)	-0.0179	(0.0454)			0.0562	(0.0352)	0.0645	(0.0474)
Govt. info			-0.0674	(0.0503)	-0.263***	(0.0584)			0.0258	(0.0564)	-0.113**	(0.0550)
International info			0.0191**	(0.00852)	-0.181***	(0.0173)			-0.0502	(0.0613)	-0.199***	(0.0570)
Vita A knowledge			0.0542	(0.117)	0.0442	(0.136)			-0.0102	(0.0243)	0.00414	(0.0219)
Hh size			0.0281***	(0.00427)	0.0330***	(0.00200)			0.00145	(0.00671)	0.00408	(0.00696)
Gari at home					-0.0337	(0.0914)					-0.0472	(0.0474)
LY variety log age					-0.0838	(0.145)					0.0986	(0.0687)
DY variety x log age					0.0589***	(0.0184)					-0.000979	(0.0588)
LY variety x log education					-0.0829***	(0.0293)					0.0149	(0.0366)
DY variety x log education					-0.0285***	(0.00491)					0.0265	(0.0307)
LY variety x assets					-0.0227**	(0.00951)					0.00115	(0.0123)
DY variety x assets					0.0379***	(0.00929)					-0.00973	(0.0118)
LY variety x children					0.0230**	(0.0110)					-0.0244	(0.0152)
DY variety x children					0.0938***	(0.00978)					-0.0197	(0.0191)
LY variety x gender					-0.131***	(0.0477)					-0.0504	(0.0582)
DY variety x gender					0.00329	(0.0313)					0.0274	(0.0558)
LY variety x govt.info					0.240***	(0.0630)					0.211***	(0.0602)
LY variety x Int.info					0.229**	(0.111)					0.231***	(0.0356)
DY variety x govt.info					0.311***	(0.0399)					0.222***	(0.0584)
DY variety x Int.info					0.350***	(0.0401)					0.218***	(0.0480)
LY variety x Know vitA					0.0691***	(0.0177)					0.0441	(0.0564)
DY variety x Know vitA					-0.0153	(0.0243)					-0.0888*	(0.0468)
LY variety x hh size					-0.00223	(0.00816)					-0.00369	(0.00374)
DY variety x hh size					-0.0146***	(0.00304)					-0.00344	(0.00344)
LY variety x gari					-0.0675**	(0.0317)					-0.0432	(0.0603)
DY variety x gari					-0.0964***	(0.00688)					-0.0303	(0.0811)
Constant	3.429***	(0.00919)	3.515***	(0.368)	3.556***	(0.175)	3.496***	(0.0341)	3.748***	(0.214)	3.993***	(0.325)
N	279		255		255		1016		992		986	

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.4.5 Willingness to pay for biofortified cassava varieties by gender in Nigeria (combined)

In this section, we examine whether WTP for biofortified cassava varieties differed by the gender of the decision-maker in Nigeria and further examined whether any of the covariates had a different impact on men's and females' WTP. Due to fewer observations in Oyo state, combined datasets for Oyo and Imo states were used. A random-effect model, with clustered standard errors, was specified while controlling for the state dummy. The shot model shows WTP for the two biofortified varieties by state. Focusing on the interaction terms, results indicate that respondents were willing to pay less for both biofortified varieties relative to the conventional varieties in Imo state when compared to Oyo state ($p < 0.05$). Table 6.10, model 2, lists estimates of factors that affected bidding for biofortified cassava varieties. Results suggested that both nutrition information variables had a significant positive effect on WTP ($p < 0.05$) for both biofortified cassava varieties.

In Table 6.10, model 3, covariates were allowed to differ by gender. As can be seen, males and females differed in their WTP for both biofortified cassava varieties based on nutrition information associated with international agency support. Specifically, males submitted higher bids for both biofortified varieties when nutrition information was associated with an endorsement from an international agency. These results are consistent with the assertion in the literature that men's and females' perceptions of a particular product can be influenced through advertising (Fowles 1996). In particular, males and females would respond positively to products and spokespersons that match their own sense of gender (Fry 1971). Men's positive response to nutrition information, with support from an international agent, may indicate the trust that males had in the international agencies' delivery channel for cassava planting materials. This may be the case if, in the past, international agencies have been more responsive to delivery needs of males for planting materials. Further, males were likely to participate in markets relative to females, and therefore, better placed to make judgments about better delivery channels. Additionally, international agent support for agriculture in Africa was sometimes associated with initial farming grants to farmers, thus, some male consumers may have had this in mind when bidding for the new cassava varieties. Males and females' WTP also differed based on their wealth status, with men's WTP, relative to females, reducing as wealth status increased, and the effect was stronger for the dense yellow variety ($p < 0.05$). This finding is contrary to some findings in literature associating diet quality and income (wealth), suggesting the reduced capacity to purchase for lower-income buyers (Palma et al. 2017). This, however, may be explained by the differences in females' and men's perceptions towards healthier foods.

Table 6.10: Exploring gender differences in respondents' bidding behaviour

Log bid	(1) Basic model		(2) Variety interactions		(3) Gender x variety interactions	
LY variety	0.219***	(0.0380)	0.134**	(0.0580)	0.182***	(0.0322)
DY variety	0.164**	(0.0639)	0.0385	(0.0983)	0.0712	(0.0902)
State (1=Imo, 0=Oyo)	0.0670**	(0.0300)	0.0528*	(0.0274)	0.0643	(0.0448)
LY variety x Imo	-0.360***	(0.0455)	-0.346***	(0.0605)	-0.369***	(0.0367)
DY variety x Imo	-0.191***	(0.0642)	-0.179**	(0.0743)	-0.179**	(0.0813)
Asset index			-0.0285***	(0.00931)	-0.00696	(0.0175)
No. of children			-0.00806	(0.0102)	-0.00347	(0.0358)
Govt. info			-0.150***	(0.0447)	-0.185	(0.140)
International info			-0.193***	(0.0538)	-0.164**	(0.0825)
Household size			0.00949	(0.00594)	-0.000606	(0.0239)
Gender			0.0525*	(0.0309)	-0.0193	(0.179)
LY variety x assets			-0.00247	(0.0106)	0.0229***	(0.00791)
DY variety x assets			-0.000971	(0.0108)	0.0249	(0.0187)
LY variety x children			-0.0167	(0.0133)	-0.0218*	(0.0132)
DY variety x children			-0.00157	(0.0225)	0.0181	(0.0402)
LY variety x govt.info			0.206***	(0.0478)	0.220***	(0.0369)
LY variety x Int.info			0.218***	(0.0277)	0.132***	(0.0422)
DY variety x govt.info			0.239***	(0.0540)	0.219***	(0.0770)
DY variety x Int.info			0.244***	(0.0436)	0.166***	(0.0645)
LY variety x hh size			-0.00169	(0.00268)	-0.000940	(0.00470)
DY variety x hh size			-0.00545*	(0.00305)	-0.00805	(0.00678)
LY variety x gender			-0.0495	(0.0424)	-0.143	(0.109)
DY variety x gender			-0.000368	(0.0442)	-0.0647	(0.0838)
Gender x assets					-0.0373	(0.0258)
Gender x children					-0.00758	(0.0563)
Gender x govt. info					0.0501	(0.155)
Gender x Int. info					-0.0408	(0.0894)
Gender x hh size					0.0131	(0.0287)
Gender x state					-0.0138	(0.0428)
Gender x LY variety x assets					-0.0504*	(0.0275)
Gender x DY variety x assets					-0.0495**	(0.0231)
Gender x LY variety x children					0.00347	(0.0217)
Gender x DY variety x children					-0.0337	(0.0445)
Gender x LY variety x govt.info					-0.0271	(0.0829)
Gender x DY variety x int.info					0.149***	(0.0517)
Gender x LY variety x govt.info					0.0247	(0.0987)
Gender x DY variety x int.info					0.133**	(0.0518)
Gender x LY variety x hh size					0.000361	(0.00532)
Gender x DY variety x hh size					0.00527	(0.00783)
Gender x LY variety x state					0.0565	(0.0925)
Gender x DY variety x state					0.0181	(0.0536)
Constant	3.429***	(0.00684)	3.464***	(0.0557)	3.520***	(0.145)
N	1295		1271		1271	

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.4.6 Summary

The question of whether there were gender differences in consumer’s WTP for the two cassava varieties biofortified with Vitamin A, relative to the local variety was analysed in this study. Two datasets from two regions of southern Nigeria where cassava is a staple food and the preference for the cassava products varied by product colour were considered. These included Imo state which preferred the yellow coloured cassava products and Oyo state where consumers preferred the white cassava varieties. Given that the Vitamin A cassava biofortified varieties were more likely to be yellow in colour from the biofortification process, it was unclear how consumers would react to such differences in their staple food, and whether there would be gender differences in acceptance. The two biofortified cassava varieties were identified as light yellow and dense yellow varieties based on the intensity of the yellow colour.

Gender differences were observed in WTP for *gari-cassava* in combined datasets, with the light yellow cassava variety showing a negative gender difference in WTP ($p<0.1$). males submitted lower bids for the light yellow cassava compared to females. This gap, however, was eliminated with the provision of nutrition information and controlling for the wealth status. In particular, males’ bids increased with nutrition information endorsed by an international agency. On the other hand, WTP for males decreased with assets. The results so far suggest that personal characteristics of males and females such as wealth, as well as, the agency that supports cassava cuttings distribution may influence males and females’ WTP. A gendered approach may be necessary for the promotion of nutritious cassava varieties based on these characteristics. Endorsing agents that meet men’s needs may need to be involved in the promotion.

6.5 Summary on gender differences in acceptance of BFC across three countries

The third objective of this thesis explored gender differences in the acceptance of BFC in three sub-Saharan countries and was analysed theoretically and empirically in chapters 4-6. The study used experimental data from HarvestPlus on the acceptance of new food crop varieties that were biofortified with micronutrients. Specifically, hypotheses tested gender differences in the acceptance of micronutrient-biofortified food crops in Nigeria, Rwanda, and Zambia. Survey instruments used in these studies were virtually identical while covering different biofortified food crops and diverse product promotional tools across three countries. This gave us an opportunity to explore gender differences in acceptance from diverse angles, thus providing a better understanding of gender differences in the acceptance of BFC being introduced in the sub-Saharan African region.

As the crops targeted for biofortification were staple food crops consumed across gender in respective countries, we anticipated that acceptance will be similar for males and females, as no dietary habits were expected to change. However, evidence from the crops that have been biofortified so far, indicates that some of the intrinsic attributes of the staple food crops were likely to change. For example, crops that have been biofortified with vitamin A tend to change the colour of the crop products from the familiar white colour to yellow or orange. With evident gender differences in literature in choice behaviour at various stages of the food supply chain, an exploration of possible gender differences was necessary to ensure equitable access to biofortified food crops. To check for the robustness of the results, gender differences are explored in both hedonic preferences and WTP for micronutrient BFC.

In Zambia, gender differences were investigated in the sensory preferences and WTP for a maize variety that was biofortified with vitamin A, relative to the commonly consumed conventional white maize varieties, and yellow maize varieties, also available on the market at a discount. Additionally, the study assessed the importance of nutrition information to enhance the acceptance of BFC. The Rwanda study examined gender differences in the hedonic preferences and WTP for the two bean varieties biofortified with iron, relative to a popular local bean variety that was likely to be 40 percent lower in iron concentration. The study also investigated whether gender differences existed in the consumers' attitudes and behaviour towards the biofortified bean varieties, based on responses to nutrition information, and how the nutrition message was framed. While there was no apparent or visual evidence of the bean varieties biofortified by iron, as was the case with crop varieties biofortified by vitamin A, it was still unclear whether an increase in iron content would affect other intrinsic attributes of the beans that may be important to consumers.

Similarly, in Nigeria, gender differences were examined in the acceptance of two cassava varieties that were biofortified with Vitamin A, relative to a local cassava variety. Specifically, two datasets from two states of southern Nigeria where cassava was a staple food, but with two culturally distinct populations on the preferences for the colour of cassava products were considered. These included Imo state with a preference for the yellow coloured cassava products and Oyo state where consumers preferred the white cassava products. Given that the Vitamin A cassava biofortified varieties were more likely to be yellow in colour from the biofortification process, it was unclear how consumers would react to such differences in their staple foods and whether there would be gender differences in acceptance. As in the above two countries, the possible effect of nutrition information on acceptance was also tested by gender. Further, the effect of an endorsing agent in cassava plant material distribution was also tested, based on the premise that males and females' responses to advertisements were also influenced by adverts that match there on gender identity.

The results in this study suggest that the gender of the respondent may play an important role in determining consumer's acceptance of BFC. However, the effect of gender differed widely across the three countries, and also by the biofortified crop variety in question. In Rwanda for, example, the results suggested that males and females may be looking for different attributes when making choices regarding the consumption of biofortified food crops. This was more prominent in the biofortified red iron beans where female respondents significantly preferred a red iron bean variety for its cover hardiness, taste, taste when mixed with staple food, cooking time, ease of cooking, bean size when cooked, overnight cooking quality and overall attributes. Men, on the other hand, liked the same variety for its bean size when uncooked. Gender differences were also observed in the hedonic ratings of the white iron beans, where, females rated higher scores for the size of the bean when cooked and the cooking quality, while males relative to females, rated higher, the raw size of the bean. This difference in preferences suggested that desired attributes may vary based on the role played by males and females in the food chain. As can be seen, females tended to care more for attributes that involved household food consumption and preparation, while males cared for market-oriented attributes such as the size of the bean. A gender gap was also observed for the red iron variety when estimating factors impacting hedonic preferences where females were more likely to give a higher score than men. This was also translated to a higher WTP for the same red iron bean variety among females.

In Zambia, gender differences were observed in mean hedonic scores for orange maize where the probability of scoring high in the overall liking of orange maize was higher for males than females. Gender differences were also observed in WTP, where males were willing to pay more for orange maize than females. In Nigeria, gender differences were not observed in the hedonic preferences for biofortified cassava varieties but observed in the WTP for the light yellow biofortified cassava variety.

Men's and females' attitudes towards BFC were shaped by their personal characteristics and promotional tools in all the three countries. In particular, hedonic preferences for BFC among females and males varied among respondents with young children in both Rwanda and Zambia, with ambiguous effects. In Rwanda, the probability of reporting the highest overall liking category of red iron-biofortified beans was higher among females with children than males of the same status. While, in Zambia the probability of reporting the highest overall liking category of the biofortified orange maize was lower among females with younger children. The ambiguous effect of this variable, according to literature indicate that, on one hand females with children would be more willing to accept a novel food if perceived beneficial to their children (Smith et al. 2003), females also tend to take a more cautious attitude on feeding novel food to their children (Moerbeek and Casimir, 2005). We expect the later explanation to have been present among females with children in Zambia, and the former to be in Rwanda. Age did influence WTP for biofortified maize where females' WTP reduced with age, the results of which can be explained by the risk aversion behavior that is usually associated with females and older respondents towards new technology, especially in the absence of nutrition information as was the case with this group of respondents in Zambia. In Nigeria, wealth status affected men's and females' perceptions towards biofortified cassava, with men's WTP reducing with increasing amounts of assets. We noted earlier that, females' wealth status relative to men's is lower in all three countries. However, in Nigeria, not only is females' wealth status higher, but it also had a significant negative effect on the hedonic preferences for a nutritious cassava variety. This implies that inequality in the wealth status of males and females may affect perceptions about nutritious varieties. One possible explanation is that richer males may have considered cassava as an inferior good, while, females may have placed more importance on the nutrition aspect of the crop varieties. Having prior knowledge about the micronutrient deficiencies also had a gender effect as observed in Rwanda where females who had prior knowledge or experience about iron deficiency or anaemia expressed a higher WTP for red iron-biofortified beans. Generally, the prevalence of aneamia is higher among premenopausal females (WHO 2014), thus, females than males in Rwanda were more likely to feel the impact of aneamia.

We also assessed whether the impact of promotional tools used in BFC studies had a gender effect in respective BFC. Specifically, we assess whether nutrition information, how it is framed and the endorsing agent used to promote BFC had gender effects. Males are believed to be less concerned about the health attribute of novel food (Holgado et al. 2000) and evidence from the hedonic preferences in Zambia and Rwanda are in favour of this assertion. In particular, females in both studies had a stronger preference for BFC in the presence of nutrition information compared to males. In Rwanda, WTP for males and females differed based on the nutrition messages with females willing to pay more for the red iron variety when nutrition messages were given. We also tested the effect of message framing either positively or negatively. Meyers-Levy and Loken (2015) assert that females were more likely to respond in the negatively framed information. We find evidence in favour of this assertion in the hedonic preferences for the white iron-biofortified beans in Rwanda. Specifically, females' liking increased when nutrition messages reported in the negative frame of not having adequate iron and the impotance of iron-biofortified beans in mitigating iron deficiencies. Grohmann (2009) also asserts that males and females would rather have brands portraying personalities that speak to their own gender identity. We also find evidence in support of this assertion in Nigeria, where males were more of those that trusted the international support in the delivery of biofortified cassava planting materials and expressed a higher WTP for both biofortified varieties than females.

CHAPTER 7: CONCLUSION, POLICY IMPLICATIONS AND LIMITATIONS

7.1 Thesis summary and conclusion

This thesis compared the performance of the Becker-DeGroot-Marschak (BDM) mechanism and the non-hypothetical choice experiment (nHCE), and also explored gender differences in the demand for micronutrient-biofortified staple food crops (BFC) in three sub-Saharan African countries. The study used data from the HarvestPlus project that elicited preferences for BFC in Nigeria, Rwanda, and Zambia. In the absence of market data as it is the case when launching a new product, researchers have relied on non-hypothetical economic experiments such as the BDM and the nHCE, to estimate consumer's willingness to pay (WTP) for a good or service, based on their demand revealing or incentive-compatibility property. This is in contrast to the stated preference techniques that have been discredited for their hypothetical nature. Despite the incentive compatibility property, the non-hypothetical methods have also shown that, in practice, some variables may be concealed that may bias participants' WTP (Voelckner 2006; Berry et al. 2011). Evidence from divergent WTP values yielded from these non-hypothetical methods compared to one another (e.g., Banerji et al. 2013; Gracia et al.2011 and Lusk and Schroeder 2006) supports this assertation. Researchers have thus continued to explore better ways to minimize the WTP disparities associated with these methods as a way to attain validity.

The study found that experimental design features in the alternative valuation techniques could bias WTP, which may account for some of the disparities in WTP estimates, and thus proposes methodological improvements in the application of these methods in a developing country setting. A comparison made between WTP estimates elicited from the BDM mechanism and the nHCE for a new vitamin A-biofortified maize variety, under a field setting in Zambia indicate that, the two methods were comparable after controlling for bidding rounds in the BDM mechanism, and lexicographic responses in the nHCE.

An exploration of gender differences in the demand for country-specific BFC was carried out based on the premise that, in addition to the evident gender differences in many domains of life, research is increasingly demonstrating that developmental interventions sometimes work differently across subgroups within a target population such as males and females (Tannenbaum and Greaves, 2016).

In the current study, demand was measured using both hedonic preferences and willingness to pay for BFC. The new BFC could impact gender in the following ways. First, the likely changes in the BFC's intrinsic properties could evoke gender differences in acceptance, based on males' and females' biological differences in reactions to the sensory appeal of food, and to the gender roles occupied in the food chain. Second, as consumers will have to pay to have access to BFC, gender differences in personal characteristics could influence decisions to accept BFC. Lastly, males and females may also respond differently to the promotional tools used. Results in this thesis indicated that gender may play a significant role in the acceptance of BFC. However, results were varied based on the measure of demand, and also on the biofortified crop variety in question.

In chapter two; the thesis tested the hypothesis that, under similar research conditions, non-hypothetical valuation techniques such as the BDM mechanism and the nHCE would yield comparable WTP estimates. Mean WTP values for vitamin A- biofortified maize variety elicited from the nHCE were compared to that from the BDM experiments in the absence of dietary information. Individuals under both experiments made bids and choices based on the sensory evaluations undertaken before their participation in the BDM experiment. The results indicate that WTP values under the two valuation techniques were not comparable, with the nHCE yielding estimates that are approximately twice as large as those from the BDM experiment, confirming previous research findings.

In chapter three, the thesis explored experimental specific design factors with the potential to bias WTP and possibly explain WTP estimates disparity in the BDM mechanism and the nHCE. Three design features considered in the BDM experiment were order-effects (the order in which participants tasted maize varieties' samples during sensory evaluations), experimenter's effect (enumerator's influence on subject's bidding behaviour), and the impact of using single or multiple bidding rounds before the main BDM bid (which are the two alternative approaches commonly used in the implementation of the BDM experiment). In the nHCE, the study examined the impact of lexicographic responses on the subjects' choice behaviour.

Results indicate that participants exposed to only one single bidding round in the BDM experiment were susceptible to order effects. They also submitted lower bids than those exposed to multiple bidding rounds. Although the order-effects of food sample tasting are typically associated with impacting sensory scores (O'Mahony 1986), this finding suggests that such order-effects could also persist in the BDM experiment bids for respondents with less exposure to the BDM mechanism. The use of repeated or multiple bidding in the BDM experiment can, therefore, eliminate biases such as order effects, and consumers' heuristics of wanting to purchase the item at a lower price, even if they are willing and able to buy it at a higher price.

The choice experiment, on the other hand, was susceptible to lexicographic behaviour which significantly inflated WTP estimates. Results further indicate that multiple bidding rounds in the BDM experiment, and controlling for lexicographic responses in the nHCE substantially narrowed the WTP disparity between the two valuation techniques by 50 percent. Although the reduction was not statistically significant, this outcome was economically meaningful given the reduction of the WTP gap by half.

Chapters 4-6 cover the objective of exploring gender differences in demand for BFC. Chapter 4, in particular, covers the methodological analysis of gender differences. Theories that purport to explain the origins of gender differences in consumption behaviour from various fields of science are explained first. This was followed by the gender methodology, comprising of data sources, conceptual analysis of the conditions under which gender differences can occur. The chapter concludes with research questions, hypotheses, and empirical estimations.

Chapter 5 examined gender differences in the hedonic preferences for respective BFC in Nigeria, Rwanda, and Zambia. Results revealed that males and females may be looking for different attributes when evaluating hedonic preferences for BFC products. In Zambia, males had stronger preferences for vitamin A biofortified maize than females, while the converse was true for Rwanda where females had a stronger preference for the red iron bean variety than did their male counterparts. Gender differences were however, not observed in the hedonic preferences for vitamin A biofortified cassava in Nigeria, in the white iron biofortified beans in Rwanda, and among respondents who were surveyed at a central location in Zambia.

As the presence of micronutrients in the staple food crops represents a credence attribute or the desired quality that cannot be observed after the immediate consumption of BFC but only observed after long-term use (Darby and Karni, 1973), promoting BFC was a necessary step. Based on literature predictions of gender differences in risk-taking behaviour, and response to promotional tools (Meyers-Levy and Loken, 2015), the study investigated the effect of promotional tools on males' and females' hedonic preferences for BFC. The results indicate that hedonic preferences varied by gender in Rwanda and Zambia, based on nutrition information, and how the nutrition message was framed. In both countries, female participants exposed to nutrition information had stronger preferences for respective BFC than their male counterparts.

In the Rwandan study, females exposed to the "loss-framed" messages in comparison to the "gain frame" had a stronger preference for the less liked white iron beans than their male counterparts. Both outcomes are in support of literature predictions which considers males to be less concerned about the nutrition aspects of food. The loss-framed messages are considered to be more persuasive to individuals who perceive an element of risk in their choices (Rothman and Salovey 1997), and females being more risk-averse than males were more likely to respond favourably to negative framed messages (Meyers-Levy and Loken 2015).

There were also gender differences in hedonic preferences for BFC among respondents with young children in Rwanda and Zambia. The gender effect was, however, in opposite directions. While the liking of the biofortified maize in Zambia was less among females with young children compared to their male counterparts, the converse was true in Rwanda, where females with young children were more likely to be in the highest liking category of the red iron-biofortified bean variety than males of the same status. This ambiguous effect is supported by literature, where on one hand women with children would be less reluctant to feed novel food to their children (Moerbeek and Casimir, 2005). On the other hand, women with children would be more willing to feed their children novel food if perceived to be nutritious (Smith et al.2003).

Chapter 6 explored consumer's WTP for biofortified food products in each of the three countries i.e., Nigeria, Rwanda, and Zambia. The results suggest that WTP and its determinants varied significantly by gender in all three countries. In Zambia, males' WTP for vitamin-A biofortified orange maize was significantly higher than that of females. Females' WTP for the biofortified light yellow cassava was higher than that of males in the Nigerian state of Oyo. In Rwanda, females' WTP for the red iron bean variety was also significantly higher than that of their male counterparts.

Males' and females' WTP for BFC differed based on nutrition information promotion tools used. In Rwanda, females' bids for beans increased with nutrition information, regardless of the treatment. In Nigeria, males' bids were higher in the presence of nutrition information with support from an international agency in both varieties of biofortified cassava. The effects of demographics on BFC's WTP based on the respondent's gender were also observed across the three countries, although the results were varied.

In Zambia, using WTP data available only in the absence of nutritional information, results indicate that female subjects were less willing to pay for biofortified maize as their age increased. As being older and female are associated with risk aversion (Meyer-Levy and Loken 2015), without information, uncertainty may have influenced the subject's attitudes towards the new maize variety, and females could have been more sceptical about the new biofortified maize variety compared to males. In Rwanda, a gender difference in WTP was observed in the red iron biofortified beans relative to a local bean variety. The results revealed gender differences in WTP outcomes based on whether one had prior knowledge or incidence of anaemia. Females, in particular, submitted higher bids if they had the knowledge or an incidence with anaemia. In Nigeria, wealthier male respondents were less likely to submit higher bids than females of the same status.

7.2 Contribution and policy implication

The results of this thesis have several implications for researchers, nutrition educationists, public, private and developmental actors alike. First, despite the consensus in literature of the superiority of the non-hypothetical valuation techniques over the stated valuation techniques, the choice of method to use when eliciting demand for a new product is still an open question. This stems from WTP disparities among alternative valuation techniques such as the BDM and the nHCE. Results from this thesis seem to point to the experimental specific design features as one of the possible sources of the WTP disparities between the BDM mechanism and the nHCE. As shown earlier, adequate training through repeated bidding in the BDM seems to be necessary to fully reveal the BDM's incentive structure. Similarly, controlling for lexicographic behaviour in the choice experiment is necessary to attain valid estimates. Researchers could, therefore, use repeated bidding or multiple bidding in the BDM experiment, and control for lexicographic responses in the nHCE to obtain estimates of WTP that are more comparable than they would be in a typical situation.

Second, the thesis provides an initial perspective on the dimensions of the demand for BFC in three sub-Saharan African countries that may vary by gender. While, there is evidence that demographics, product characteristics and promotional tools conditioned the acceptance of BFC in prior studies, this thesis indicates that there may be significant differences between males and females in that conditioning, depending on the BFC variety in question. Specifically, males' and females' preferences in certain BFC as revealed in the Rwandan and Zambian studies may differ based on the sensory appeal and quality (preparation and handling) attributes. These results point toward a gender difference in the level of BFC acceptance that may be attributed to biological differences as well as gender roles occupied in the food chain. To the product developers, these results suggest the need to design gender-targeted products that will consider both males' and females' expectations of the BFC.

Additionally, this thesis provides key demographic characteristics that may affect males' and females' attitudes for BFC. We find that females' demand for BFC differs from males', through differences in age and household assets, prior knowledge about micronutrient deficiencies and also among respondents with young children. As demographic characteristics may influence decisions that males and females make towards consumption and adoption of BFC, the provision of knowledge and nutrition information may be necessary. This may require providing educational programs that reassure women of the safety and benefits of BFC for themselves and their children. Similarly, asset ownership influence access and the capacity to bear the risk of trying to adopt BFC (De Groote et al.2013), and as shown earlier, women have significantly lower assets than males across the three countries under study. Thus, a positive association of wealth and females' attitudes towards BFC observed in Nigeria suggest the need to empower women with the means to have productive assets.

Different responses to nutritional promotional tools by males and females observed also call for public health advocates and nutrition educationists to engage in a gendered approach to nutritional campaigns by considering messages that appeal to both males and females. As shown in this thesis, nutrition information, endorsement agent and nutrition massage presented in the negative frame may all influence males' and females' decisions on the acceptance of BFC.

7.3 Study limitation and recommendations for future studies

Readers of this thesis should be cognizant of some limitations to this research. As the original data used in this thesis was not intended to measure WTP disparities between the two valuation techniques, nor gender differences in the acceptance of biofortified food crops, the following limitations were encountered. First, sample characteristics with respect to age, differed between the BDM and nHCE participants, where respondents in the nHCE were significantly older than those from the BDM experiments. Differences in age could be one of the reasons why age had a significant positive effect on the choice behaviour among the nHCE participants while demonstrating no effect among the BDM experiment participants in the biofortified maize. However, this did not affect the marginal effects, given that age had no effect on the alternative yellow maize variety.

Second, understanding the source of lexicographic responses was beyond the scope of this thesis. Literature indicates that lexicographic behaviour may at times be as a result of the poor design of the experiment, among others (Killi et al. 2007). Future research may consider understanding the sources of lexicographic behaviour in the nHCE and possibly take corrective measures. Killi et al. (2007) suggested incorporating qualitative questions in the survey to allow lexicographic respondents to provide reasons for their behaviour. This could help determine which factor(s) are at play in triggering lexicographic behaviour in a given choice experiment.

Third, in testing gender differences in consumer behaviour towards BFC, male subjects were over-represented in most samples, which was not a true reflection of male to female ratios in the countries under study, and therefore the study could not make inferences to the population. To explain the causality of gender differences, future studies may consider randomizing gender in experiments and select comparable group sample sizes of males and females.

Fourth, except for the Rwandan study, categories of food attributes used in analysing gender differences were limited and focused mainly on the sensory characteristics of the food. As shown in the Rwandan study, additional quality aspects of food evaluation encompassing processing and preparation such as cooking and flour quality, time for preparation, among others, could be valued differently by males and females. Although there has been a move over the years for males and females to share gender roles, females still do most of the food processing and preparation among many African households.

Thus, future studies could consider extending attribute categories of BFC beyond the sensory appeal and also conduct studies in a home setting, where hypotheses testing regarding gender differences in consumption can be understood better. As Tomlins et al. (2007) observed, conducting food evaluations in a home setting tend to provide more valid estimates, allowing consumers to evaluate a wide range of attributes, as food decisions are made in their natural environment. This is in contrast to the central location experience, where food samples are prepared for consumers, often limiting consumer's evaluation choices to the sensory dimension of food.

Fifth, in this thesis the sources of gender differences in the promotion tools used for BFC could not be empirically established. Nevertheless, our findings are backed by both the concept of brain lateralisation and the selectivity hypothesis. With only audio or verbal messages used in the BFC promotions across the three countries, the brain lateralization theory seems to suggest that males may have been at a disadvantage when responding to verbal messages, as they are inclined to capture visual-spatial adverts (Meyers-Levy and Loken, 2015). Thus, future advertising of BFC could be accompanied by adding nonverbal reinforcements to the nutritional information campaigns that may capture males' attention as well. The selective hypothesis theory's perspective, on the other hand, classifies females as comprehensive processors of information, while males as selective processors of information (Meyers-Levy and Sternthal, 1991). Thus, the messages targeted at males, according to this theory, could be simpler and concentrate on a single theme, while that for females could be more elaborate (Putrevu, 2004). Depending on which theory is at play, future research could consider a holistic way of capturing both males' and females' attention in future advertising. Further, researchers may consider to not only to routinely collect the gender variable in surveys, but also incorporate gender heterogeneity in modelling health outcomes from biofortification interventions.

Lastly, this thesis used experimental data to examine gender differences which often provide limited evidence of consumer preferences of a product such as BFC as would be in the real market (Banerji et al. 2013; Birol et al. 2015), partly due to some design factors affecting valuation techniques as shown in this thesis. Thus, with BFC already in some markets of sub-Saharan African countries, additional lessons may be learned by observing real market behaviour of males and female consumers of BFC. Gender differences can be further analysed based on the area cultivated, quantities produced and consumed of these new varieties. Intra-household allocation models could be used to further understand gender dynamics within a household that may influence decisions that consumers might make on BFC consumption. Additionally, analysis of demand for BFC among rural consumers who are also producing households could consider using a non-separable dual agricultural household model as production and consumption decisions are usually intertwined as evidenced from previous studies done in sub-Saharan Africa amid market failures (Singh et al. 1986; Barrett 1996; Udry 1996 and Muller 2014).

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