Consumer willingness to pay for genetically modified food in Kenya

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Abstract

Genetically modified (GM) crops are popular in many regions of the world, but their deployment in Africa is hindered by safety concerns and regulatory issues, although the continent is in dire need of boosting its food production. Although consumers’ acceptance of GM food has been analyzed in many continents, no such studies have been conducted in Africa. Therefore, a survey of 604 consumers was conducted in Nairobi, Kenya, in 2003, to gauge consumers’ awareness of GM crops, their willingness to pay (WTP) for GM food, and the factors that influence their WTP. Consumers’ knowledge of GM crops was limited and only 38% of the 604 respondents were aware of GM crops. People in higher education and income groups were more aware than others. Regardless, people were generally appreciative of the technology, and a large majority (68%) would be willing to buy GM maize meal at the same price as their favorite brand. Consumers were, however, concerned about possible side effects, especially on the environment and biodiversity.

WTP was estimated using a double-bounded dichotomous choice model, and the mean WTP was found to be 13.8% higher than the average price of non-GM maize meal. Perceptions of health risk, and ethical and equity concerns had a negative influence on the likelihood of purchasing GM maize meal, whereas trust in government to ensure food quality had a positive influence on WTP. People with at least some secondary education and those in the high-income category were more likely to purchase GM maize meal at the same price. The study concludes that, because awareness is still low, appropriate communications are needed to involve the consumer in the debate. Consumers’ acceptance in this study was high, but the research needs to be expanded to rural areas, where most consumers live, and other survey methods need to be explored.

\textit{JEL classification:} D12, O33, Q18

\textit{Keywords:} GM food; Biotechnology; Double bound; Consumer; Maize; Kenya

1. Biotechnology in Africa

Since their introduction in 1996, genetically modified (GM) crops have spread at a rate seldom seen in the dissemination of agricultural technology. In 2005, GM crops were grown on 90 million ha, by 8.5 million farmers in 21 countries (James, 2006), with more than a third of that area (33.9 million ha) in developing countries. After herbicide resistance, the most important trait used in GM crops is Bt insect resistance. A gene derived from the common soil bacterium, \textit{Bacillus thuringiensis} (Bt), is inserted in the plants (especially cotton and maize), which causes them to produce proteins that are toxic to certain insect pests, in particular lepidopteran stem borer pests (FAO, 2004, p. 44).

GM crops have been the subject of an intense debate, with critics questioning whether the benefits outweigh the risks, and whether the poor will benefit. The major benefits are reduced pest damage and costs of pest control. Bt crops provide very good control of lepidopteran insect pests, so for farmers who tend to use insecticides, as most commercial farmers do, production costs are reduced substantially (FAO, 2004, p. 48). Resource-poor farmers, who rarely use pesticides, benefit from reduced crop losses, and higher and more stable yields (FAO, 2004, p. 43; Qaim, 2003). In Kenya alone, crop losses from stem borers in maize are estimated at 13.5% or 417,000 tons annually (De Groote, Bett, et al., 2004). In South Africa, Bt cotton has been shown to increase yields and reduce costs for small holders (Thirtle et al., 2003). Reduced pesticide use is also beneficial to the environment and to human health (McGloughlin, 1999).

The adoption of GM crops has been very rapid in North and South America and most parts of Asia. GM crops were first approved in the United States, for feed as well as food, and are now accepted by most consumers (Ganiere and Chern, 2004). Between 60 and 70% of processed foods sold in U.S.
supermarket is estimated to contain genetically engineered ingredients (Onyango et al., 2006).

In Europe and Japan, however, adoption has been slow and consumer acceptance has been a major factor (Chern et al., 2002; Zhang et al., 2004). Safety and regulatory concerns still constitute a major hurdle for developing countries (FAO, 2004), as well as the fear of losing export markets (Curtis and Moeltner, 2006). This is a particular problem for Africa, with its high population growth and high levels of food insecurity, as it stands to gain most from GM crops.

In Sub-Saharan Africa, only South Africa is growing GM crops commercially (Eicher et al., 2006), with 0.5 million ha in 2005 (James, 2006). It is also the only country where a staple GM food crop is grown (Eicher et al., 2006; Gouse et al., 2006). Several other countries are at different stages of trials for different GM crops. In Kenya, confined field trials with Bt maize and Bt cotton are ongoing (Mugo et al., 2005). Trials with Bt cotton are also ongoing in Tanzania, Mali, and Burkina Faso. Research is being conducted on Bt cowpeas in Zimbabwe, virus-resistant cassava in Kenya, disease-resistant bananas in Uganda, and GM potatoes in South Africa. Egypt, however, has halted the commercialization of GM potatoes, despite years of successful research, for fear of losing its European export market (Eicher et al., 2006).

Because of its importance, many studies of consumer acceptance have taken place in the developed countries and Asia (Curtis et al., 2004). Although Africa could benefit substantially from GM technology and GM varieties are being produced for this region, similar research on the opinions of African consumers or producers is lacking. Such studies are important because the successful introduction of GM crops into Africa will depend largely on consumer acceptance (Hossain et al., 2003; Springer et al., 2002).

The critical crop for East and Southern Africa is likely to be Bt maize. Maize is the most important food staple in this region, but production has not kept up with population growth (De Groote et al., 2005). Major constraints as perceived by farmers are lack of cash, access to technology and improved seed, and soil fertility, whereas the major pest problems are stem borers and storage pests (De Groote, Okuro, et al., 2004). Therefore, the Insect Resistant Maize for Africa (IRMA) project—a collaborative effort of the International Maize and Wheat Improvement Centre (CIMMYT) and the Kenya Agricultural Research Institute (KARI)—is developing maize varieties resistant to pest stem borers, using both conventional breeding and Bt technology (Mugo et al., 2005).

To study the acceptance of Bt maize by consumers, a survey was carried out in Nairobi in 2003, exploring consumers’ awareness of GM crops and their attitudes toward GM foods in general. Willingness to pay (WTP) was estimated through the contingent valuation (CV) method, and the factors that influence consumers’ acceptance and mean WTP were analyzed. This article reports the results of that study. To our knowledge, this is the first study of consumers’ attitudes and acceptance of a major GM crop in Sub-Saharan Africa, and the first study to use CV and the double-bound method in the region.

2. Consumer acceptance of GM food

Consumer acceptance of GM foods differs substantially around the world. In the United States, consumers generally accept GM products (Ganiere and Chern, 2004), and the premiums they are willing to pay for non-GM products are small (Chen and Chern, 2002). A study comparing U.S. and Chinese consumers found their attitudes generally supportive of the new technology (Zhang et al., 2004). European consumers, on the other hand, have strong reservations about GM crops. In the United Kingdom, only few consumers would accept to eat GM food, even with a discount (Moon et al., 2004). U.K. consumers would pay much higher premiums for non-GM food than their U.S. counterparts (Moon and Balasubramanian, 2001). On average, 73% of consumers in 15 European countries rejected GM food, ranging from 58% in the United Kingdom to 85% in Greece (Springer et al., 2002). Swedish consumers, in particular, disliked GM food, and would even pay a premium to ban GM feed for their livestock (Carlsson et al., 2004).

In Asia, Japan and Korea stand out as countries with low consumer acceptance for GM food, compared with China and Taiwan (Kim and Kim, 2004). Consumers in Beijing were willing to pay more for GM food (38% for rice and 16% for GM soybean) than for the conventional counterpart (Li et al., 2002). In Korea, large numbers of consumers are willing to buy GM products when offered at a discount (Kim and Kim, 2004). Compared with developed nations and Asia, however, few studies have addressed consumer acceptance of GM crops in developing countries, especially in Africa.

Several factors have been found that influence consumer acceptance of GM food. In the United States, consumers’ perceptions and attitudes toward GM food were found to influence their WTP (Kaneko and Chern, 2003), and the perception that GM food offers particular benefits such as a price discount, health attributes, or environmental benefits had a positive effect (Ganiere and Chern, 2004). Income and presence of children in the household, on the other hand, had a negative effect on U.S. respondents’ acceptance of GM food products, and female respondents and middle-aged consumers were found to be willing to pay a higher premium for non-GM food products (Chen and Chern, 2002).

In Europe, negative perceptions of GM food were found to decrease WTP, both in the United Kingdom (Moon and Balasubramanian, 2004) and Belgium (Verdurme and Viaene, 2003). Cognitive factors emerged as the most important factors to explain the differences in WTP between EU countries (Springer et al., 2002), with risk perception having a negative effect on WTP, and beliefs, knowledge, and trust in government having a positive effect.

In China, consumers’ positive opinions toward GM rice and soybean oil increase their WTP, and higher knowledge levels increased the WTP for GM soybean oil (Li et al., 2002). In
Japan, concern about food safety and knowledge about biotechnology decrease WTP for GM food (McCluskey et al., 2003). Consumer acceptance was much higher in countries with low-risk perceptions such as China, than in countries with high-risk perceptions such as Romania (Curtis and Moeltner, 2006). Consumers in developing nations (China and Colombia) were found to have more positive attitudes than those in developed countries (UK and US; Curtis et al., 2004).

It can be argued that food security problems are more urgent in developing countries, whereas perceived levels of risk may be smaller because of a higher trust in government, more positive perceptions of science, and more positive media influences. Similarly, per capita food production struggles to keep pace with population growth in Sub-Saharan Africa, and serious food shortages are a regular occurrence, so arguments in favor of GM crops are stronger (De Groote, Mugo, et al., 2004; Pinstrup-Andersen and Schioler, 2002). The fear of losing export markets, on the other hand, is a negative factor for many developing countries, and was the major reason why Romania stopped the commercialization of GM crops (Curtis and Moeltner, 2006) and Egypt the development of GM potatoes (Eicher et al., 2006). However, the risk of losing export markets for Kenyan maize can be considered small. The country rarely produces enough maize for export (the last time was in 1996), as the country struggles to meet food self-sufficiency and had to import on average 335,000 tons annually over the last 10 years (FAO Statistics Division, 2007). About 50% of the Kenyan population lacks access to adequate food, and the government has been spending roughly US$40–65 million annually on food relief (Republic of Kenya, 2004).

3. Methodology

Based on this literature review, and given a limited budget, suitable sites were selected, a sample survey designed with suitable tools, and an appropriate conceptual and analytical framework developed.

3.1. Site selection and data collection

Consumers’ access to information and knowledge of GM food are likely to be higher in urban areas, and surveys in these areas are cheaper and easier to organize. Therefore, Nairobi was selected for the first consumer survey on GM food. Interviews were conducted in November and December 2003 at three types of outlets: supermarkets, kiosks (small roadside shops), and posho mills (small hammer mills). Supermarkets provide a wide variety of finished maize products at central locations, catering to higher-income groups. Kiosks also provide finished products, but in a much smaller assortment, and are located in residential areas. Posho mills, mechanical hammer mills, are typically found in neighborhoods with high concentrations of low-income households. Their clients bring maize grain from the market and have it ground to flour, resulting in a less refined but much cheaper meal.

From a list of supermarkets obtained from Kenya’s Central Bureau of Statistics, 15 supermarkets were randomly selected: 10 large ones (with more than three local branches), and 5 small ones. For the kiosks, seven estates (administrative subdivisions of Nairobi) were selected from a list of city estates, and three kiosks randomly selected per estate. Twenty-one posho mills were randomly selected from the 16 estates known to house them, and the number selected in each was proportional to the total number in the estate.

In total, 604 consumers were interviewed: 183 at supermarkets, 210 at kiosks, and 211 at posho mills. Five enumerators were hired and trained specifically for this survey. In the selected outlets, they approached every third consumer looking for maize products and asked for an interview. Interviewing consumers was more difficult in the supermarkets where shoppers were usually in a hurry and about one out of every four shoppers approached refused to cooperate, mostly citing lack of time. Another 27 shoppers left without completing the interview as they thought it was taking too long, reducing the number of interviews to 183 for this type of outlet. Consumers in the other outlets, however, had more time, and only a few consumers in the kiosks refused to be interviewed, and none in the posho mills.

First, the consumers’ awareness of GM crops was assessed by checking whether they had read or heard about biotechnology and GM crops in general, and about Bt maize, Bt cotton, and virus-resistant sweet potato in particular. Respondents aware of GM crops were then administered the entire questionnaire, whereas those unaware were first presented with a short explanation of the scientific background of GM crops, their advantages and disadvantages, and the countries currently growing them (see Appendix). In order to control for possible order effects, two formats of the questionnaire were developed. Half of them presented the short explanation with benefits of GM crops first, whereas the other half presented risks first. After the presentation, those previously unaware were also administered the questionnaire. This questionnaire included questions about consumers’ sources of information on GM crops, their attitudes toward GM food, their demographic characteristics, and their WTP for GM food.

Risk perceptions of consumers were gauged by asking respondents if they agreed or disagreed with 16 statements on the risks and benefits associated with GM crops, and how strongly. There were four statements on benefit perception, three each for environmental risk and health risk perceptions, and six for equity and ethical concerns. The replies were transformed into a score (from −1 for “totally disagree,” −0.5 for “disagree,” 0 for “neutral,” 0.5 for “agree,” and 1 for “totally agree”). The scores were then averaged to form a perception index for each category: benefit perceptions (IBP), health risk perceptions (IHRP), environmental risk perceptions (IERP), and ethical and equity concerns (IEEC). Age was expressed in years, and gender transformed into a dummy variable (1 for female, 0 for male).
Respondents were classified into four education categories, according to the highest education level attained: no schooling or some primary (combined, because only six respondents did not attend any school); at least some secondary education, at least some tertiary college; and at least some university education, with a binary variable for each category. Finally, respondents were classified into five income categories: people without income (excluding students), students, students without income (because their behavior often reflects that of higher-income groups), people with a low income of up to 15,000 Kenyan shilling (KShs) per month, middle income (between KShs 15,001 and KShs 50,000), and high income (more than KShs 50,000/month) (US$1 = KShs 75 at the time of the survey). Of the 604 respondents, 52 had some missing values, so 553 remained for the regression analysis.

This is the first study of its kind to use maize meal outlets, stratified by type, as the first stage in the sampling design. This design avoids the expense of constructing a sampling frame, typical for the common, urban household surveys with city blocks or estates as the first stage. Another novelty is the use of indices to quantify consumer attitudes, allowing the estimation of marginal effects on WTP.

3.2. Consumer characteristics, awareness, and attitudes

Overall, there were slightly more men (55%) than women in the sample. Most respondents had attended school, and had either some primary education (20%), some secondary education (40%), or higher (39%) (Table 1). Most respondents worked, either in formal employment (41%) or self-employment (29%). Almost half (48%) had an income below KShs 15,000, and a large group (28%) had no income. Most of the consumers (72%) lived in households together with children under 18. The socioeconomic characteristics of maize consumers surveyed in this study differed substantially between the different types of outlets. Supermarkets, in particular, had more clients with formal employment, university education, and higher income. This had an effect on consumers’ awareness and attitudes, which has been analyzed elsewhere (Kimenju et al., 2005). Average sample statistics, however, compare well with the city’s population characteristics derived from the 1999 census. The census found 56% of Nairobi residents older than 14 years to be male, with few people having no education, a large group (52%) with at least some secondary education, and a large group who worked for pay (37%; Central Bureau of Statistics, 2001).

Almost half of the respondents (46%) had heard or read something about biotechnology, and slightly less (38%) about GM crops (Table 1). Of those respondents who were aware of GM crops, 95% were aware of the term “gene”; 65% had heard of virus-resistant sweet potato; 54% knew about Bt maize; and 21% about Bt cotton. These numbers likely reflect the order of introduction of the different GM crops in Kenya. Virus-resistant sweet potatoes were introduced in 2000, Bt maize in 2001, and Bt cotton in 2004. Trust in the government was high: most respondents (76%) thought that there were sufficient government controls to ensure food quality.

There were large differences in awareness between the socioeconomic groups. It increased strongly with education, from 17% in those with no formal education to 90% for those with some university education. Awareness increased strongly with income, from 28% for those with no income (excluding students) to 92% for those with monthly incomes of over KShs 50,000 per month (around US$667). Men were more aware (45%) than women (29%).

Most of the respondents agreed (73%) or strongly agreed (9%) that GM crops can increase productivity (Table 2). The average score for the perception of increased productivity was calculated at 0.38 (from −1 for “strongly disagree” to 1 for “strongly agree”). Similarly, most respondents agreed that GM crops could reduce pesticides on food (average score 0.37) and improve the nutritional quality (0.36). Averaging the score for the four questions on potential benefits provided a perception index $I_{BP}$, with an average of 0.36. Respondents aware of GM crops had slightly lower benefit perceptions, reflected in higher scores, than the others.

Many respondents, however, had concerns about environmental risks. More than half of the consumers agreed that GM crops could cause death of nontarget insects (score = 0.11), and can lead to the loss of land races (score = 0.07). However, more than half of the respondents disagreed with the general statement that GM threatens the environment (a negative score of −0.09). Averaging the three scores led to a slightly positive index of environmental risk perception ($I_{ERP}$ = 0.03). Consumers aware of GM crops had slightly higher environmental risk perceptions ($I_{ERP} = 0.07$) than the others ($I_{ERP} = 0.01$).

Respondents’ opinion about the effect of GM food on human health was mixed. Asked if GM foods would cause allergic reaction, about equal numbers disagreed (39%) as agreed (40%). Slightly more people disagreed with the statement that GM
Table 2
Consumers’ attitudes and perception of GM technology

<table>
<thead>
<tr>
<th>Perceptions of</th>
<th>Statement</th>
<th>Percentage of respondents</th>
<th>Mean score</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly disagree (score = −1)</td>
<td>Disagree (score = −0.5)</td>
<td>Neutral (score = 0)</td>
<td>Agree (score = 0.5)</td>
</tr>
<tr>
<td>Benefits</td>
<td>GM technology increases productivity and offers solution to world food problem</td>
<td>2</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>GM can reduce pesticides on food</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>GM can create foods with enhanced nutritional value</td>
<td>2</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>GM has the potential of reducing pesticide residues in the environment</td>
<td>2</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Benefit perceptions index (IBP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental risks</td>
<td>Insect-resistant GM crops may cause death of untargeted insects</td>
<td>2</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>GM can lead to a loss of original plant varieties</td>
<td>2</td>
<td>39</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>GM threatens the environment</td>
<td>3</td>
<td>49</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Environmental risk perception index (IERP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health risks</td>
<td>People could suffer allergic reaction after consuming GM foods</td>
<td>3</td>
<td>36</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Consuming GM foods can damage one’s health</td>
<td>4</td>
<td>44</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Consuming GM foods might lead to an increase in antibiotic-resistant diseases</td>
<td>3</td>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Health risk perception index (IHRP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethical and equity concerns</td>
<td>GM is tampering with nature</td>
<td>4</td>
<td>42</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>GM food is artificial</td>
<td>3</td>
<td>38</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>GM technology makers are playing god</td>
<td>10</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>GM products are being forced on developing countries by developed countries</td>
<td>3</td>
<td>51</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>GM products only benefit multinationals making them</td>
<td>4</td>
<td>61</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>GM products do not benefit small-scale farmers</td>
<td>4</td>
<td>67</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Ethical and equity concerns index (IEEC)</td>
<td></td>
<td></td>
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</tbody>
</table>

food can damage one’s health (48%) than agreed (37%). Similarly, more people disagreed with the statement that GM foods could lead to an increase in antibiotic-resistant diseases (43% vs. 35%), leading to a slightly negative index of health risk perception (I_{HRP} = −0.02; Table 2).

About half of the consumers agreed that genetic modification is tampering with nature and that GM food is artificial. Otherwise, more people disagreed with the ethical and equity concerns, in particular that GM technology developers are playing God (72%), and that GM products are being forced upon
developing countries (54%), that they only benefit the multinationals (64%) and not the small-scale farmer (71%). This led to a slightly negative perception score (\(I_{EEC} = -0.10\)), with the group aware of GM crops having a slightly higher index of ethical and equity concerns (\(I_{EEC} = -0.08\)) than the others (\(I_{EEC} = -0.12\); Table 2).

### 3.3. Conceptual framework

CV is a survey-based method of eliciting how consumers evaluate goods and services not found in the market place. These surveys only give meaningful results if they are properly grounded in a consumer maximization framework (Hanemann and Kanninen, 1998). It is generally assumed that consumers maximize their utility subject to a budget constraint and will, therefore, choose the option that gives them the highest utility. In this context, WTP is the maximum amount of money a consumer would be willing to pay for the new product. Different people have different WTP for a particular good, and it is the distribution of this WTP among the target population that offers interesting market information. This distribution can be estimated through open-ended or close-ended questions. Open-ended questions provide direct estimates and are easy to analyze, but people often find it difficult to state their WTP for a new product (Hanemann and Kanninen, 1998). Close-ended questions are closer to real-life situations and have, therefore, become the method of choice (Arrow et al., 1993). In this method, WTP is not directly observed, but assumptions about its distribution can be made, and its parameters, including the mean WTP of a population in monetary terms, can be estimated from survey data (Lusk and Hudson, 2004).

Several approaches have been developed, including the single-bounded, the double-bounded, and the multi-bounded approaches. In the single-bounded, dichotomous choice approach, the respondent is offered only one bid (a certain product at a certain price), to accept or reject. This method is incentive compatible because it is in the respondent’s strategic interest to accept whether her WTP is greater or equal to the price asked and to reject otherwise (Mitchell and Carson, 1989). Utility maximization implies that a person will then only answer “yes” to the offered bid if his maximum WTP is greater or equal to the bid. However, the method requires a large sample size and is statistically not very efficient (Hanemann et al., 1991). In the double-bounded approach, a second bid is offered, higher or lower depending on the first response. This method incorporates more information about an individual’s WTP and, therefore, provides more efficient estimates and tighter confidence intervals (Hanemann et al., 1991). The double-bounded approach has been used extensively in valuing nonmarket goods, as well as for consumer acceptance of GM crops (Kaneko and Chern, 2003; Li et al., 2002; McCluskey et al., 2003). The analysis, however, requires maximum likelihood estimation, and the interpretation is not always straightforward.

Recently, multiple-bounded and polychotomous choice methods are being explored, which offer multiple bids as well as multiple response options (Alberini et al., 2003). They allow for multiple bids, which is useful when limited information is available initially to decide which bids to include. They also allow for multiple choices, which offer the possibility of including options for uncertainty. Multiple-bounded approaches are, however, subject to design bias, and are influenced by the range of bids included (Roach et al., 2002; Vossler et al., 2004). The underlying assumptions of the approach when including uncertainty is still under debate (Vossler and Poe, 2005). More research, currently under way, is expected to shed more light on these issues.

When this survey was conducted, however, multiple-bounded models were still being developed, so the double-bounded model was chosen. This method has a good theoretical justification; it is incentive compatible and leads to unbiased estimates. It is more efficient than the single-bounded approach (Hanemann et al., 1991) and has been used in many consumer studies on acceptance of GM food. The maximum likelihood procedure using the logistic distribution is fairly straightforward with standard econometric software. Moreover, average prices of related products are sufficiently known to help set the bids.

Conceptually, the WTP of a group of consumers for a particular product at a price (or bid) \(B\) can be assumed to have a certain probability distribution function. Moreover, this distribution function can be seen as a function of the price, with a higher price having a lesser probability of being accepted. In applied research, the logistic distribution is commonly used, and the effect of the price is entered indirectly in an argument called the index function, denoted as \(v\). The most common index function is linear in the price or bid, \(B\):

\[
v = \alpha - \rho B,\quad (1)
\]

and the probability distribution of the WTP is then presented by

\[
P(WTP = B) = \exp(v)/(1 + \exp(v))^2.\quad (2)
\]

The logistic function has the advantage of a closed-form cumulative distribution function \(G(.)\), which then represents the proportion of the population whose WTP lies below a certain value \(B\):

\[
G(B) = P(WTP < B) = \exp(v)/(1 + \exp(v)).\quad (3)
\]

People who would accept an offer of value \(B\) are those whose WTP is equal to, or higher than, \(B\) (Hanemann and Kanninen, 1998; Hanemann et al., 1991). In the double-bounded dichotomous choice model, the consumer is presented with two consecutive bids, and the second bid depends on the response to the first. If the consumer answers “yes” to the first bid \(B_1\), the second bid \(B_2^y\) is set higher, but if the individual responds “no” to the first bid, the second bid \(B_2^n\) is set lower. There are four possible outcomes: “yes” to the first bid followed by a “yes” to the second bid (with probability
denoted by \( \pi^y \); “yes” followed by “no” (\( \pi^yn \)); “no” followed by “yes” (\( \pi^nn \)); and two consecutive “no” answers (\( \pi^nnn \)). To receive information on a wider range of values, different amounts for the bids are assigned randomly between respondents \( i \). The probability of receiving a “yes” answer to both questions equals the probability that the respondent’s WTP is higher than the highest bid offered:

\[
\pi^y(B_i, B_u) = \Pr(B_i < W T P_i) = 1 - G(B_u). \tag{4}
\]

Similarly, the probability of receiving a “yes” followed by a “no” equals the probability that the WTP of respondent \( i \) lies between the initial bid and the second, higher bid offered:

\[
\pi^yn(B_i, B_u) = \Pr(B_i < W T P_i < B_u) = G(B_u) - G(B_i). \tag{5}
\]

The probability of receiving a “no” followed by a “yes” is again the probability that \( W T P_i \) lies between the initial and the second, now lower, bid offered:

\[
\pi^ny(B_i, B_d) = \Pr(B_i < W T P_i < B_d) = G(B_d) - G(B_i). \tag{6}
\]

Finally, the probability of receiving two “no” answers is equal to the probability that \( W T P_i \) lies below the second, lowest bid offered:

\[
\pi^nn(B_i, B_d) = \Pr(B_i < W T P_i) = G(B_d). \tag{7}
\]

Combining the probabilities of the four outcomes, the log-likelihood function for a sample of \( N \) consumers takes the form

\[
\ln L^D(\theta) = \sum_{i=1}^{N} \left[ d^y_i \ln \pi^y(B_i, B_u) + d^{yn}_i \ln \pi^{yn}(B_i, B_u) + d^{ny}_i \ln \pi^{ny}(B_i, B_d) + d^{nn}_i \ln \pi^{nn}(B_i, B_d) \right], \tag{8}
\]

where \( d^y_i, d^{yn}_i, d^{ny}_i, \) and \( d^{nn}_i \) are binary variables with 1 denoting the occurrence of that particular outcome, and 0 otherwise. To operationalize this model, we need to specify the cumulative distribution function \( G(\bullet) \). We use the logistic function (Eq. (3)) with a linear index function (Eq. (1)). Substituting this function for \( G(\bullet) \) in Eqs. (4)–(7) fully specifies the probabilities of the four outcomes and the likelihood function (Eq. (8)). Parameter estimates can then be obtained by maximizing the likelihood function, the mean WTP is calculated as \( \omega / \rho \) (Hanemann and Kanninen, 1998; Hanemann et al., 1991), and the standard errors are calculated using the bootstrap method.

### 3.4. Factors that influence WTP

Market analyses traditionally deal with the demand for homogeneous goods, determined by a set of relevant prices and demographic variables. Demand for quality traits, however, need not be determined by the same set of variables. Research needs to give more attention to the demand for differentiated, frequently branded food products, to the disaggregation of the population, and to a recognition that traditional demographic factors may have limited explanatory power (Senauer, 2001). Even if there is an objective measure of a particular quality, it does not follow that all consumers perceive quality in the same way. It is not unusual to find that one consumer’s utility increases with a particular quality, whereas another consumer’s utility decreases. In such cases, demand for quality depends on an individual’s knowledge and perception of that quality, as well as trust in the authorities guarding this quality. The effect of these factors on consumers’ acceptance of GM food has already been demonstrated in several studies in developed countries and Asia, as was reviewed earlier, but no such studies have been conducted in Africa.

Given the general nature of consumer theory, we explore whether the same cognitive variables influence WTP in Africa, in addition to price and socioeconomic factors. Formally, the probability of consumer \( i \) buying a new product, in particular a GM food, when offered at a certain price \( B_i \) can be hypothesized to be a function of a vector of cognitive and socioeconomic factors \( z_i \):

\[
\pi^y(B_i, z_i) = \pi^y(v_i), \tag{9}
\]

where \( v_i \), as defined earlier, is the index function with the predetermined relationship between \( B_i \) and \( z_i \), assumed here to be linear:

\[
v_i = \alpha - \rho B_i + \lambda z_i + \varepsilon_i, \tag{10}
\]

and \( \varepsilon_i \) is a random term. As in the basic model of the previous section, the probability of a bid being accepted (either the first or the second bid in the double-bounded method), taking into account other consumer characteristics, becomes

\[
\pi^y(v_i) = 1 - G(v_i) \quad \text{or} \quad \pi^y(B_i, z_i) = 1 - 1/(1 + \exp(\alpha - \rho B_i + \lambda z_i)). \tag{11}
\]

The proper log-likelihood function for the double-bound method can then be constructed in analogy to Eq. (8).

Based on results from studies on GM food from other regions worldwide, the cognitive factors included were awareness of GM technology (binary variable), perceptions of GM food as measured by the benefit perception index (I_{BP}), health perception index (I_{HRP}), ethical and equity concerns index (I_{IEEC}), and having trust in the government (yes = 1, no = 0).

Further, the socioeconomic variables such as age, gender, presence of children in the household, education, and income were included. For education, binary variables were included for at least some secondary, tertiary college, or university education, with none or at least some primary education as base. For income, binary variables were included for students without income and for the low-, middle- and high-income groups. The group without income, excluding students, was used as the base.
Fig. 1. Consumers’ willingness to buy GM maize meal at the same price as their preferred brand (first bid), at a premium (second bid, after they accepted the first bid), or at a discount (second bid, after they rejected the first bid).

Consumers were first asked which is their favorite maize meal brand, and which price they usually pay for a 2-kg packet. Then, they were asked whether they would be willing to buy GM maize meal at that same price, in Kenya shillings for a 2 kg packet. Those who answered “yes” were then asked if they would be willing to buy GM maize meal at a higher price (premium). Therefore, different premium levels were assigned randomly to different respondents (5%, 10%, 20%, 30%, or 50% of the price of their favorite brand), but each respondent was only offered one second bid: the price of their favorite brand plus the random premium level, calculated by the enumerator and expressed in KShs per 2-kg packet.

Respondents who answered “no” to the first bid were offered a lower price; the price of their favorite brand, reduced by a randomly assigned discount (5%, 10%, 20%, 30%, or 50%), calculated in KShs/2 kg. The premium or discount percentages were equally distributed across the sample. The average price of the consumers’ favorite brand was 51 KShs/2 kg, and the second bid ranged from 18 to 105 KShs/2 kg.

To calculate the mean WTP, the simple model (without consumer characteristics or setting, all $\lambda_i = 0$) was estimated first with the maximum likelihood procedure, and average WTP was calculated as $\alpha / \rho$. The confidence interval for mean WTP was estimated with the bootstrap method (Greene, 1991). Then the full model, including consumer characteristics, was estimated. Marginal effects were calculated to determine the influence of respondents’ characteristics on WTP. The mean WTP was calculated from the full model, by adjusting the $\alpha$ to include the estimated parameters and the average values for the vector of factors $\bar{z}$:

$$E(WTP|\alpha, \lambda, \rho, \bar{z}) = \left[ (\alpha + \lambda' \bar{z}) / \rho \right]$$  (12)

(after Haab and McConnel, 2002, p. 35). The standard error was again calculated using the bootstrap method.

The results of the different steps in this research methodology are presented in the next section, covering the level of awareness and willingness to buy GM maize meal, the estimation of the short model and calculation of the average WTP for GM maize, and the analysis of the different factors influencing this WTP.

4. Results

A large majority of the surveyed consumers (68%) would be willing to buy GM maize meal at the same price as their favorite maize meal brand. They are represented by the hatched bars in Fig. 1. A third of the consumers (32%), however, rejected the first bid. They were then offered a discount, ranging from 5% to 50% of the price of their favorite brand, but presented as a monetary amount (in KShs for a 2 kg packet). Of those who were offered the largest discount (50%), almost half (41%) would accept. In other words, an additional 13% of consumers (32% × 41%), would be willing to buy GM maize meal if offered a discount of 50%. This is represented by the gray section of the first bar at the left of Fig. 1. Because 68% of consumers would already buy it at no discount (hatched proportion of the bar), a total of 81% of consumers would buy GM maize at the 50% discount (represented by the stacked bars). The proportion of consumers accepting the bid generally declined with its size, down to 31% of consumers accepting the 5% discount. This represents 9% (32% × 31%) of all consumers, so on top of the 68% who accepted the initial bid, this makes 77% of consumers who would buy GM maize at a 5% discount (fifth bar in Fig. 1).
The 68% of consumers who accepted the first bid (central bar, at 0% premium or discount) were then asked whether they would be willing to buy GM maize meal at a higher price, or a premium, ranging from 5% to 50%. Of those offered a premium of 5%, half would accept (next bar on the right). At a premium of 10%, most consumers (43%) would still accept. The proportion of consumers willing to accept the bid generally decreased with its size, with a quarter of consumers (26%) still willing to accept the highest premium of 50% (last bar on the right in Fig. 1). The bars roughly represent the logistic curve of the size of the effects can be gauged by analyzing the marginal effects, which are indicators of percentage change in people willing to pay, when all other factors, including price, are kept at their average value. An increase in the health perception index of 1, for example, decreased the number of consumers willing to pay for GM maize meal, at the average price, by 18%. An increase in the ethical and equity perception index, indicating that consumers are willing to pay a premium for GM maize meal.

To analyze the impact of different factors on WTP, the parameters of the expanded model (Eq. (11)) were estimated, the marginal effects calculated at the means of the explanatory variables, and the mean WTP recalculated (Table 4). Calculating the mean WTP from the estimated coefficients of the full model, following Eq. (12), results in an estimate of 57.9 KShs/2 kg packet, slightly less than the first estimate, but still leading to a premium of 13.8%.

Among the factors tested, awareness of GM crops was clearly not significant. This is not unexpected, because unaware consumers were provided with an explanatory text on the topic. The information provided did not seem to influence their WTP in a way different from aware consumers, who did not receive that information. Consumers’ perceptions, on the other hand, were very important. Interestingly, the effects of the positive benefit perceptions were not significant, whereas the effects of the negative perceptions, health risks, and concerns about ethics and equity were large and significant. Trust in the government’s capacity to control and regulate the industry, on the other hand, was a strong positive factor.

The size of the effects can be gauged by analyzing the marginal effects, which are indicators of percentage change in people willing to pay, when all other factors, including price, are kept at their average value. An increase in the health perception index of 1, for example, decreased the number of consumers willing to pay for GM maize meal, at the average price, by 18%. An increase in the ethical and equity perception index

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Table 3
Parameter estimates for WTP model without consumer characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Symbol parameter</th>
<th>Estimate</th>
<th>Standard error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant ($\alpha$)</td>
<td>$\alpha$</td>
<td>3.4759**</td>
<td>0.5008</td>
<td>0.0000</td>
</tr>
<tr>
<td>Bid ($\rho$)</td>
<td>$\rho$</td>
<td>0.0799**</td>
<td>0.0041</td>
<td>0.0000</td>
</tr>
<tr>
<td>Mean WTP ($\alpha/\rho$)</td>
<td>$\alpha/\rho$</td>
<td>57.9958</td>
<td>1.1290</td>
<td>0.0000</td>
</tr>
<tr>
<td>Number of observations</td>
<td></td>
<td>553</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log-likelihood function</td>
<td></td>
<td>807.6581</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi-square</td>
<td></td>
<td>1,615.316</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a*Calculated using the bootstrap method.

*Indicates statistically significant at the 99% confidence level.

Table 4
Parameter estimates for WTP model with consumer characteristics

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Symbol parameter</th>
<th>Estimate</th>
<th>Standard error</th>
<th>P-value</th>
<th>Marginal effects</th>
<th>Mean values ($\bar{x}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant ($\alpha$)</td>
<td>$\alpha$</td>
<td>3.4759**</td>
<td>0.5008</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bid ($\rho$)</td>
<td>$\rho$</td>
<td>0.0799**</td>
<td>0.0041</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean WTP ($\alpha/\rho$)</td>
<td>$\alpha/\rho$</td>
<td>57.9958</td>
<td>1.1290</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness about GM crops</td>
<td>$\lambda_1$</td>
<td>0.0008</td>
<td>0.2044</td>
<td>0.9969</td>
<td>0.0002</td>
<td>0.382</td>
</tr>
<tr>
<td>Benefit perception index</td>
<td>$\lambda_2$</td>
<td>0.0059</td>
<td>0.2825</td>
<td>0.9835</td>
<td>0.0014</td>
<td>0.366</td>
</tr>
<tr>
<td>Health risk perception index</td>
<td>$\lambda_3$</td>
<td>-0.8417**</td>
<td>0.2358</td>
<td>0.0004</td>
<td>-0.1947</td>
<td>-0.032</td>
</tr>
<tr>
<td>Ethical and equity concerns index</td>
<td>$\lambda_4$</td>
<td>-0.5939**</td>
<td>0.2848</td>
<td>0.0370</td>
<td>-0.1374</td>
<td>-0.122</td>
</tr>
<tr>
<td>Trust in government</td>
<td>$\lambda_5$</td>
<td>0.7590**</td>
<td>0.2020</td>
<td>0.0002</td>
<td>0.1815</td>
<td>0.438</td>
</tr>
<tr>
<td>Age</td>
<td>$\lambda_6$</td>
<td>-0.0031</td>
<td>0.0106</td>
<td>0.7699</td>
<td>-0.0007</td>
<td>30.069</td>
</tr>
<tr>
<td>Gender (female = 1, male = 0)</td>
<td>$\lambda_7$</td>
<td>0.0389</td>
<td>0.1825</td>
<td>0.8311</td>
<td>0.1471</td>
<td>0.394</td>
</tr>
<tr>
<td>Presence of children</td>
<td>$\lambda_8$</td>
<td>0.0186</td>
<td>0.1940</td>
<td>0.9238</td>
<td>0.0043</td>
<td>0.280</td>
</tr>
<tr>
<td>At least secondary education</td>
<td>$\lambda_9$</td>
<td>0.6530**</td>
<td>0.2328</td>
<td>0.0050</td>
<td>0.1471</td>
<td>0.116</td>
</tr>
<tr>
<td>At least tertiary education</td>
<td>$\lambda_{10}$</td>
<td>0.2772</td>
<td>0.2718</td>
<td>0.3079</td>
<td>0.0629</td>
<td>0.101</td>
</tr>
<tr>
<td>At least university education</td>
<td>$\lambda_{11}$</td>
<td>-0.1240</td>
<td>0.3465</td>
<td>0.7205</td>
<td>-0.0290</td>
<td>0.486</td>
</tr>
<tr>
<td>None (students)</td>
<td>$\lambda_{12}$</td>
<td>0.1019</td>
<td>0.3209</td>
<td>0.7508</td>
<td>0.0233</td>
<td>0.215</td>
</tr>
<tr>
<td>Low (KShs 1–15,000)</td>
<td>$\lambda_{13}$</td>
<td>0.1492</td>
<td>0.2336</td>
<td>0.5231</td>
<td>0.0345</td>
<td>0.022</td>
</tr>
<tr>
<td>Medium (15,001–50,000)</td>
<td>$\lambda_{14}$</td>
<td>0.4432</td>
<td>0.2817</td>
<td>0.1156</td>
<td>0.0984</td>
<td>0.714</td>
</tr>
<tr>
<td>High (over 50,000)</td>
<td>$\lambda_{15}$</td>
<td>2.0258**</td>
<td>0.6118</td>
<td>0.0009</td>
<td>0.3007</td>
<td>0.754</td>
</tr>
</tbody>
</table>

*a*Calculated using the bootstrap method.

***, * indicate statistically significant at the 99% and 90% confidence levels, respectively.
by 1 reduced the percentage of people willing to pay by 13%, whereas people who trusted the government were 18% more likely to pay for GM maize meal.

Of the socioeconomic characteristics, only education and income showed significant effects. Age, gender, and presence of children did not have significant effects. The effect of education was mixed, however. People with some secondary schooling had a significantly higher WTP than those with either less or more education, but those with higher education levels did not. WTP does clearly increase with income, and consumers in the high-income group are 30% more likely to buy GM food.

5. Conclusions

The survey results indicate that more than a third (38%) of the consumers in Nairobi were aware of GM crops. People with higher education and income levels are generally more aware. The majority of consumers (68%) would be willing to buy GM maize meal at the price of their favorite maize meal brand. On average, they would even be willing to pay more: a 13.8% premium over the average price. Nairobi consumers’ acceptance of GM food is similar to that in other developing countries such as China, Colombia (Curtis et al., 2004; Zhang et al., 2004), United States (Chen and Chern, 2002; Ganiere and Chern, 2004), and Taiwan (Kim and Kim, 2004). They clearly differ from consumers in Europe (Moon and Balasubramanian, 2001; Moon et al., 2004; Springer et al., 2002), Japan, and South Korea (Kim and Kim, 2004). However, although respondents in this study generally appreciated the positive benefits of the GM technology, they were concerned about the potential negative effects, especially on the environment and the loss of land races.

Econometric estimation indicates that these consumer perceptions have an effect on WTP, as has been observed elsewhere. Awareness and positive perceptions of the technology, however, did not have significant effects, unlike the result of consumer studies in China (Li et al., 2002). Negative perceptions, in particular perceived negative effects on health, had a clear negative effect on WTP, as observed in other countries (Curtis and Moeltner, 2006; McCluskey et al., 2003). Perceived ethical and equity concerns also influenced WTP negatively. Trust in the government’s ability to ensure food quality had a positive influence on WTP, as has been observed in Europe (Springer et al., 2002). Among socioeconomic factors, only income and education significantly influenced WTP, similar to the findings of Chen and Chern (2002) who found that U.S. consumers with higher incomes were willing to pay more. People with at least some secondary education have higher WTP for GM maize meal than those with only some primary education. Similarly, consumers with an income higher than KShs 50,000 per month have a higher WTP than those in the lowest income categories. Consumers’ demographic characteristics such as age, gender, and presence of children had no significant effects, unlike in consumers in the United States (Chen and Chern, 2002).

It also emerges that general knowledge on biotechnology and GM technology is limited, and that some consumers’ WTP for GM crops is influenced by perceptions clearly not based on scientific evidence. The scientific community has come to a consensus, for example, that consumption of GM foods poses no health risks different from the consumption of their conventional counterparts (FAO, 2004). Moreover, the new GM maize varieties no longer use antibiotic markers, so the transformed plants cannot generate resistance to antibiotics as is often perceived. The positive perceptions, on the other hand, have scientific justification, but do not seem to influence WTP. Because this information is important for people to participate effectively in the debate, there is a need for increased education on GM technology. Attention is needed to communicate the effects of GM crops to consumers. Regular consumer surveys will better inform scientists and media practitioners about the perceptions regarding GM crops in the country.

Given the experience of this survey, some methodological improvements can be suggested for future studies. For instance, people might be asked to elaborate on the reasons for their opinions or perceptions. We found that consumer characteristics, as well as perceptions and attitudes, differ between socioeconomic groups, and that different groups buy their maize at different types of outlets. Therefore, household surveys, although expensive, would yield more representative results. This survey only covered urban consumers in the capital city. To capture consumers’ opinions fully, surveys in other urban centers and rural areas are needed. Based on experience in other countries, other approaches should also be considered. Several studies have used experimental auctions (Lusk et al., 2003), although they require that GM food is approved for testing in the country. In CV, multiple-bound polychotomous choice methods are becoming more prominent. These have the advantage that they allow for the inclusion of uncertainty, which might be of particular interest for consumer surveys on GM food.

Acknowledgments

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Appendix: Information text presented to respondents unaware of GM crops

Transgenic crops (generally referred to as genetically modified crops) contain genes that have been artificially inserted by scientists instead of the plant acquiring them from pollination. The inserted gene may come from plants of the same species, another unrelated plant, or from other organisms such as bacteria.

Traditional breeding takes a long time to achieve desired results and frequently fails. GM technology enables scientists to bring useful genes from a wide range of living sources to a crop plant, not just from within the plant species or from closely related plants. This allows scientists to generate superior plant varieties quickly and with precision, and add traits that are not possible through conventional breeding.

Traits targeted by plant breeders for genetic modification include plant characteristics such as increased yields, disease resistance, and pest resistance; plus consumption traits such as food color, size, shape, nutrition, and taste.

KARI, together with international research organizations, is undertaking research on GM maize and sweet potato. This is aimed at developing insect-resistant maize (Bt maize) and virus-resistant sweet potato. Insect-resistant maize will enable the maize plant to protect itself against insects (in particular stem borers) by producing its own insecticide.

The use of GM crops has resulted in significant benefits where these crops are grown. These are

1. higher yielding crops that address food shortages,
2. reduced losses from insect pests and diseases,
3. reduced pesticide costs,
4. reduced pesticide residues in the environment,
5. lower food prices for the consumers because of lower production costs,
6. ability of plants to grow in harsh and stressful conditions, and
7. reduced toxic health effect on farmers.

Future GM crops will have traits that will benefit consumers. Their potential benefits include

1. nutritionally enriched foods that help alleviate malnutrition,
2. edible vaccines for children diseases (e.g., polio) in food crops and fruits, and
3. food that stays fresh for longer periods.

Potential risks and perceived concerns about GM crops are

4. the danger of unintentionally introducing allergic substances or toxins to foods,
5. the possibility of these genes escaping from cultivated crops into wild relatives,
6. the possibility that transgenic crops carrying antibiotic genes will generate antibiotic resistance in livestock and humans after eating food from these crops,
7. the potential for pests to develop resistance to the pesticide produced by GM crops, and
8. the risk of substances from these crops affecting nontarget and beneficial insects.

Generally, after genetic modification, seeds are tested to ensure their safety for human consumption. Then plants are tested in a special biosafety green house to check their effectiveness, such as insect resistance. If these trials proceed without problems, the authorities may give permission for trials on test plots in quarantine stations. If these trials go well, scientists may seek permission to try the varieties on the farm. After successful trials for several years, authorities can grant permission to commercialize and sell these varieties to farmers.

Most GM crops are grown in the developed countries especially the United States and Canada. Some developing countries, such as China and India, have adopted the technology. In Africa, commercial growing is taking place in South Africa only. These crops have, however, not generally been accepted in Europe. Kenya is not growing them commercially but is doing research in order to develop insect-resistant maize and virus-resistant sweet potato.

The leading GM crops grown in the world are soybean (herbicide resistant), maize, and cotton (both insect and herbicide resistant).

(Note: To half of the interviewed consumers, the section of the potential risks and dangers was read before the section of benefits).

References


