Citation:

Meenakshi, J.V., Banerji, A., Manyong, Victor, Tomlins, Keith, Hamukwala, Priscilla, Zulu, Rodah and Mungoma, Catherine (2010) *Consumer acceptance of provitamin A orange maize in rural Zambia (HarvestPlus Working Paper No.4).*

The definitive version is available at: http://www.ifpri.org/publication/consumer-acceptance-provitamin-orange-maize-rural-zambia

HarvestPlus Working Paper

No.4

March 2010

Consumer Acceptance of Provitamin A Orange Maize in Rural Zambia

J.V. Meenakshi, A. Banerji, Victor Manyong,
Keith Tomlins, Priscilla Hamukwala, Rodah Zulu,
and Catherine Mungoma

HarvestPlus is a global alliance of research institutions and implementing agencies that have come together to breed and disseminate biofortified crops for better nutrition. HarvestPlus is coordinated by the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI). HarvestPlus is an initiative of the Consultative Group on International Agricultural Research (CGIAR).

HarvestPlus, c/o IFPRI 2033 K Street, NW, Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600 • Fax: +1-202-467-4439 • www.harvestplus.org

HarvestPlus

Consumer Acceptance of Provitamin A Orange Maize in Rural Zambia

J.V. Meenakshi[1], A. Banerji[1], Victor Manyong[2], Keith Tomlins[3], Priscilla Hamukwala[4], Rodah Zulu[5], and Catherine Mungoma[6]

ABSTRACT

This study analyzes consumer acceptance of biofortified orange maize in rural Zambia by eliciting consumers' willingness to pay. It attempts to examine the impact of nutrition information, comparing the use of simulated radio versus community leaders in transmitting the nutrition message, on consumer acceptance. Finally, it assesses whether product experience in a home-use setting influences the magnitude of premiums or discounts. The results suggest that (a) the negative perception of yellow maize does not affect orange maize which is well liked, (b) there is a premium for orange maize with nutrition information, (c) the mode of nutritional-message dissemination does not have a large impact on consumer acceptance, and (d) product experience does not translate into lower willingness to pay for orange maize.

Acknowledgements: We are indebted to several people for the successful completion of this research: Brian Chisanga, Cornelius Kalonga, Dominic Mambo, and Likando Muyatwa and the team of enumerators who worked hard to successfully meet the rigorous demands of the survey schedule and painstakingly undertook the subsequent data entry. Yiannis Kountouris and Nitya Mittal provided excellent research assistance, and Shyamal Chowdhury provided helpful input during the entire course of the study. We are also grateful to a referee for suggestions that have substantially improved the paper. This research was funded by HarvestPlus. Any errors are those of the authors.

[1]Delhi School of Economics, University of Delhi
[2]International Institute of Tropical Agriculture
[3]Natural Resources Institute, University of Greenwich
[4]University of Zambia
[5]National Institute for Scientific and Industrial Research
[6]Zambia Agriculture Research Institute

TABLE OF CONTENTS

I. BIOFORTIFIED ORANGE MAIZE

Biofortification is a new public health intervention that seeks to improve the micronutrient content of staple foods consumed by the majority of poor people using conventional plant-breeding techniques in order to make a measurable impact on the magnitude of micronutrient malnutrition. Recently, plant breeders have developed biofortified varieties of maize that contain higher concentrations of beta-carotene (provitamin A) and are therefore orange in color. In this paper, maize that contains significant amounts of beta-carotene is referred to as "orange maize" to distinguish it from yellow maize (which contains levels of carotenoids that are too low to significantly contribute to human health) and white maize (which has no carotenoids) (Menkir et al. 2008).

The success of such biofortified maize depends on whether it is accepted and consumed by the target populations. This research seeks to evaluate preferences for orange maize relative to white and yellow maize in rural Zambia, since it is in these areas that biofortified staples are most needed because of the high prevalence of vitamin A deficiency: more than half of preschool children in Zambia are at risk (Micronutrient Initiative, 2009). Since maize is a staple food in Zambia, as in much of Sub-Saharan Africa, the successful introduction of biofortified provitamin A maize could have a significant impact on reducing the prevalence of vitamin A deficiency in Zambia and elsewhere in Sub-Saharan Africa, where it is a major public health concern. Consumer acceptance is also important in marketing strategies and product development. For example, while consumers seek convenient and healthy products, they consistently rate taste as the most important factor driving consumption and, in particular, repeat purchase (Grunert et al. 2000 and Cardello et al. 2007). Therefore, if it can be demonstrated that orange maize is accepted by rural consumers in Zambia, this will give policymakers and donors more confidence to invest in orange maize.

Consumer acceptance may pose a particular problem with a product such as maize because in the past yellow varieties have typically not found consumer acceptance. In large part, this is because such varieties are believed to have inferior taste—yellow maize was bred primarily for cattle feed. In addition, yellow maize is perceived as "drought" food and associated with bad times because it was frequently distributed as food aid (Muzhingi et al. 2008). If this negative perception carries over to orange maize, there is reason to be skeptical that biofortified maize will find enough of a niche in Sub-Saharan Africa to be able to make an appreciable difference in micronutrient intakes among target populations.

However, there are several reasons to challenge this perception and to conduct further research on this issue. First, biofortified maize is likely to be agronomically superior to those presently cultivated; farmers have reported being willing to switch to yellow maize if it were pest-resistant, drought-resistant, and early-maturing. Second, plant breeders and nutritionists have determined that biofortified maize is likely to be orange and, as such, may avoid the negative perceptions associated with yellow maize. Third, in an account of the introduction of maize into the African continent, McCann (2005) notes that traditional maize varieties were typically colored and devotes an entire chapter to its transformation, titled "How Africa's Maize Turned White." There are also reasons to believe that market restrictions may have more to do with the popularity of white maize than consumer preferences per se (see literature cited by Muzhingi et al. 2008). It is also believed that consumers will switch to a new product perceived to be superior to existing alternatives.

Objectives of the Study

The present study analyzes consumer acceptance of biofortified maize in rural Zambia since it is in these areas that biofortified staples will be first introduced.[1] It attempts to quantify the magnitude of price discounts, if any, that may be associated with orange maize by eliciting prices that consumers are willing to pay for white, yellow, and orange maize varieties. Consumption choices depend critically on relative prices, especially for those who are food insecure as they are extremely vulnerable to even small increases in the price of food. Therefore, an assessment of consumer acceptance of biofortified maize cannot be made independently of its price.

Behavior change communication is essential to any successful nutrition intervention and can play a significant role in driving consumer acceptance. There are several means of effecting behavior change communication, each of which has different cost implications. Radio messages are relatively cheap and can reach a broad audience. At the other end of the cost spectrum, using community leaders to convey nutrition information can be extremely expensive. This paper tries to assess how information and the platform used to communicate it influence consumer preferences and their ranking of white, yellow, and orange types of maize.

Another challenge to analyzing consumer acceptance is accounting for product experience. Behavior during first-time purchases, where consumers may wish to try out a new product and therefore may be willing to pay more for it, can be very different than behavior during repeat purchases. This is likely to be the case for maize that is so

[1] We do not focus on the agronomic characteristics of the maize seed, as the expectation is that the orange maize will be equivalent, if not superior, to varieties presently cultivated in this respect.

visibly different from that already available in the market. This paper attempts to account for product experience by comparing behavior in two different settings: at home (where consumers try the product for a few days at home) and in a central location (where consumers are exposed to the new maize only once). Home-use testing surveys are considerably more expensive to undertake than central-location testing surveys.

The paper thus has three principal objectives:

1. To evaluate consumer acceptance of orange maize and quantify the magnitude of its premium/discount relative to white maize in the absence of any information on its nutritive value;
2. To examine the impact of nutrition education on the willingness to pay for orange maize, and, in particular, to compare the impact of nutrition education delivered through either radio messages or community leaders; and
3. To examine whether novelty effects significantly influence premiums by comparing willingness to pay as elicited in a home-use setting (where consumers have more time to get used to a product) with that elicited from a central-location setting (which has a short exposure time).

As detailed later, a survey of nearly 500 respondents in two provinces of rural Zambia forms the basis of analysis. The survey has five treatment arms corresponding to the objectives outlined above.

The study incorporates expertise from food scientists using sensory evaluation methods, behavior change specialists who work on nutrition messages, and economists, using a framed choice experiment with a fractional factorial design to elicit prices and price discounts (or, willingness to pay) for goods that are not as yet on the market. The study is in the same spirit as Jaeger's (2005), which argues for an interdisciplinary approach to the study of consumer acceptance. She notes that while taste and sensory factors significantly influence the choice of food, equally important are factors such as "convenience, price, production technology, personal health, branding, and societal issues."

The paper is organized as follows: the rest of this introductory section details the motivation for and literature on consumer acceptance of colored maize and the roles of information and product experience. Section 2 then sets out the survey design and experimental procedure. Section 3 presents summary statistics, while Section 4 analyzes results on consumer acceptability rankings. Section 5 investigates whether there is a premium for orange maize and how this is influenced by the absence or presence of information on its nutritive value. Section 6 summarizes the results and draws implications for the successful introduction of biofortified maize in rural Zambia.

Orange and Yellow Maize in Sub-Saharan Africa

There have been several studies on the consumer acceptance of yellow maize, although many of them tend to have an urban focus. A comparison between yellow and white maize varieties is facilitated by the fact that both products are available in the market, so price data can be used to make inferences about the magnitude of discounts. For example, the existence of a price premium for white maize in Maputo, Mozambique (at a time of relative abundance in supply of both yellow and white maize) is evidence that white varieties are preferred. In their study, Tschirley and Santos (1995) found that white maize is preferred to yellow when the two are sold at equal prices. However, a price discount of only 14 percent on yellow grain was found to be sufficient to cause a quarter of respondents—typically those with lower incomes on average—to switch to yellow maize. At discounts of up to 43 percent, nearly three-quarters of consumers would shift to yellow maize.

There are several other examples: In Zimbabwe, following the maize market reform, after which prices of the two varieties were no longer determined administratively, poor consumers perceived yellow maize to be an acceptable alternative to white maize depending on the relative prices (Rubey et al. 1997).

Another analysis using experimental auctions to assess willingness to pay and focusing on yellow (that is, commercially fortified) maize flour in Nairobi suggests that a discount of 33 percent would be necessary for consumers to accept yellow maize, although poorer consumers are more likely to switch for a given discount (De Groote and Kimenju 2008).

The literature on comparing white with orange—rather than yellow—maize is limited. One exception is the study by Steven and Winter-Nelson (2008), which includes white, yellow, and orange (imported from the United States) varieties of maize. These were cooked as *nshima* (a stiff porridge made from maize flour) and tested in two markets in and near Maputo. Researchers provided all participants with a bag of white maize and made an announcement about the nutritional value of orange maize. They then assessed whether participants were willing to trade their bag for one containing either a fraction or a multiple of the amount of orange maize. Their results suggest that orange maize meal is as preferred as white and that no price discounts are likely to be necessary to promote its consumption. In addition, families with young children and those that did not consume diets rich in animal products were more likely to accept orange maize.

Several other papers that consider rural areas have producer preferences for varietal characteristics as their focus and do not explicitly address consumer acceptance (for example, Smale and Jayne 2003).

The Role of Nutrition Information

The role nutrition information plays in influencing consumer acceptance can be critical. Muzhingi et al. (2008) find that nutrition information is the single most important factor in determining a household's decision to purchase nutritionally enhanced maize; a nutrition campaign can significantly alter consumers' perceptions and lead to a much higher probability that nonwhite maize would be consumed.

Determining the impact of nutrition information on reducing price discounts associated with biofortified maize is made difficult by the fact that a successful nutrition message requires repetition, which a survey cannot really implement, except by providing intensive training. The Nairobi study demonstrates evidence of a substantial reduction in the discount for commercially fortified yellow maize flour as a consequence of nutrition education. Furthermore, the authors find that while there is an interest in commercially fortified maize, the average premium for fortification is less than half the discount on yellow maize. Of particular concern is the Nairobi study's finding that poorer people tend to place lower premiums on nutritionally enhanced foods (De Groote and Kimenju 2008, Morawetz et al. 2006).

Nutrition campaigns are conducted using several methods, including mass media; local theater; and endorsements from public figures, community-level actors, or organizations. Although most interventions employ a multiplicity of media, it is important to recognize that each of these media vary significantly in impact and have very different cost implications. This study attempts to examine the impact of nutritional information by comparing two of the more commonly used methods for behavior change communication: community leaders and radio messages.

In a developed-country context, health information is typically conveyed through the use of written labels, and the literature suggests that premiums for health labeling can be significant (Kinnucan et al. 1997). The use of written labeling is not practical in the context of rural Zambia, given low levels of literacy, costs of labeling, and maize being sold in open sacks. By using community leaders and radio messages for conveying health information, the context is more realistic than using enumerators to read out the nutrition message.

The use of community leaders and interpersonal contact to deliver a message is the most effective method (Zimicki 1997). It is believed that community leaders or other community-level actors are likely to be the most effective agents of change with the greatest impact on outcomes since they occupy positions of trust and respect within the community. Examples could include extension workers, teachers, and health workers. However, outside of a pilot setting, mobilizing community leaders on a wide scale is difficult, and the monitoring costs of ensuring that messages are not diluted or distorted are extremely high.

At the other end of the spectrum are radio messages, which enable a wide reach with relatively low investment and a high degree of control over the content of the message (although there is less control over who will hear the message). However, radio messages represent an anonymous voice that consumers may not trust, and therefore they may not be effective. It is estimated that there are 1.9 million radios in Zambia (Taylor 2006), of which around 30 percent are in rural areas (Zimicki 1997). As shown later, our survey indicates that a decade later, the percentage of households possessing a radio in rural areas is much higher.

We attempt to quantify the magnitude of this differential impact by randomly allocating respondents/communities to arms that (a) receive no information (termed "control"), (b) receive information from (simulated) radio messages, or (c) receive information from community leaders.

The nutrition message was developed by nutritionists working on public health campaigns and is similar to messages used in disseminating information on biofortified crops in Uganda and Mozambique. It contained the following points:

- A new type of maize that is orange (and not yellow) in color has been developed by researchers that is healthier than white maize.
- The new orange-colored maize contains vitamin A and can be used in the same way as traditional maize.
- The benefits of vitamin A are that it is important for health, especially for children, because it helps to prevent infectious diseases, to improve growth, and to contribute toward good vision. A deficiency of vitamin A can contribute to higher mortality rates. Foods that commonly contain vitamin A include dairy products, liver, egg yolks, and fruits and vegetables, especially those that are deep orange or dark green in color.

The Zambia National Broadcasting Corporation then wrote and produced a five-minute program in English in a format that would typically be used in such promotions. This was translated and recorded in the study area's three local languages—Bemba, Lenje, and Tonga. Since orange maize varieties are yet to be released, the radio message could obviously not be broadcast nor could the project ensure that only the selected households heard the message. Therefore, the message was recorded on audio tapes and MP3 players that were used in the survey for treatment arms 2 and 5 in Table 1. The text of the radio message is in Appendix 1.

Camp officers—who are village-level functionaries—were recruited for training and sensitization at the respective district headquarters, since they are the natural entry point for introducing an agricultural technology. Enumerators explained and reviewed the nutrition message and answered questions on what could and could not be said about the new orange maize. They were asked to convey these messages to their respective communities before the survey and to reiterate them during the survey. An information sheet was also made available to guide the camp officers. Through these sensitization meetings, camp leaders were made aware that this was a study and that orange maize varieties are not yet available in the market.

Novelty Value versus Product Experience: Comparing Central-Location Testing with Home-Use Testing

Test marketing of new products typically takes places in a marketplace or a similar community venue, in a format referred to in food science literature as "central-location testing" (CLT). One potential drawback of using CLT to elicit willingness to pay for a new product is that estimates may be influenced by its novelty value, since consumers have only a short period of time to evaluate a product (typically 30 minutes). Consumers may be willing to pay a premium to try out a new product for the first time, so that the estimated willingness to pay may not reflect the product's intrinsic value. As Stevens and Winter-Nelson (2008) note in their study of biofortified orange maize in Mozambique, "measurement of acceptance may reflect an attraction to novelty than true acceptability of the product." The premise then is that with time and experience with the product, repeat purchases may well reflect declining premiums.

A similar concern relates to taste tests conducted in such settings where the consumer is asked to taste the product alone, although the common practice is to eat the food as part of a meal with other condiments. Therefore, asking consumers to taste a new maize and score it immediately afterward for various sensory and acceptability attributes may provide different rankings than if the product were tried in a more familiar setting.

For this reason, food scientists also conduct "home-use testing" (HUT), where the new product is tried in home situations for a few days, and consumers are asked subsequently to characterize it. Clearly, the degree of researchers' control over the experiment is lower in HUT because households are free to cook or use the product in any manner, so that it is possible that sensory scores vary across respondents not necessarily because of intrinsic differences on how the product is perceived but on how the product was processed and consumed. Nevertheless, to the extent that the in-home testing more closely mimics actual product use, it is considered the gold standard for conducting consumer acceptance studies. However, the costs of administering home-use testing are orders of magnitude greater than those associated with central-location testing; the question is whether these additional costs are justified.

Comparisons of the effectiveness of CLT and HUT methods with respect to acceptance (Boutrolle et al. 2005, Meilgaard et al. 2007) suggest that both gave similar overall results, but the CLT results were more robust and less variable. These methods have thus far not been compared in a developing country and with rural consumers who do not have much formal education. Furthermore, CLT and HUT approaches have not been compared when consumers have been given information about the benefits of the product.

In the economics literature, willingness-to-pay studies that use real products are typically conducted in a central-location setting (Lusk and Shroeder 2004, Alfines et al. 2006). In situations where natural field experiments—for example, where retailers are provided with the new product and repeat purchases can be tracked—are not feasible, as is the case with the biofortified maize considered here, HUT can provide an alternative way of at least partially controlling for this novelty value effect. Consumers are provided with various products to try at home for a few days each and asked about their willingness to pay only after they have tried all the products.

This study uses both central-location testing and home-use testing to assess consumers' willingness to pay (WTP) for orange maize, relative to other varieties. For reasons outlined later, a strict comparison of the estimated WTP from HUT and CLT is not possible; however, the inclusion of both treatment arms permits a check on the robustness of the main findings of this study.

II. STUDY DESIGN AND SURVEY PROTOCOL

The study has five treatment arms, summarized in Table 1 along with each arm's sample size. In each case, consumers were asked to taste cooked samples of *nshima* and make purchase decisions on the corresponding maize grain. Two of these treatments correspond to one-time use of orange maize (CLT) while three consider the impact of product experience (HUT).

Table 1: The study design and sample size

	No nutrition information—control	Nutrition information through:	
		Simulated Radio	Community leaders
Home-Use Testing	(1) 103	(2) 89	(3) 87
Central-Location Testing	(4) 107	(5) 101	X

Figures in parentheses refer to the treatment number, and those outside refer to the sample size in each treatment arm.

The role of nutrition information is assessed within both the CLT and HUT settings. Since it is not possible to replicate the use of community leaders to impart nutrition information in a central-location setting, the CLT arm of the design considers only the impact of the provision of nutrition information through simulated radio messages.

Treatments 1 and 4 provide estimates of the willingness to pay for the three maize varieties in the absence of any information on the nutritive value of the orange maize in the HUT and CLT settings respectively. These values reflect how well orange maize is likely to do in comparison to the familiar white varieties in the absence of any nutrition campaign. A comparison of treatments 1 and 2 and of 4 and 5 provides an estimate of the impact of nutrition information transmitted through radio on valuations in each of the HUT and CLT settings respectively, and may be used to evaluate whether premiums vary with and without novelty value. Finally, a comparison of treatments 1 and 2 and 1 and 3 yields insights on whether community leaders are more effective in improving consumer acceptance compared with the more impersonal radio message.

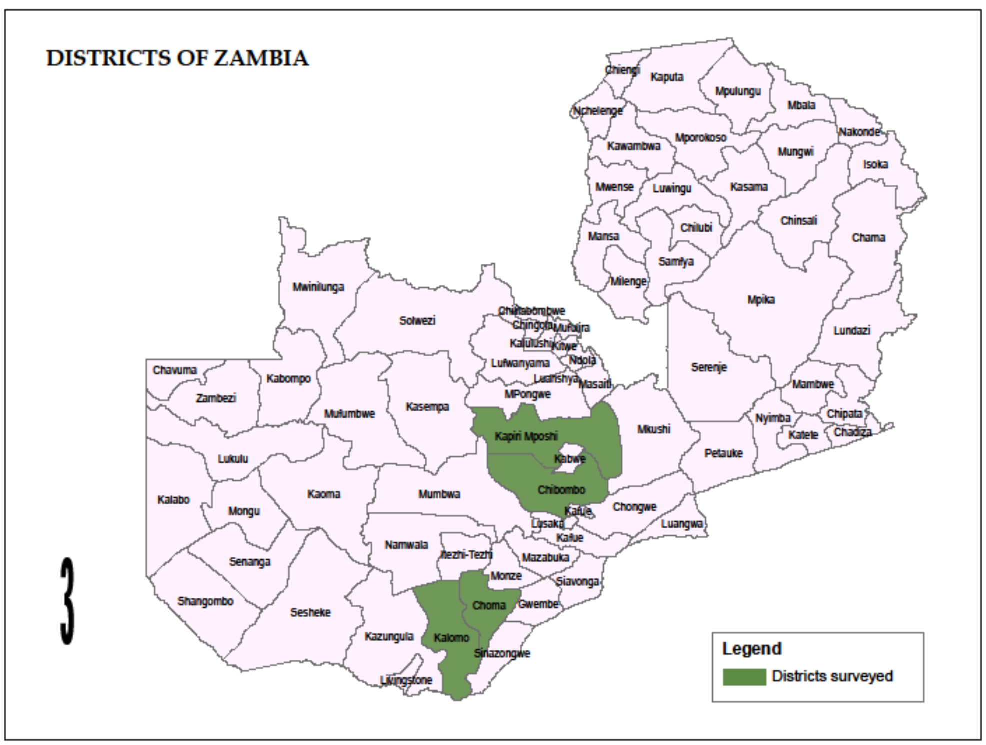
The Sample and Experimental Procedure

The research was assessed and approved by the Research Ethics Committees of the University of Zambia and the University of Greenwich. Written consent was sought for adults participating in this study. Written and parental/guardian consent was obtained for children under the age of 18. The trained enumerators informed participants about the study and explained that their participation was entirely voluntary, which meant they could stop the interview at any point and that their responses would be anonymous.

The study made use of prototype orange maize grown in Zambia. Unlike the Stevens and Winter-Nelson study that used isogenic lines of white and orange maize cultivated in the United States, high beta-carotene orange maize sourced from the International Center for Maize and Wheat Improvement (CIMMYT) was cultivated in country by the Zambia Agricultural Research Institute and used in the present study. In addition, traditional white and yellow varieties were acquired locally. The provitamin A content of the orange maize flour ranged from 3.3 to 4.9 micrograms per gram (Tanumihardjo). With a 400 gram per day consumption of maize (common in rural Zambia), and 60% retention of provitamin A, a 5 micrograms per gram content would translate into an additional intake of 100 micrograms per day of vitamin A, or about 20 percent of the estimated average requirement for an adult (nonpregnant, nonlacatating) woman. These varieties were all milled in a hammer mill commonly used in rural areas, rather than in commercial mills that mill to a different texture and cater primarily to urban markets. The National Institute for Scientific and Industrial Research in Lusaka undertook the milling, bagging, and preparation.

The study was conducted in the Central and Southern Provinces of Zambia, which were purposively selected because they have the highest production and consumption of maize. These provinces also had a relatively high percent of their populations in poverty. In each province, a listing of districts was made, and one district was randomly selected. For logistical reasons, a second district was then chosen as the one closest to the randomly selected one. Thus, Chibombo and Kapiri Mposhi districts in the Central Province and Choma and Kalomo districts in the Southern Province were selected (depicted in Figure 1).

Figure 1: Districts involved in the study



Home-Use Testing

To select participating households for these districts, a listing of blocks and camps (villages) was obtained. Three blocks were randomly selected from each district, and eight camps were randomly drawn from within these three blocks. In the selected camps, existing census data (known as "farmers' register") were obtained where possible. These census data categorize farmers as "small-scale," "medium-scale," and "commercial." A random sample of 10 households was drawn from the "small-scale" list in each camp. In other words, the sample has no representation of either medium-scale or commercial producers, so that it best approximates the target population for biofortified crops. Where the census data were not available, a census was undertaken and then a random sample drawn. A replacement sample was also selected randomly in the event that the selected household was either not to be found or did not want to participate in the study. Two villages were dropped because they were relatively inaccessible, and the rest were randomly allocated to the treatment arms:

Group 1:	Control group (10 camps)
Group 2:	Group receiving nutrition information from camp officers (10 camps)
Group 3:	Group receiving nutrition information through simulated (recorded) radio messages (10 camps)

In each camp, a list of ten households was identified as described above for a total of 300 households; the realized sample size was somewhat different, as noted in Table 1, because, in one Group 2 village, the camp officer did not hold any meetings or, in fact, convey the nutrition message, even though he had participated in the training. For this reason, there were only nine communities that received nutrition information through their leaders. Although data were collected in this tenth camp, it is not used in the analysis that follows. We decided against allocating it to the control group of villages. The total number of households canvassed under HUT is therefore 279.[2]

Respondents in home-use testing were provided 2 kilos each of the three types of maize flour—white, yellow, and orange—sequentially and in random order, to control for possible order-effects in preference elicitation.[3] The flour was not identified by variety; instead, a three-digit random number was assigned to each of the three varieties. Visually, of course, the three types of maize are distinct. Respondents had two days to

[2] We also interviewed an additional adult and at least one child in each household in the HUT to analyze whether preferences vary within the household, especially between adults and children. This will be analyzed separately in a companion paper.

[3] Constraints on the total amount of orange maize available precluded the provision of larger amounts to each household.

try each type of maize, using their usual household recipes. After handing out the first sample, enumerators would return two days later and ask the sensory perception questions pertaining to the first sample, while handing over the second sample. The process was repeated every two days until the fourth and final visit when respondents were asked about their willingness to pay (using a framed choice experiment detailed later), and a brief questionnaire eliciting demographic information and other socioeconomic indicators was administered. Most of the respondents who participated in the choice experiment—nearly three quarters—reported that they (and not some other member of the family) were responsible for making the decision to purchase maize within the family.

Central-Location Testing

For the central-location testing, a village was first selected in each of the two provinces. In each village, the community leader visited adjacent camps to invite villagers to participate in the survey at a pre-specified location, typically the local market or agricultural training center. As participants came to the location, they were randomly assigned to one of the two treatments. The first treatment corresponded to the control group, and, in the second, the nutrition message was conveyed through the simulated radio using MP3 players. We used spatial separation to ensure that there was no contamination of the control group with messages diffusing from participants who had already participated in the survey. More than 100 consumers were canvassed at each of the two locations, for a total sample size of 208.

In the central-location testing, consumers were provided with cooked samples of the three types of *nshima*, presented in random order on white plates with water to cleanse the palate between samples. To prepare the thick *nshima* paste, maize flours from each variety were added to boiling water followed by "paddling" (not stirring). Additional flour was added until a thick paste was formed. The cooking time was usually 5 to 10 minutes depending on the variety.

After tasting each sample, the respondents were asked to score their preferences and answer the questions related to willingness to pay. The respondents in the nutrition-information treatment arm heard the radio message before they tasted the three types of *nshima*.

Eliciting Willingness to Pay with a Framed Choice Experiment

As described later, a framed choice experiment using a fractional factorial design was used to elicit willingness to pay. That is, different prices were ascribed to each of the three maize grains, and consumers were asked which of the three they would purchase given these prices. A series of sixteen different price scenarios were presented to the consumer, and, in each case, he or she had to choose one price–maize combination as their preferred choice. In each case, a "none of the above" choice was also available.

To determine the price scenarios, the median prevailing prices for white maize in the study area were first ascertained over the course of a pretest. Prices of the maize were then varied reflecting a range of discounts and premiums—from 30 to 50 percent of the median price. The order of the sixteen price scenarios was scrambled and presented in random order.

In all cases—whether they were given cooked samples of *nshima* (CLT) or maize flour (HUT)—consumers scored the attributes of each type of maize using a five-point hedonic box scale, which ranged from "dislike extremely" to "like extremely." After this, the willingness-to-pay part of the questionnaire was administered. These questions referred to the maize grain, since it is the grain that is typically purchased and not the flour. The correspondence between the flour/*nshima* and the grain was obvious by color but also by the use of the same random number to label the grain and flour/*nshima*.

Additional information on factors that could condition price and sensory evaluation responses—such as household incomes and assets, household composition, frequency of intakes of maize, attitudes towards maize, demographic structure of the household, and access to sources of information—was also collected. Depending on the treatment arm, a set of questions testing retention of nutrition messages was also posed to consumers. This demographic module was asked at the end of the survey because it may be the case that asking it at the beginning can bias responses.

III. SUMMARY STATISTICS

Table 2 presents some summary statistics about maize consumption, cultivation practices, and other characteristics of the sample. As might be expected, virtually the entire sample reported that maize was their primary staple, consumed daily. They also reported that *nshima* was consumed every day thereby validating the use of *nshima* in the sensory-testing component of the survey.

Table 2: Characterizing maize production and consumption characteristics and other summary statistics

	Home-Use Testing	Central-Location Testing
Total number of respondents canvassed	279	208
% reporting maize as primary staple	100	100
% reporting maize consumption every day	98	100
% reporting nshima consumption every day	97	100
% reporting sale of maize	52	76
% reporting own production as primary source of maize consumed	53	59
% reporting purchasing maize for consumption	62	63
% maize area under hybrids	57	67
% maize area under modern open pollinated varieties	11	12
% maize area under local varieties	32	21
% naming a hybrid as their favorite maize variety	65	73
% reporting buying improved maize seed once a year	69	82
% reporting receiving information about maize cultivation	49	51
Of those who received information on maize,		
% who received information from public extension	65	55
% who received information from NGOs	12	16
% who received information from radio	15	14
% who received information from other sources	8	15
% reporting that they usually consumed sugar*	79	
% reporting that they consumed sugar every day the previous week	15	
% reporting that they did not consume sugar in the previous week	34	
Of those who consumed sugar,		
% reporting Zambia/Kasama/Kafue brands	62	
% reporting unpacked/unknown/open sack	38	
% reporting ownership of a radio	57	71
Of those who listened to radio,		
% listening to community radio stations	25	42
% listening to public radio stations	72	50
% listening to private radio stations	3	8
% reporting hearing the radio after 6 p.m.	38	51

*question canvassed of a subsample of HUT respondents

Respondents' exposure to markets for maize grain is also substantial: 76 percent of the CLT sample and 52 percent of the HUT sample reported that they had sold maize. Over half the sample reported "own production" as their primary source of maize for consumption; consumption out of own production did not preclude market purchases for consumption.

The coverage of hybrid maize was also substantial, with nearly two-thirds of the area cultivated by the CLT respondents being under hybrids; the corresponding figure for HUT respondents was 57 percent. The coverage of modern open pollinated varieties was relatively limited at 11 to 12 percent. When asked to name their favorite maize variety (for consumption), two-thirds of the HUT and three-fourths of the CLT respondents named a variety that was a hybrid. Given the dominance of hybrids in acreage, it is not surprising therefore that more than 80 percent of CLT respondents and 70 percent of HUT respondents report buying improved seed at least once a year.

Nearly half the respondents reported receiving information about maize. The predominant source for information about maize was the public sector extension system for both HUT and CLT respondents, although the proportion for HUT was higher. Between 12 and 16 percent of those who received information on maize did so through nongovernmental organizations.

Given the focus on maize as a source of vitamin A and the fact that sugar is mandated to be fortified with vitamin A in Zambia, the survey also canvassed information on the consumption of sugar for a subsample of the HUT respondents. The results suggest that although nearly 80 percent of respondents reported that they "usually" consume sugar, when asked specifically about sugar consumption in the previous week, one-third of the respondents reported that they had not consumed any. The percent of respondents reporting that they had sugar every day in the previous week was only 15 percent. The modal response was "at least once or twice in the last week." The survey also asked about what brand of sugar was consumed. For those who reported at least some consumption of sugar in the previous week, 40 percent reported that it was sourced from an unknown repack/open sack, while 60 percent could name the sugar as being one of the following brands: Zambia, Kasama, or Kafue. This suggests that the effective coverage of fortified sugar is far from high in rural Zambia.

Exposure to radio is quite widespread in rural Zambia: 57 percent of HUT and 71 percent of CLT respondents reported owning a radio. Public radio stations seem to predominate, although community radio stations are also popular. A third of the respondents reported listening to radio after 6 p.m., while another third said that they typically listened to the radio in the mornings, before noon. This suggests that use of radio stations to convey nutrition messages can be quite effective in rural Zambia.

Comparability of the Treatment Arms

As a check on whether the random allocation of treatments to communities was successful, Table 3 provides summary statistics on key observables. Within the HUT and CLT settings, the demographic and socioeconomic characteristics appear not to vary significantly across treatment arms. In other words, more than 90 percent of respondents in the three HUT settings reported farming as the main source of employment, and the differences between the three are not significant. Similarly, nearly 80 percent of respondents in the two CLT settings reported farming as the main source of employment, and the difference between the two treatment arms was also insignificant. This is true for other variables, including the average index of assets owned (constructed as a normalized sum of the assets owned by the respondent), the percent of respondents with primary education, and so on.

Table 3: Summary statistics on selected demographic variables, by treatment

	Home-Use Testing			Central-Location Testing	
	No information (1)	**Information from Radio (2)**	**Information from Community Leaders (3)**	**No information (4)**	**Information from Radio (5)**
Sample size (number of respondents/households)	103	89	87	107	101
Average age in years	48	43	47	42	40
Percent of respondents with primary education	54	60	54	45	45
Percent reporting farming as main employment	90	98	95	82	80
Average land cultivated in hectares	2.2	2.3	2.0	2.9	2.8
Average index of assets owned	0.2	0.3	0.3	0.4	0.3

Standard errors available with authors on request; t-tests of differences in means within CLT and HUT are insignificant by and large, but differences in means between CLT and HUT are significant.

However, this is not the case across the HUT and CLT groups. On average, respondents in the HUT treatment arms were older (by about five years), more likely to have had a primary education, and cultivated less area but relied more on farming as their main occupation than their CLT counterparts. In part, this is likely a reflection of the different sampling strategies followed in the CLT and HUT settings (outlined above). Therefore, while the randomization exercise appears to have been successful within the HUT and CLT in that key demographic variables do not vary across treatments, respondents in the CLT arms had a statistically different demographic and socioeconomic profile than those in the HUT arms. The net impact of these differences on estimated willingness to pay is hard to predict.

Another factor that vitiates a direct comparison between the HUT and CLT relates to the differential endowments received: HUT consumers received maize flour to try at home, in addition to a participation fee, while CLT respondents received only a participation fee.

However, while the endowment effect may be expected to increase the estimated willingness to pay of HUT respondents relative to those in the CLT, there is no reason to expect that this would also affect the magnitude of premiums and discounts of the orange maize relative to white maize.

IV. CONSUMER ACCEPTANCE OF ORANGE MAIZE

Sensory Testing

The semi-trained sensory panel consisted of 10 assessors at the National Institute for Scientific and Industrial Research in Lusaka, Zambia. The panel generated descriptive terms for the cooked form (a stiff paste) and the whole kernel using a range of white, yellow, and orange maize varieties. Standards were not provided. For the cooked paste, the terms were orange color, yellow color, cream color, dull appearance, rough appearance, sweet odor, *nshima* odor, burnt odor, flat taste, sweet taste, soft texture, and coarse texture. The descriptive terms for the whole kernels were size, yellow color, cream color, orange color, dull appearance, round shape, flat shape, cone shape, dented, corn smell, damp smell, discolored grains, and smooth feel.

At each sensory panel session, four maize samples (either whole grain or stiff paste) were coded with three-figure random numbers and served in random order. Intensity ratings were scored on a 100 millimeter unstructured scale, anchored with the terms "not very" at the low end and "very" at the high end. Panel sessions were repeated until all samples were scored in triplicate. During the panel sessions, the lighting (fluorescent) remained constant to facilitate scoring of cooked flesh color while the room temperature was ambient.

These results were analyzed using a two-way analysis of variance. The sensory attributes that significantly differed with respect to the *nshima* are shown in Table 4. The *nshima* samples significantly differed with respect to orange, yellow, and cream color, dull appearance, sweet and *nshima* odor, and soft texture. The significant difference between the panelists is common, but the lack of interaction for many sensory attributes suggests similar trends for each panelist.

Table 4: Differences (using ANOVA) with respect to panelist and maize variety used to make *nshima* (p values)

Sensory Attribute	Panelist	Variety	Interaction
Orange color	<0.05	<0.05	0.236
Yellow color	<0.05	<0.05	0.113
Cream color	<0.05	<0.05	0.152
Dull appearance	<0.05	<0.05	0.080
Rough appearance	<0.05	0.196	0.768
Sweet odor	<0.05	<0.05	<0.05
Nshima odor	<0.05	<0.05	0.651
Burnt odor	<0.05	0.066	0.988
Flat taste	<0.05	0.629	0.922
Sweet taste	<0.05	0.097	0.013
Soft texture	<0.05	<0.05	0.081
Coarse texture	<0.05	0.215	0.916

Consumer Acceptability

For this research, ordinal logistic regression was used to analyze the consumer acceptability scores, where consumers ranked various attributes, including taste, odor, texture, and overall acceptability, on a scale of 1 to 5, with 1 corresponding to "dislike very much" and 5 corresponding to "like very much." Meullenet et al. (2007) have suggested using ordinal logistic regression models in consumer research and, in particular, hedonic scales because they are categorical rather than continuous.

The premise is that although the underlying preferences y^* for the attribute may be continuous, they are latent and unobserved; instead, what is observed is the rank y the consumer gives the attribute. The model may be specified as:

$$y^* = Z\beta + \varepsilon;$$
$$y = 1 \text{ if } -\infty < y^* \leq \mu_1$$
$$y = 2 \text{ if } \mu_1 < y^* \leq \mu_2$$
$$y = 3 \text{ if } \mu_2 < y^* \leq \mu_3$$
$$y = 4 \text{ if } \mu_3 < y^* \leq \mu_4$$
$$y = 5 \text{ if } \mu_4 < y^* < \infty$$

where Z is a set of covariates and the μ_is are acceptability thresholds that cannot be observed but may be estimated. A further advantage of ordinal regression is that it does not assume that the difference between each category in the ordinal scale is the same.

This specification implies that the probability a consumer ranks an attribute j is given by (Cameron and Trivedi 2005):

$$\Pr[y = j] = \Pr[\mu_{j-1} < y^* \leq \mu_j] = F[\mu_j - Z\beta] - F[\mu_{j-1} - Z\beta]$$

where F is the cumulative distribution function of ε . The marginal effects can be computed analogously. We assume here that F has a logistic distribution. Also, the age of the respondent, their gender, and the assets they access are the key demographic variables in Z. Also included are dummy variables indicating whether the respondent received nutrition information, and, if so, whether from radio or a community leader.

Central-Location Testing

The consumers scored the desirability of each maize sample with respect to its appearance, aroma, taste, texture, and overall likeability. But because all of these terms are highly correlated with each other, the analysis only uses the overall likeability variable.

Coefficients of the ordinal logistic regression analysis are presented in Table 5. The results suggest that while yellow maize is not liked as much as white maize, as expected, this is not the case with orange maize. In general, acceptability was greater among women, older respondents, and those with more assets. The provision of nutrition information translated into a greater acceptance for orange and yellow varieties and (somewhat surprisingly) a lower acceptance of white maize.

Table 5: Ordinal logistic regression analysis—coefficients for CLT sample

	Coefficient	Standard error
Maize=yellow	-1.166	0.033
Maize = orange	0,022	0.033
Gender	-0.302	0.020
Age	0.003	0.002
Assets	0.134	0.054
Nutrition message = Radio	-0.315	0.033
[Maize=yellow]*[Nutrition message=radio]	0.557	0.045
[Maize=orange]*[Nutrition message=radio]	0.603	0.047
Threshold = 1	-3.934	0.064
Threshold = 2	-2.796	0.059
Threshold = 3	-1.735	0.058
Threshold = 4	-0.102	0.057

Home-Use Testing

As with the central-location testing, households scored the desirability of each maize sample with respect to appearance, aroma, taste, texture, and overall liking. Also, in this case, the hedonic attributes were highly correlated with each other; therefore, the analysis only uses the overall liking rankings.

The results from the ordinal logistic regression for the home-use testing treatment arms are set out in Table 6. As expected, yellow maize is least liked; however, unlike with CLT, orange maize had a significantly greater acceptability than white maize.

Among demographic variables, age and assets of the consumer have positive coefficients and are significant while the gender coefficient is insignificant. The provision of nutrition information translates into increased acceptability for both yellow and orange maize but does not convert the lower overall acceptability of yellow maize compared to white into an equal or higher acceptance. This is the case irrespective of whether the information is provided by community leaders or by radio. The mode of nutrition information dissemination is important, however: the use of community leaders translated overall into greater increases in acceptability as compared to the use of radio.

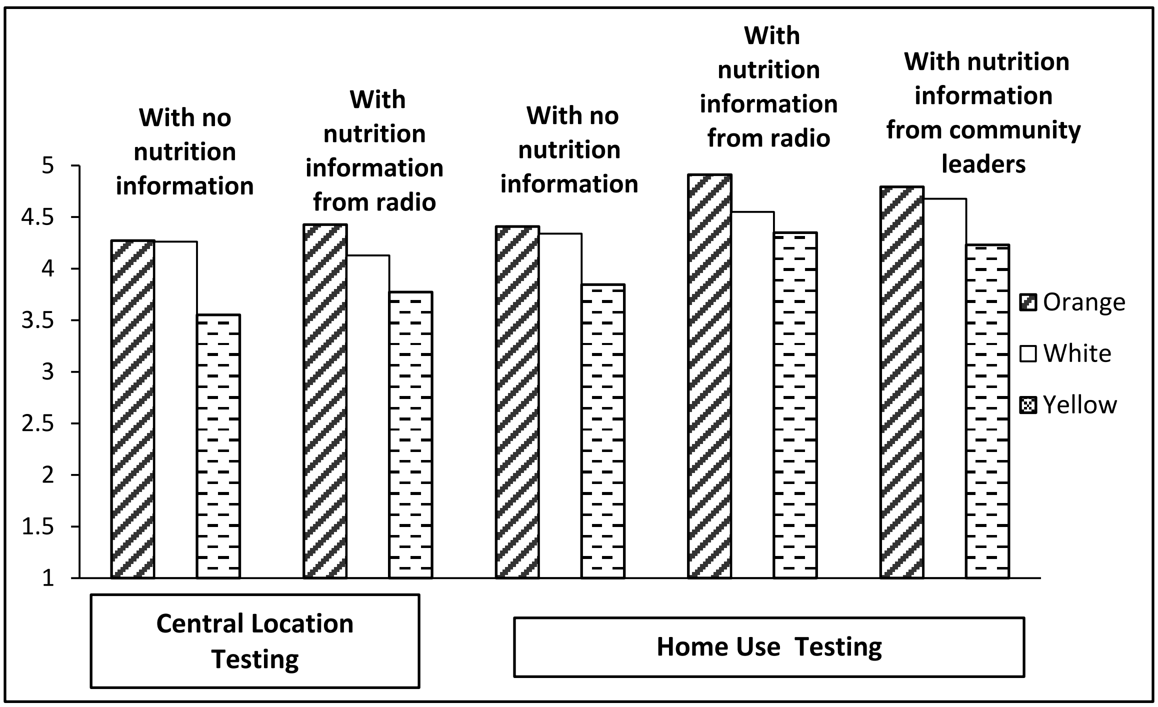
Table 6: Ordinal logistic regression analysis—coefficients for HUT sample

	Coefficient	Standard Error
Maize=yellow	-1.016	0.033
Maize = orange	0,122	0.034
Gender	0.017	0.019
Age	0.007	0.001
Assets	0.423	0.059
Nutrition message = Radio	0.468	0.037
Nutrition message = Community Leaders	0.803	0.039
[Maize=yellow]*Nutrition message=radio]	0.468	0.037
[Maize=orange]*[Nutrition message=radio]	0.803	0.039
[Maize=yellow]*Nutrition message=community leaders]	0.303	0.052
[Maize=orange]*[Nutrition message=community leaders]	0.526	0.058
Threshold = 1	-3.690	0.059
Threshold = 2	-2.667	0.051
Threshold = 3	-1,333	0.048
Threshold = 4	0.297	0.047

Comparison of Results from CLT and HUT for Acceptability of Maize

This appears to be the first time that CLT and HUT have been compared in a developing country and in a scenario where consumers have received information about the product. Figure 2 presents mean overall acceptance scores across the various treatment arms. Because all the sensory attributes are highly correlated with each other, their rankings are virtually identical to the overall acceptability score. When no information was given, HUT and CLT produced similar results, which is consistent with other findings (Boutrolle et al. 2005). This suggests that giving consumers more time to evaluate the product at home is probably not particularly critical, and the exposure time of 30 minutes in central-location testing seems to be sufficient for consumers to form an opinion about the product. Also, the way that the product was prepared (that is, consistently by a trained technician for CLT or variedly by individual consumers in HUT) did not appear to influence the outcome. While older and more financially well-off consumers seemed to have higher acceptability scores in both CLT and HUT settings, gender was significant only in the CLT setting.

Figure 2: Consumer acceptability scores, by treatment arm



V. WILLINGNESS TO PAY FOR ORANGE MAIZE

The quantification of the relative discounts or premiums for products that are not yet on the market—as is the case with the orange maize studied here—poses particular challenges. Economists have used various methods to quantify these; for example, consumers may be asked what they would be willing to pay for a hypothetical good or service. In other methods, the actual product or its prototype is used in the taste experiments and surveys.

Over the years, a consensus has emerged that results from the use of hypothetical scenarios tend to have an upward bias in that consumers often overstate their willingness to pay for a commodity or service. (See for example, Jaeger 2005 and Lusk and Schroeder 2006.) This is corroborated by a more recent study on maize in Kenya by de Groote and Kimenju (2008) that finds that consumers have no incentive not to overstate the price they are willing to pay in a hypothetical scenario. One method that has been proposed in the literature to mitigate hypothetical bias is the use of "cheap talk" scripts, where respondents are explicitly encouraged to think through responses carefully and act as if they were facing a real choice. Some studies (Carlsson and Martinsson 2001, and List et al. 2006) found that the extent of hypothetical market bias may not be high when a cheap talk script is used. In the context of Sub-Saharan Africa, Chowdhury et al. (2008) found, however, that even though the use of "cheap talk" significantly lowers the magnitude of hypothetical bias, it does not eliminate it. For this reason, this study makes use of actual products (orange, yellow, and white maize) and uses incentive-compatible ways (that is, methods conducive to eliciting truthful responses) to elicit willingness to pay for biofortified maize.

Conceptual Framework

A framed choice experiment using a fractional factorial design may be used to design the choice frames that elicit willingness to pay for the various types of maize. Even though there are concerns over the efficiency of orthogonal designs (Scarpa and Rose 2008), according to Louviere et al. (2000) these are the most suitable designs that are currently available. (See Ferrini and Scarpa 2007 for a discussion of the issue). In a choice experiment, prices are posted for each of the three types, and the respondent indicates which of the alternatives he or she would be willing to purchase. The set of three posted prices is then varied in a series of alternative scenarios, and the respondent makes a decision each time. A fourth alternative of "none of the above" is always available. These are real choices that the respondent makes with real money. Respondents are given a lump sum amount of money as participation fee so that they are not out of pocket as a consequence of buying a product in the experiment. After the respondent has made a decision in each of the sixteen price scenarios, one of the scenarios is picked by a random draw to "bind"; that is, the respondent has to purchase the maize that he or she had indicated as most preferred for this scenario at the price for which it was offered. In this way, the choice experiment is an incentive-compatible method of eliciting consumer preferences.

In the central-location testing, consumers first tasted the *nshima* made from the three types of maize then answered the choice experiment scenarios. In the home-use testing treatments, the choice experiment was administered on the final day, after they had a chance to experience the three different maize types in their home environment for a few days each.

These choices can be used to determine consumers' willingness to pay for the various alternatives by using the random utility model (McFadden 1974). Faced with the three alternative products—orange, white, or yellow maize—each priced differently, respondents make a choice of which of the three they would prefer to purchase based on the utility they derive from the consumption of the product. That is, the utility—U_{ij}—that consumer *i* derives from product *j* is postulated to have a systematic component (V_{ij}) and a random component (e_{ij}).

$$U_{ij} = V_{ij} + e_{ij} \; ; \; V_{ij} = X_{ij}\,\beta$$

The systematic component V_{ij} is a function of observable characteristics (X_{ij}) of the alternatives (such as price) and those of the respondent (such as gender, income, and age). The consumer chooses alternative *j* over alternative *k* if $U_{ij} > U_{ik} \,\forall\, k \neq j$.

The Conditional Logit and Random Parameters Logit Specifications

This basic framework can be used to estimate willingness to pay for each of the alternatives. The most commonly used specification is the conditional logit model, where the error term e_{ij} is assumed to follow an extreme value distribution. In this case, the probability P_{ij} that the *i*th consumer chooses the *j*th alternative (over all possible other alternatives, or *k*) is given by[4]:

$$P_{ij} = P\left(U_{ij} > U_{ik}\right) \forall\, k \neq j = \frac{\exp\,(V_{ij})}{\Sigma \exp(V_{ik})}$$

Another more general class of models is the random parameters logit model, also referred to as the mixed logit model, which allows for individual taste variation through random or individual-specific effects and can account for unobserved heterogeneity (Train 1998; Louviere et al. 2000). In this model, one or more of the coefficients β are assumed to be random (it is common to assume normal, log-normal, uniform, or triangular distributions for these), while the error term follows the extreme value distribution (Campbell et al. 2006). In this paper, the alternative-specific constant is specified to be random, following a uniform distribution.

---

[4] Alternatively, the error term may be assumed to be normally distributed, leading to the multinomial probit specification.

Accounting for Lexicographic Preferences

Given the magnitude of the participation fee, which is equivalent to about US$0.50 per day—a substantial amount for rural Zambians—one concern in implementing the survey was that consumers would choose to consistently mark "none of the above" as their preferred choice, as this would guarantee that they could keep the entire participation fee without having to make a purchase. This did not happen at all in the survey, however.

Instead, another response was at play—consumers consistently chose only one type of maize in all choice scenarios. A substantial proportion of respondents almost invariably chose orange maize, irrespective of the prices of the three types of maize on offer. This clearly translated into an assurance that they would be able to purchase the orange maize. In our sample, one-fifth of the control group in the central-location testing scenario consistently chose only orange maize, while nearly one-third of those who received nutrition information did the same. Similarly, one-fourth of those in treatment 1 and one-third of those in treatment groups 2 and 3 consistently chose orange maize, irrespective of the prices they faced. A relatively small proportion of consumers—about 4 percent—also systematically chose only white maize, irrespective of the prices they faced.

As indicated in Table 7, for most demographic characteristics, including age and assets, there were no statistically significant differences between those individuals who exhibited lexicographic preferences and those who did not, with one important exception: gender. A significantly higher proportion of the lexicographic individuals were men, as compared to the rest of the sample.

Table 7: Demographic characteristics of those exhibiting lexicographic preferences

	Those with lexicographic preferences (consistently chose orange across all choice scenarios)	**Those who did not consistently choose orange across all choice scenarios**
Age in years	44.6 (15.3)	43.6 (15.7)
Index of assets owned	0.29 (0.19)	0.30 (0.18)
Proportion of males	**0.33 (0.47)**	**0.44 (0.50)**
Household size	7.92 (3.83)	7.41 (4.73)
Land accessed in hectares	2.80 (2.52)	2.32 (2.46)

Note: Figures in parentheses are standard deviations. Figures in bold are statistically different across the two groups.

This behavior indicates that for this subset of consumers, the price attribute is irrelevant. This has consequences for the estimation strategy as the inclusion of consumers who exhibited such lexicographic preferences without accounting for their lack of responsiveness to price would result in estimated WTP for orange maize that are likely to be overstated. For this reason, both the conditional logit and random parameters logit models are estimated following the approach of Campbell et al. (2006) and Hensher et al. (2005) by assuming that for these consumers, the coefficient associated with price is zero. We term these conditional logit/random parameters logit with lexicographic preferences.

Estimating the Model and Willingness to Pay

By suitably parameterizing V_{ij}, these models may be estimated using maximum likelihood (conditional logit) or simulated maximum likelihood (random parameters logit). The willingness to pay for each variety can then be computed as a function of the estimated parameters.

After some experimentation with alternative functional forms and variables, the following formulation for V_{ij} works best:

$$V_{ij} = \beta_{1j} + \beta_2 \text{Price}_j + \beta_3 \text{Age}_i * \text{Price}_j + \beta_{4j} \text{gender}_i + \beta_5 \text{Asset}_i * \text{Price}_j$$

where price refers to the price of the *j*th alternative, gender, age, and asset refer to the gender, age, and index of assets accessed by the *i*th respondent. The inclusion of color dummies yields insignificant coefficients and is therefore not used in the estimation.

The WTP for the *j*th alternative can then be written as: $\frac{\beta 1j + \beta 4j * (\overline{gender})}{\beta 2 + \beta 3 * (\overline{age}) + \beta 5 * (\overline{asset})}$

where the variables are evaluated at the sample means after excluding those respondents who exhibited lexicographic preferences. It is also possible to construct the average willingness to pay by first estimating the WTP for each respondent then taking an average across respondents. The two estimates do not, however, vary widely.

As noted earlier for the random parameters logit model, we specified the alternative-specific constant to be random following a uniform distribution.

Table 8 presents the log likelihood values and McFadden's R-squared values for the conditional and random parameters logit models, both in the basic and lexicographic variants, for each of the five treatment arms. It is clear that the lexicographic models have significantly higher log likelihood values in each treatment arm and that the random parameter logit models have somewhat higher log likelihood values than their conditional logit counterparts, but the difference is not large. That is, accounting for lexicographic preferences matters more than the random parameters generalization. Table 9 presents the estimated coefficients for the random parameters logit model with lexicographic preferences for all five treatment arms. By and large, the estimated coefficients all have the correct signs and are statistically significant.

Table 8: Log likelihood and Mc Fadden's R-squared values of various models, by treatment arm

	Home-Use Testing			Central-Location Testing	
	No information (1)	**Information from Radio (2)**	**Information from Community Leaders (3)**	**No information (4)**	**Information from Radio (5)**
Log likelihood values					
Conditional logit—basic model	-1449.43	-974.19	-1070.45	-1640.93	-1342.29
Random parameters logit—basic model	-1438.50	-972.94	-1060.89	-1636.66	-1339.81
Conditional logit—lexicographic model	-1267.22	-861.17	-914.94	-1506.89	-1165.59
Random parameters logit—lexicographic model	-1265.24	-857.84	-906.10	-1498.78	-1157.37
Mc Fadden's R-squared					
Conditional logit—basic model	0.116	0.176	0.148	0.122	0.099
Random parameters logit—basic model	0.370	0.502	0.444	0.310	.0402
Conditional logit—lexicographic model	0.227	0.271	0.272	0.193	0.218
Random parameters logit—lexicographic model	0.446	0.561	0.525	0.369	0.483

Table 9: Parameter estimates: Random parameter logit model incorporating lexicographic preferences

	Home-Use Testing			Central-Location Testing	
	No information (1)	**Information through radio (2)**	**Information from Community Leaders (3)**	**No information (4)**	**Information from Radio (5)**
White (ASC)	7.49 (1.06)	8.40 4(1.52)	4.588 (0.92)	6.593 (0.70)	2.951 (0.95)
Yellow (ASC)	6.77 (1.04)	5.245 (1.60)	3.863 (0.94)	5.02 4(0.66)	5.249 (0.86)
Orange (ASC)	9.03 (1.06)	10.738 (1.53)	7.432 (1.10)	7.725(0.74)	8.289 (1.02)
Price	-0.002 (Neg)	-0.002 (Neg)	-0.001 (0.001)	-0.003 (Neg)	-0.005 (Neg)
Age*Price	-0.00004 (Neg)	-0.00007 (Neg)	-0,00004 (Neg)	0.00001(Neg)	0.00001 (Neg)
Asset*Price	0.003 (0.001)	0.001 (0.001)	-0.003 (0.001)	-0.002 (Neg)	0.002 (Neg)
White*Gender	0.266 (0.61)	-0.832 (0.83)	2.480 (0.68)	0.095 (0.37)	2.298 (0.67)
Yellow*Gender	-0.198 (0.62))	0.257 (0.87)	1.772 (0.68)	0.267 (0.39)	0.196 (0.50)
Orange*Gender	-0.144 (0.54)	-1.69 (0.83)	1.532 (0.66)	-0.371 (0.38)	-0.055 (0.48)

Notes: Figures within parentheses are standard errors; "Neg" denotes negligible, extremely small standard errors.

Table 10 presents the estimated premiums/discounts for yellow and orange varieties relative to white maize for the conditional and random parameters logit models with lexicographic preferences for each of the five treatments, while Table 11 provides the corresponding willingness-to-pay estimates along with the 95 percent confidence intervals.[5] The percentage premiums do not vary widely between the two models; we focus, therefore, on the premiums/discounts derived from the random parameters logit models.

Table 10: Estimated premiums/discounts in willingness to pay for yellow and orange maize relative to white maize, by treatment arm (as percent of willingness to pay for white maize)

	Home-Use Testing			**Central-Location Testing**	
	No information (1)	**Information from Radio (2)**	**Information from Community Leaders (3)**	**No information (4)**	**Information from Radio (5)**
Random parameters logit model with lexicographic preferences					
Orange relative to white	5	15*	17**	7	32**
Yellow relative to white	-18**	-21**	-21**	-19**	-11
Conditional logit model with lexicographic preferences					
Orange relative to white	5	15*	17**	7*	20**
Yellow relative to white	-14**	-13*	-12**	-10**	-10*

Note: **refers to statistical significance at 5 percent using a one-sided test; * refers to statistical significance at the 10 percent level, using a one-sided test.

[5] As Poe et al. (1994) have argued, it may be appropriate to use a convolutions approach to test whether the distributions of the estimated willingness to pay vary significantly. We leave this for a future exercise and focus instead on differences in the mean willingness to pay.

Table 11: Estimated willingness to pay per respondent, by maize color, and treatment arm (Zambian kwacha per half-meda)

	Conditional logit lexicographic	Random parameters logit lexicographic	Random parameters logit all five treatments accounting for endowment effects, lexicographic
Home-Use Testing—No information (1)			
White	2752 (138) [2481 – 3022]	2691 (134) [2428 - 2954]	2543 (108) [2331 – 2755]
Yellow	2367 (135) [2102 – 2633]	2211 (150) [1917 – 2505]	1975 (115) [1750 – 2200]
Orange	2899 (140) [2625 – 3173]	2831 (136) [2564 – 3098]	2661 (108) [2449 – 2873]
Home-Use Testing—Information from radio (2)			
White	2794 (196) [2411 – 3178]	2644 (189) [2274 - 3014]	2493 (113) [2272 – 2714]
Yellow	2437 (191) [2062 – 2812]	2077 (231) [1624 – 2530]	1963 (126) [1716 – 2210]
Orange	3209 (201) [2815 – 3603]	3034 (195) [2652 – 3416]	2923 (116) [2696 – 3150]
Home-Use Testing—Information from community leaders (3)			
White	2321 (123) [2080 – 2562]	2146 (123) [1905 – 2387]	2109 (88) [1937 – 2281]
Yellow	2037 (123) [1796 – 2278]	1686 (140) [1412 – 1960]	1682 (103) [1480 – 1884]
Orange	2728 (126) [2480 – 2976]	2520 (126) [2273 – 2767]	2523 (89) [2349 – 2697]
Central- Location Testing—No information (4)			
White	2336 (90) [2159 – 2514]	2219 (87) [2048 – 2390]	2210 (75) [2063 – 2357]
Yellow	2103 (88) [1930 – 2276]	1801 (115) [1576 – 2026]	1822 (86) [1653 – 1991]
Orange	2509 (93) [2327 – 2690]	2377 (92) [2197 – 2557]	2324 (78) [2171 – 2477]
Central-Location Testing—information from radio (5)			
White	2392 (120) [2157 – 2626]	1870 (144) [1588 – 2152]	2142 (83) [1979 – 2305]
Yellow	2158 (118) [1927 – 2390]	1664 (161) [1348 – 1980]	1800 (96) [1612 – 1988]
Orange	2870 (128) [2619 – 3122]	2472 (121) [2235 – 2709]	2579 (86) [2410 – 2748]

Notes: Figures in round parentheses refer to standard errors; those in square brackets refer to 95 percent confidence bands.
A meda is a common measure of weight in Zambia and corresponds to 5 kilos.

It is clear that orange varieties do not suffer any price disadvantage relative to white maize. In the absence of any nutritional information, orange varieties are liked and do not suffer a discount. The difference in willingness to pay between white and orange varieties is insignificant in both CLT and HUT scenarios. With nutrition information from the radio, orange varieties command a premium of 15 percent in the HUT case and 32 percent in the CLT case. Interestingly, while the provision of nutrition information through community leaders also translates into a premium for orange maize of 17 percent, it is not substantially larger than the 15 percent premium from simulated radio. That is, the magnitudes of the premiums for orange maize appear to be the same for both sources of nutrition information. This is consistent with results from the consumer acceptability analysis outlined in Section 4.

As expected, yellow maize varieties suffer a discount relative to white maize in all treatment arms, and the difference is statistically significant in nearly all cases. The provision of nutrition information does nothing to alter the discount on yellow varieties. This agrees with prior hypotheses about the acceptability of yellow maize in Zambia and, more importantly, indicates that consumers do not confuse orange for yellow maize.

Respondents in the CLT and HUT arms are not directly comparable, as noted in Section 3. However, it is interesting to note that the broad conclusion of a premium for orange varieties and a discount for yellow varieties holds regardless of whether the CLT or HUT was used. Given the much greater simplicity of the CLT approach, this would argue in favor of using CLT.

Accounting for Possible Endowment Effects

In addition to the somewhat different demographic profile of respondents in the CLT and HUT arms, a direct comparison between the two sets of treatments is vitiated by the presence of an endowment effect. Respondents in the CLT arms received a participation fee of 2000 Zambian kwachas (ZK), whereas those in the HUT arms received about 6 kilos of maize flour in addition to the ZK 2000 participation fee. Valuing the maize flour at median prices for white maize translates into an endowment for the HUT participants more than five times higher than that of the CLT participants. In addition, those in the HUT treatments who received the radio message obtained, albeit temporarily, a radio-cum-cassette player.

Although the endowment effect does not seem to have been felt on the magnitudes of premiums (for orange) and discounts (for yellow), there are systematic differences in the absolute magnitudes of the willingness-to-pay estimates. A comparison of the willingness-to-pay estimates between treatments 1 and 4 (those given no nutrition information) and between 2 and 5 (those given nutrition information from radio) in Table 11 suggests that, in general, the estimated willingness to pay is higher in the HUT treatment arms. Whether this result is because of the different demographic profile of the two sets of respondents, the higher endowments implied by the design of the HUT, or whether consumers just grew to like orange maize more as they gained experience with it cannot be determined precisely.

The endowment effect merits closer attention. The literature reviewed by Clark (2002) suggests that a "windfall" income, such as that represented by the participation fee, is treated differently by consumers and may result, for example, in a greater marginal propensity to consume—in our case, a higher willingness to pay as a result of receiving the participation fee. Clark's paper suggests that such "house money" effects are not significant, a result disputed by Harrison (2007). Other work on the role of house money includes that of Cherry et al. (2005). Although there appears to be no consensus in the literature on the significance of the endowment, the potential influence of a large endowment effect implicit in the participation fee and maize given to respondents cannot be ruled out.

Therefore, we attempted to account for the role of the endowment effect by estimating a combined model for all five treatment arms. In addition to the other covariates, we included dummy variables for (a) the HUT treatment arms, (b) treatments 2 and 5 that received information through the simulated radio, and (c) treatment 3 that received information through community leaders. The coefficients associated with the HUT dummy are positive and significant (see Table 12), which suggests that, to the extent that the dummy variable captures endowment effects, it significantly influences consumers' willingness to pay. The last column of Table 11 presents the willingness-to-pay estimates from this model as well. While this model does result in lowering the differences in the willingness to pay between the CLT and HUT treatments, the differences are not eliminated. This may be attributed to the impact of product experience or perhaps an experimenter effect. Note also that the coefficient associated with the provision of radio information is significant for orange but insignificant when associated with community leaders. Also, viewed as a restricted version of a more general model where parameters vary across treatments, this combined model does not do as well as the more general model.

Table 12: Accounting for an endowment effect: Parameter estimates of a random parameters logit model, combining all treatment arms, lexicographic preferences

Variable	
White (alternative-specific constant)	5.586 (0.40)
Yellow (alternative-specific constant)	4.821 (0.38)
Orange (alternative-specific constant)	7.094 (0.44)
Price	-0.002 (Neg)
Age*Price	-0.000001 (Neg)
Asset*Price	-0.0002 (Neg)
White*Gender	0.579 (0.21)
White*HUT	1.056 (0.28)
White*Radio	-0.264 (0.25)
White*Community Leaders	-1.270 (0.34)
Yellow*Gender	0.326 (0.22)
Yellow*HUT	0.520 (0.29)
Yellow*Radio	-0.122 (0.26)
Yellow*Community Leaders	-0.853 (0.36)
Orange*Gender	-0.250 (0.21)
Orange*HUT	1.116 (0.28)
Orange*Radio	0.657 (0.25)
Orange*Community Leaders	-0.382 (0.34)

Notes:
HUT: Dummy variable taking value one for HUT treatments 1, 2, and 3
Radio: Dummy variable taking value one for radio treatments 2 and 5
Community leader: Dummy variable taking value one for treatment 3

VI. CONCLUSIONS AND IMPLICATIONS

Two distinct approaches—from food science and from economics—were used to assess consumers' acceptance of orange maize biofortified with provitamin A. Both approaches endorse the following main conclusions.

- Orange maize is likely to be accepted by rural consumers in Zambia.
- Nutrition campaigns translate into improved acceptance and willingness to pay for orange maize.
- There is no appreciable difference in the impact of information received from community leaders versus information received from the radio, which has significant cost implications. This result merits further investigation, but it is possible that the intrinsic nature of the orange maize is driving this result.
- While the results for the home-use testing are different from the central-location testing in terms of magnitudes and are, strictly speaking, not comparable,

speaking qualitatively the results are consistent across both methods.

The primary implication is that there is reason to be confident that any negative connotations associated with yellow maize are unlikely to carry over to orange maize; orange maize carries a premium and no discount even in the absence of nutrition information. On the other hand, the willingness-to-pay estimates clearly indicate a discount for yellow maize relative to white varieties, which is not eliminated with the provision of nutrition information.

Even though magnitudes of premiums vary, since this result is arrived at in both CLT and HUT settings, the implication is that the additional cost of conducting a HUT survey could be avoided and the simpler-to-implement central-location testing method should be used in subsequent analyses of consumer acceptance.

An intriguing result relates to the near equivalence of mass media and interpersonal communication strategies in influencing consumer acceptance. While it is not the intention to posit these as "either–or" strategies, these results suggest that the role of mass media in communicating and reinforcing messages is likely to be significant. Retention of nutrition messages, at least in the short term, from radio messages appears to have been the same as retention from listening to community leaders. The fact that more than 60 percent of the sample reported owning a radio suggests that the impact of this medium of communication is likely to be significant.

Given equal or superior agronomic performance of the orange maize varieties, they may attract a premium in the market. Small-scale producers in rural Zambia (who constituted our sample) have considerable market exposure, both as sellers of maize and buyers of maize. They also rely substantially on public extension services and report using their own production as the primary source of maize consumed. This is a near-ideal combination of characteristics necessary to maximize the adoption—and public health impact—of provitamin A orange maize.

APPENDIX 1: RADIO MESSAGE IN ENGLISH

Orange Maize: Good for the Health of the Whole Family

M = Mr. Kalembula (male voice)
F = Mrs. Kandolo (female voice)

[At home: Sound of a brazier, natural environment]

M: Oodi! Oodi!

F: Oh Hi, its bana Kalembula, What a surprise, I have not seen you in a long time.

M: Oh well, that's the more reason I am passing through because it's been so long. How is your family?

F: We are fine, only that we are very busy.

M: Yes, I can see you have been very busy!

F: Oh yes my dear, you just found me sorting seed maize ready for planting.

M: I see that you are all set for the planting season.

F: Of course, my dear, these days you just have to be on time, if you have to have a good harvest. But also the selection of the type of seed matters.

M: So what type of seed are you planting this season?

F: Of course both the local and hybrid, but what I am sorting out now is the improved variety. I already planted some early maturing variety, which will allow the family to taste fresh maize early. But this particular improved variety is actually a special one as it is a new type that has been developed by researchers.

M: Ooh, let's see. *[Surprised]* Orange seed maize!

F: Oh yes, it's orange in color because it contains vitamins!

M: Did you say vitamins?

F: Yes vitamins. It actually contains vitamin A.

M: What is vitamin A? And what's so special about this vitamin?

F: Vitamins are nutrients found in food that are essential for good health. Vitamin A is important for the family especially in children. It helps reduce diseases found in children and helps prevent severity in measles and many other childhood diseases. And, vitamin A is good for the eyesight! Moreover, it improves general immunity in both adults and children. This orange maize has vitamin A.

M: How interesting! Is it only orange maize, or are there other foods rich in vitamin A?

F: But of course there are other rich sources of vitamin A apart from the orange maize. These include meats, milk, egg yolk, fruits and vegetables, especially those that are deep orange like paw-paws, carrots, pumpkins and those that are dark green in color, such as spinach, bondwe, and pumpkin leaves.

M: But this orange seed my dear, are you sure it can grow in the same way as the white seed?

F: Why not? We actually had a meeting with the researchers in the village. Maybe that it was the same time that you must have been away in the city. These researchers explained that orange maize is actually the same as the white maize, except that this one is orange in color and healthier. It can be used in the same way as the other traditional white maize.

M: You mean this maize can also be used to prepare my *nshima*?

F: Exactly, you can use the grain to grind your maize meal for your *nshima* and porridge for the children. You should give it a try. Remember, the vitamin A in orange maize means it is healthier for all of the family, especially the children.

I already planted my first grains, which have already germinated. You can't tell the difference between the orange and white maize.

M: This is interesting. I want to see for myself, let's go!

F: You see, this is what I told you!

M: Oh, this looks good, amake Kandolo. I think I should try this orange maize. I did well to pass through, it was worthwhile.

F: Ok my dear do well, and thanks for passing by….

REFERENCES

Alfines, F., G. Atle, G. Guttormsen, and K. Kolstad. 2006. Consumers' willingness to pay for the color of salmon: A choice experiment with real economic incentives. *American Journal of Agricultural Economics* 88(4): 1050–1061.

Boutrolle, I., D. Arranz, M. Rogeaux, and J. Delarue. 2005. Comparing central location test and home use test results: Application of a new criterion. *Food Quality and Preference* 16: 704–713.

Cameron, A., C. Pravin, and K. Trivedi. 2005. *Microeconometrics: Methods and applications.* Cambridge, England: Cambridge University Press.

Campbell, D., W. George Hutchinson, and R. Scarpa. 2006. *Lexicographic preferences in discrete choice experiments: Consequences on individual willingness to pay estimates.* Working Paper. Italy: Fondazione Eni Enrico Mattei Note di Lavoro.

Cardello, A. V., H. G. Schutz, and L. L. Lesber. 2007. Consumer perceptions of foods processed by innovative and emerging technologies: A conjoint analytic study. *Innovative Food Science and Emerging Technologies* 8: 73-83.

Carlsson, F and P. Martinsson. 2001. Do hypothetical and actual willingness to pay differ in choice experiments? *Journal of Environmental Economics and Managament.* 41: 179-92.

Cherry, T. L., S. Kroll, and J. Shogren. 2005. The impact of endowment heterogeneity and origin on public good contributions: Evidence from the lab. *Journal of Economic Behavior and Organization* 57: 357–365.

Chowdhury, S., J. V. Meenakshi, K. Tomlins, and C. Owori. 2009. *Are consumers willing to pay more for biofortified foods? Evidence from a field experiment in Uganda.* HarvestPlus Working Paper 3. Washington, D.C.: HavestPlus.

Clark, J. 2002. House money effects in public good experiments. *Experimental Economics* 5 (3): 223–231.

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

De Groote, H., and E. Rutto. 2006. African consumers' preferences for maize attributes (color, texture, sifting for meal). Mimeo, CIMMYT.

De Groote, H., M. Siambi, D. Friesen, and A. Diallo. Identifying farmers' preferences for new maize varieties in Eastern Africa. In *Quantitative Analysis of Data from Participatory Methods in Plant Breeding*, ed. M. Bellon and J. Reeves. Mexico: International Center for Maize and Wheat Improvement (CIMMYT).

Ferrini, S. and R. Scarpa. 2007. Designs with a priori information for nonmarket valuation with choice experiments: A Monte Carlo study. *Journal of Environmental Economics and Management* 53(3): 342-63.

Grunert, K. G., T. Bech-Larsen, and L. Bredahl. 2000. Three issues in consumer quality perception and acceptance of dairy products. *International Dairy Journal* 10: 575–584.

Harrison, G. W. 2007. House money effects in public good experiments: Comment. *Experimental Economics* 10: 429–437.

Hensher, D. A., J. Rose, and W. H. Greene. 2005. The implications on willingness to pay of respondents ignoring specific attributes. *Transportation* 32: 203–22.

Jaeger, S. R. 2005. Non sensory factors in sensory science research. *Food Quality and Preference*. 17(1-2): 132-44.

Kinnucan, H. W., H. Xiao, C. J. Hsia, and J. D. Jackson. 1997. Effects of health information and generic advertising on US meat demand. *American Journal of Agricultural Economics* 79(1): 13–23.

Langyuintuo, A., and C. Mungoma. 2008. The effect of household wealth on the adoption of improved maize varieties in Zambia. *Food Policy* 33: 550–559.

List, J. P. Singha and M. Taylor. 2006. Using choice experiments to value non market goods and services: evidence from field experiments. *Advances in Economic Analysis and Policy.* 6(2): 1-37.

Louviere, J. J., D. A. Hensher, and J. D. Swait. 2000. *Stated choice methods: Analysis and application*. Cambridge, England: Cambridge University Press.

Lusk, J. L., and T. C. Schroeder. 2006. Auction bids and shopping choices. *Advances in Economic Analysis and Policy* 6(1): 1-37.

Lusk, J. L., and T. C. Schroeder. 2004. Are choice experiments incentive compatible? A test with quality differentiated beef steaks. *American Journal of Agricultural Economics* 86(2): 467-82.

Grunert, K. G., T. Bech-Larsen, and L. Bredahl. 2000. Three issues in consumer quality perception and acceptance of dairy products. *International Dairy Journal* 10: 575–584.

McCann, J. 2005. *Maize and grace: Africa's encounter with a new world crop*. Cambridge, Mass., U.S.A.: Harvard University Press.

McFadden, D. 1974. Conditional logit analysis of qualitative choice behavior. In *Frontiers in Econometrics*. ed. P. Zarembka. New York: Academic Press.

Meilgaard, M., G.V. Civile and B.T. Carr. 2007. *Sensory Evaluation Techniques*. Fourth Edition. Florida, USA: CRC Press.

Menkir, A., W. Liu, W. S. White, B. Maziya-Dixon, and T. Rocheford. 2008. Carotenoid diversity in tropical-adapted yellow maize inbred lines. *Food Chemistry* 109: 521–529.

Meullenet, J. F., R. Xiong, and C. Findlay. 2007. *Multivariate and probabilistic analyses of sensory science problems*. Oxford, England: Blackwell Publishing.

Micronutrient Initiative and others. 2009. Investing in the future: A united call to action on vitamin and mineral deficiencies. Global report. Ottawa, Canada.

Morawetz, U., S. Kimeju, and H. De Groote. 2006. Estimating consumers' willingness to pay for food quality with experimental auctions: The case of yellow vs fortified maize meal in Kenya. Mimeo, CIMMYT.

Muzhingi, T., A. Langyintuo, L. Malaba, and M. Banzinger. 2008. Consumer acceptability of yellow maize products in Zimbabwe. *Food Policy* 33: 352–361.

Poe, G.L., E.K. Severance-Lossin and M.P. Welsh. 1994. Measuring the difference (X-Y) of simulated distributions: A convolutions approach. *American Journal of Agricultural Economics.* 76: 904-15.

Rubey, L., R. W. Ward, and D. Tschirley. 1997. Maize research priorities: The role of consumer preferences. In *Africa's Emerging Maize Revolution,* ed. D. Byerlee and C. Eicher. Colo., U.S.A.: Lynne Eienner Publishers.

Scarpa, R and J. Rose. 2008. Design efficiency for non-market valuation with choice modeling: How to measure it, what to report and why. *Australian Journal Agricultural and Resource Economics*. 52(3): 253-72.

Smale, M. and T. Jayne. 2003. Maize in Eastern Africa: Seeds of Success in Retrospect EPTD Discussion Paper No. 97 (IFPRI).

Stevens, R. and A. Winter-Nelson. 2008. Consumer acceptance of pro-vitamin A biofortified maize in Maputo, Mozambique. *Food Policy* 33: 341–351.

Taylor, S.D. 2006. *Culture and Customs of Zambia.* USA: Greenwood Press.

Tomlins, K., G. Ndunguru, K. Stambul, N. Joshua, T. Ngendello, E. Rwiza, R. Amour, B. Ramadhani, A. Kapande, and A. Westby. 2007. Sensory evaluation and consumer acceptability of pale-fleshed and orange-fleshed sweet potato by school children and mothers with preschool children. *Journal of the Science of Food and Agriculture* 87: 2436–2446.

Tschirley, D. L., and A. P. Santos. 1995. *Who eats yellow maize? Preliminary results of a survey of consumer maize preferences in Maputo, Mozambique.* International Development Working Paper 53. East Lansing, Mich., U.S.A.: Michigan State University.

Train, K. 1998. Recreation demand models with taste differences over people. *Land Economics.* 74: 230-39.

Zimicki, S. 1997. Promotion in Sub-Saharan Africa (Part 1). In *Net gain: A new method for preventing malaria deaths*, ed. C. Lengeler, J. Cattani, and D. de Savigny. Ottawa, Canada: International Development Research Centre.